Con Edison EEPS Programs - Impact Evaluation of Residential HVAC Electric Program

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energy & resource solutions

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Contents

1 Executive Summary

Consolidated Edison Company of New York (CECONY) requisitioned an impact evaluation of its Residential Electric HVAC Program. This document contains the results of that evaluation.

1.1 Program Background and Objectives

The Residential Electric HVAC program provides rebates to customers that install new HVAC energy efficiency measures, including air conditioners, heat pumps, furnaces, furnace fans, and programmable thermostats. This evaluation focused on the air conditioning and heat pump measures, which make up 47% and 26% of ex ante program savings, respectively. All additional measures received an engineering review as part of the evaluation.

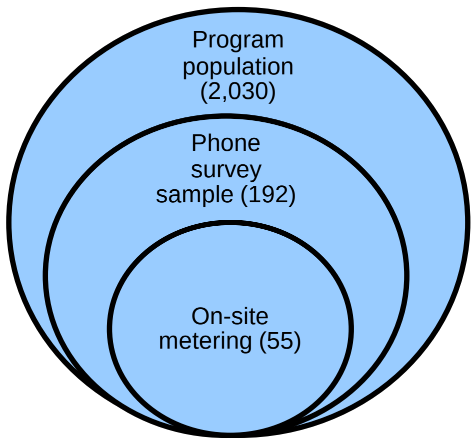
CECONY implements this program via a network of contractors/trade allies that advise their customers of the availability of rebates. A third party administers the program. When the program was launched, CECONY required that the customer's installation contractor be enrolled in the program in order for the HVAC installation to be eligible for any equipment rebates except for programmable thermostats. CECONY's trade allies were required to attend a free training course, submit proof of contractor's license and appropriate insurance, and complete a program application in order to be approved as a participating contractor. On October 1, 2010, CECONY dropped the requirement to attend the training course and submit the required documentation.

1.2 Research Approach

To determine program net energy savings and net peak demand reduction, the evaluation team sampled 192 participants via phone survey and installed metering equipment on fifty-five of those 192 surveyed participants. The equipment was installed on central air conditioners (CAC) during the cooling season and on mini-split ductless heat pumps (DHPs) during both the cooling and heating season. The phone survey and on-site metering results were used to determine equipment run time and power. Attribution was based on self-reported responses from the same telephone survey.

The evaluation team calculated gross impacts by leveraging the program tracking data, program participants' billing data, phone survey data, and on-site metered data as well as other data collected on-site. The use of a double-ratio estimation method for combining these various data sets ensured a high-quality result at a reasonable cost. By nesting the on-site sample within the phone survey sample, the evaluators were able to achieve a more accurate estimate of the frequency of some outliers, which may include extremely high air conditioning and heating usage participants or extremely low air conditioning and heating usage participants. A schematic of the sampling plan is shown below in Figure 1-1.

Figure 1-1
Nested Sampling Schematic



The fraction of program gross savings attributed to the program, indicated as a net-to-gross ratio (NTGR), is made up of free ridership (FR) and spillover (SO) and is calculated as $(1 - FR + SO)$. These components are derived from self-reported information from telephone interviews with program participants. The evaluation team relied on the self-report method to derive both FR and SO estimates. Program participants were interviewed and asked a series of structured and open-ended questions about the influence of the program and its various components on the decision to purchase or install energy efficient cooling and heating equipment.

1.3 Results

The evaluation team calculated gross and net energy and demand savings, which are presented in the following section.

1.3.1 Gross Impacts

The program achieved total first year savings of 1,891 MWh gross energy savings and 1,021 kW peak gross demand savings over the evaluation period from CACs and DHPs. The realization rates for energy and peak demand savings are 0.87 and 0.76, respectively. Savings were calculated for each of two strata – one comprising CAC participants and one comprising DHP participants. The CAC and DHP baselines assume replacement on burnout/new application. The baseline new equipment is of the same type as that installed, but at code minimum efficiency. This results in a standard efficiency DHP as the baseline for the DHP measure, rather than using a CAC or room air conditioner as the baseline.[1] For a CAC, the baseline is a standard efficiency CAC system. DHP savings take into account both cooling and heating season savings. Of the savings achieved through the DHP measure, 345 MWh (about 86%) were achieved from the cooling season savings. Additional measures within the Residential HVAC Electric program received an engineering review. In this review, the savings for all furnace fans, programmable thermostats, air sealing, and duct sealing participants were recalculated using the heating and cooling equivalent full load hours (EFLH) determined from this metering study combined with the existing New York Technical Manual (NYTM) algorithms.

The total verified gross energy savings and total verified gross peak demand savings are shown by stratum in Table 1-1 and Table 1-2, respectively.

Table 1-1
Program Gross Energy Impacts

Measure	Measure Installations	Ex Ante Gross Energy Savings (MWh)	Ex Post Gross Energy Savings (MWh)	Gross Energy Realization Rate	Relative Precision at 90% Confidence*
CAC	2,646	1,015	800	0.79	17%
DHP	754	570	577	1.01	30%
M&V Subtotal	**3,396**	**1,585**	**1,377**	**0.87**	**15%****
Programmable thermostats	1,436	374	278	0.74	N/A
Furnace fans	274	170	201	1.18	N/A
Air sealing	97	29	32	1.12	N/A
Duct sealing	5	7	3	0.38	N/A
Total	**5,212**	**2,165**	**1,891**	**0.87**	**N/A**

*Relative precision is calculated at the 90% confidence level. The relative precision is not applicable for the measures that received only engineering review to verify savings rather than metering because the review is conducted on a census of installations and there is no sampling error to report.

** The M&V subtotal relative precision is calculated based on the savings and standard error of the M&V measure population, calculated as the square root of the sum of the squares of the CAC and DHP measure-level standard errors. See Appendix D for more details.

[1] Appendix C contains a memo sent from Navigant to CECONY describing the rationale for choosing this baseline for DHPs as opposed to the alternatives. This proposal was approved by the New York Department of Public Service (DPS) in a June 6, 2013 email to CECONY and the evaluation team.

Table 1-2
Program Gross Peak Demand Impacts

Measure	Measure Installations	Ex Ante Gross Peak Demand Savings (kW)	Ex Post Gross Peak Demand Savings (kW)	Gross Peak Demand Realization Rate	Relative Precision at 90% Confidence*
CAC	2,646	1,128	901	0.80	34%
DHP	754	185	105	0.57	29%
M&V Subtotal	**3,400**	**1,313**	**1,006**	**0.77**	**27%****
Programmable thermostats	1,436	0	0	N/A	N/A
Furnace fans	274	0	0	N/A	N/A
Air sealing	97	13.3	14.8	1.11	N/A
Duct sealing	5	10	0.6	0.06	N/A
Total	**5,212**	**1,336**	**1,021**	**0.76**	**N/A**

*Relative precision is calculated at the 90% confidence level. The relative precision is not applicable for the measures that received only engineering review to verify savings rather than metering, because the review is conducted on a census of installations and no sampling error was introduced.

** The M&V subtotal relative precision is calculated based on the savings and standard error of the M&V measure population, calculated as the square root of the sum of the squares of the CAC and DHP measure-level standard errors. See Appendix D for more details.

The primary driver of the energy realization rate is lower unit run time than the EFLH used in the current NYTM. Additionally, the DHP heating hours are dramatically lower than the hours claimed in the NYTM for the central heat pump measure.[2] If the program had used the corrected EFLH assumptions based on the findings of this report, the program's gross realization rate would have been 0.99 for both energy and peak demand.[3]

The primary driver of the peak demand realization rate is a lower coincidence factor than CECONY's current assumption. The high relative precision (high uncertainty) is primarily a result of poorer correlation between customer's stated usage behavior and actual usage behavior than was assumed in the initial sampling plan.[4] This correlation is worse for peak

[2] DHPs are zonal, which drives down hours of use relative to central heat pumps. In addition, many people use DHPs as a secondary heat source. See page 7 for more information.

[3] This is different than what is shown in Table 1-1 and Table 1-2 because the program used the EFLH values from the current or previous NYTM and/or other DPS guidance.

[4] While the poor correlation resulted in a higher relative precision (higher uncertainty) than anticipated, the nested sample approach still has a lower relative precision than if only the metered sites were used in the analysis. Inability of participants to accurately report how they operate their air conditioners was the major driver behind this poor correlation. The conclusions and recommendations section describes how

usage than for overall usage. In addition, DHP usage behavior was much more variable than CAC usage behavior.

Unit Run-Time and Savings Results

For CACs, savings is determined from the run times in Table 1-3. To determine energy savings for an individual unit, use the following equation:

$$kWh_{Savings} = kWh_{Consumed,baseline} - kWh_{Consumed,efficient}$$

where,

$kWh_{Consumed,baseline}$ = The energy consumption of a baseline (SEER 13, EER 11.1) unit

$kWh_{Consumed,efficient}$ = The energy consumption of the efficient equipment installed

To determine $kWh_{Consumed,baseline}$ and $kWh_{Consumed,efficient}$, the following equation is used:

$$kWh_{Consumed} = \left(\frac{EFLH_{High}}{EER} + \frac{EFLH_{Low}}{SEER}\right) \times Size\ (tons) \times 12$$

where,

$EFLH_{high}$ = The equivalent full-load high-stage run time listed in Table 1-3

$EFLH_{Low}$ = The equivalent full-load low-stage run time listed in Table 1-3

For single-stage units, simply use 0 for the $EFLH_{low}$ variable as listed in Table 1-3.

The run-time results derived from combining phone survey data, billing data, and on-site metering for the Residential Electric HVAC program are shown in Table 1-3 for CACs.

Single-stage air conditioners run at high stage all the time. Two-stage units have a high stage and a low stage. Two-stage units run in low stage most of the time, but they run longer. The values in Table 1-3 are meant to be used in the above equations only, where EFLH is an efficiency-weighted value rather than an exact runtime.[5] The evaluation team recommends that

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the evaluation team would recommend changing the sampling design for future program evaluations of a similar nature.

[5] Typical savings algorithms, such as the one currently used in the NYTM, do not use this more accurate efficiency-weighted approach but rather a single EFLH value. Consequently, these values cannot simply be used in the existing NYTM algorithm.

this approach be adopted by the NYTM in place of its existing algorithm.[6] See section 4.1.2 for a more detailed explanation of this approach and why it is more appropriate in this application.

Table 1-3. CAC Energy Consumption and Equivalent Full-Load Hours Results

Unit Type and Mode	Equivalent Full-Load Hours (EFLH)*
Single-stage CAC	
High stage	519
Low stage	0**
Two-stage CAC	
High stage	119
Low stage	449

$$kWh_{Consumed} = \left(\frac{EFLH_{High}}{EER} + \frac{EFLH_{Low}}{SEER}\right) \times Size\ (tons) \times 12$$

*The EFLH listed in the tables already accounts for various unit efficiencies found within the program, and does not need to be further adjusted based on unit efficiency.

**Single-stage units do not have a low stage, and therefore the term of the equation that includes low-stage EFLH should be zero.

Because of their variable speed compressors and inconsistent ratings,[7] the DHPs' performance cannot be properly analyzed in the same way as that of CACs and results should be applicable only to programs with a similar mix of participating equipment. DHP cooling and heating season savings are given in Table 1-4[8]. For DHPs, savings should be determined from the following equation.[9]

$$kWh_{Saved} = \frac{Capacity_{Cool}}{12} \times \frac{Savings}{Ton}_{Cool} + \frac{Capacity_{Heat}}{12} \times \frac{Savings}{Ton}_{Heat}$$

[6] For the traditional SEER-based equation found in the current version of the NYTM, $kWh_{Consumed} = \left(\frac{EFLH}{SEER}\right) \times Size\ (tons) \times 12$, the resulting SEER-based EFLH value is 608.

[7] DHPs' manufacturer's ratings are not based on a consistent load factor, and therefore quantifying capacity and efficiency from manufacturer data is inconclusive.

[8] The NYTM does not include savings algorithms for ductless heat pumps, or any variable speed compressor technologies for residential applications, so there is currently no published value to compare with the evaluated values.

[9] For the traditional SEER and HSPF-based equations in the NYTM, the resulting cooling EFLH is 922 and the resulting heating EFLH is 234. These values should be used carefully. Because of the complicated and variable methods in rating DHP equipment, these results are only applicable to a similar mix of equipment models. The savings per ton values have the same issues, but the connotation with savings per ton values is that they have limited applicability to similar program participation mixes.

where,

$Capacity_{Cool}$ = The nominal cooling capacity of the unit in kBtu/hr

$Capacity_{Heat}$ = The nominal heating capacity of the unit in kBtu/hr

$\frac{Savings}{Ton}_{Cool}$ and $\frac{Savings}{Ton}_{Heat}$ = The savings values found in Table 1-4

Table 1-4
Ductless Heat Pumps – Energy Savings Results

Stratum	Verified Energy Savings per Ton (kWh/ton)	NYTM Energy Savings per Ton (kWh/ton)*
DHP cooling	271	197
DHP heating	51	164

*The NYTM heating savings in this table are based on 750 EFLH – the NYTM shows a range of 500 to 1000 EFLH for various residential building configurations. The NYTM cooling savings are calculated using 670 EFLH.

The DHP results derived in this evaluation are valid only for the unique mix of units in this program.[10] The average DHP SEER, EER, and HSPFs in this program were 19.3, 12.9, and 9.5, respectively.

Coincidence Factor Results

The coincidence factors by stratum are shown in Table 1-5.

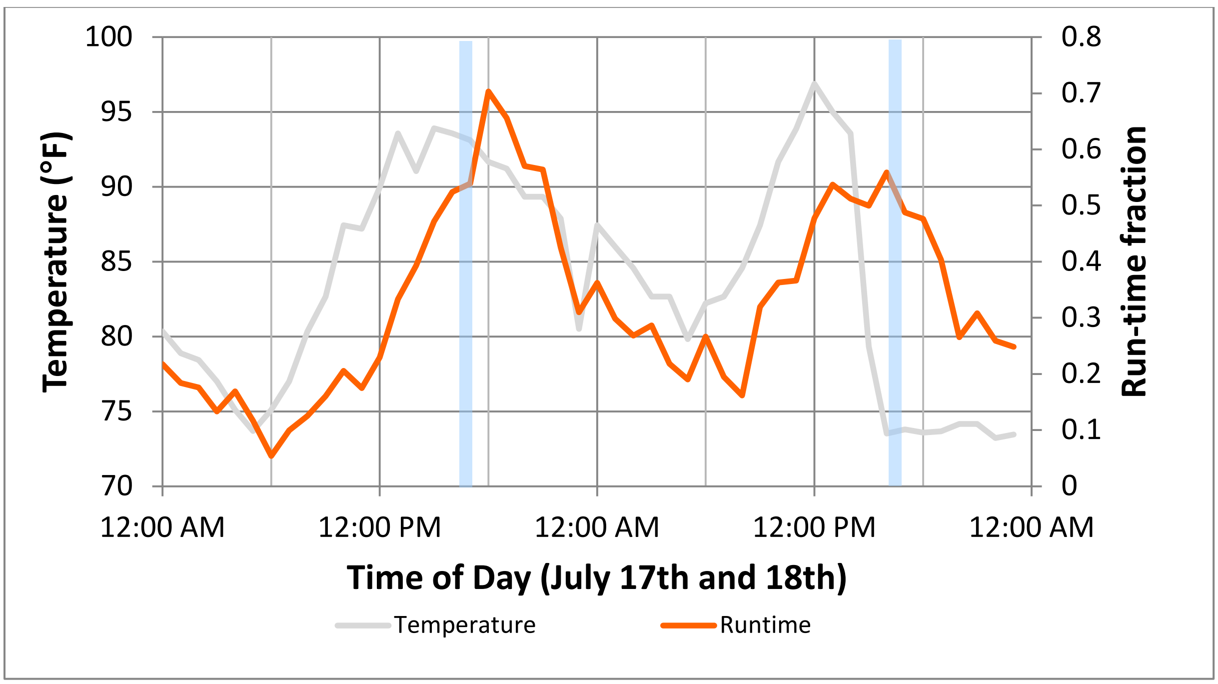
[10] For DHPs, the rated efficiency does not necessarily reflect the actual efficiency due to the nature of the technology and the testing protocols currently in place. The evaluation team does not guarantee accuracy for using these savings values beyond the next program cycle because the market for this technology is changing rapidly. However, these values are more accurate than the current NYTM values. The new values should be used in the short term but they should be re-evaluated as the technology progresses.

Table 1-5
Coincidence Factor Results by Stratum

Stratum	Coincidence Factor	Relative Precision at 90% Confidence[11]
CAC	0.52	34%
DHP	0.47	29%

While the relative precision is higher (i.e., higher uncertainty) than planned, the metered coincidence factors are still significantly lower than the 0.8 coincidence factor specified in the NYTM. Profiles of temperature and hourly run-time fraction (the average fraction of an hour that all participating units are cycling, or running) for metered CAC participants are shown in Figure 1-2. The two days shown in Figure 1-2 were the hottest days of 2012 in New York City. The thick blue vertical lines indicate CECONY's peak period.

Figure 1-2. Central Air Conditioning Run-Time Fraction and Temperature Profile over the Two Hottest Days in Summer 2012



[11] The high precision (high uncertainty) on the verified coincidence factor estimation resulted from poor correlation between how participants reported their air conditioner use in the phone surveys versus what was verified through the on-site metering. While the precision band is wide, the verified value is significantly lower than the current value of 0.8.

1.3.2 Attribution

The evaluation team estimated NTGR by measure category as well as for the program overall.[12] To arrive at the measure category NTG estimates, the evaluation team weighted individual scores by the ex post savings associated with the project and/or trade ally under question. To arrive at the program-level NTGR, the evaluation team weighted the measure-specific scores to the proportion of evaluated savings achieved by each measure category. Table 1-6 provides an overview of the NTG estimates by measure and at the program level. More than two-thirds of the incentive recipients reported that they already planned to install high efficiency systems, and more than half of them reported a high likelihood of purchasing the high efficiency option in the absence of program funding. FR rates for CAC and DHP measures are very similar (48% and 47%, respectively), which is not surprising given similarities in program design, marketing, and incentive levels. Trade ally research resulted in only a slight downward adjustment of the participant-derived FR rates. The evaluation found no participant spillover savings associated with the installation of either CACs or DHPs.[13] The final NTGR at the program level is 52%. The relative precision of this estimate is 9% at the 90% confidence level. Measure-level results are less precise (11% and 13% relative precision for CACs and DHPs, respectively). These results are shown in Table 1-6.

Table 1-6
Residential Electric HVAC Program Net-to-Gross Values and Relative Precision

Stratum	Participant FR Score	Trade Ally FR Adjustment Score	Final FR	Participant Spillover	Final NTG*	Relative Precision – NTG at 90% Confidence
CAC	0.52	0.04	0.48	0	0.52	11%
DHP	0.50	0.03	0.47	0	0.53	13%
Total	**0.48**		**0.48**	**0**	**0.52**	**9%****

*The final NTG estimate includes an estimate for the air sealing improvements. The contribution of the air sealing measure to the final NTG is negligible and is based on a small number of participant interviews (five completed interviews out of the population of 47 participants).

** The total relative precision is calculated based on the savings and standard error of the M&V measure population, calculated as the square root of the sum of the squares of the CAC and DHP measure-level standard errors. See Appendix D for more details.

As part of the evaluation, the presence of nonparticipant spillover (NPSO) was investigated through the interviews with trade allies. The results of trade ally interviews show that NPSO is rare. Quantifying savings from NPSO is a challenging and expensive task, and it was outside of

[12] Free-ridership rate for the program overall includes air sealing measure.

[13] Estimation of NPSO was outside of the scope of this study.

the scope and budget of this evaluation effort. However, a New York statewide effort is scheduled to begin in 2014 to assess NPSO.

1.3.3 Program Net Impacts

The net program results are calculated by multiplying the gross program results by the NTGR. The total program net energy impacts and total program net peak demand impacts are shown in Table 1-7 and Table 1-8, respectively.

Table 1-7
Program Net Energy Impacts

Measure	Measure Installations	Ex Post Gross Energy Savings (MWh)	NTGR	Ex Post Net Energy Savings (MWh)	Relative Precision at 90% Confidence*
CAC	2,646	800	0.52	416	20%
DHP	754	577	0.53	306	33%
M&V Subtotal	**3,400**	**1,377**	**0.52**	**722**	**18%******
Programmable thermostats	1,436	278	0.52**	145	N/A
Furnace fans	274	201	0.52**	105	N/A
Air sealing	97	32	N/A***	N/A	N/A
Duct sealing	5	3	N/A***	N/A	N/A
Total	**5,212**	**1,891**	**0.52**	**983**	**N/A**

* Relative precision is calculated at the 90% confidence level. The relative precision is not applicable for the measures that received only engineering review to verify savings rather than metering, because the review is conducted on a census of installations and no sampling error was introduced.

**Furnace fans and programmable thermostats were installed almost exclusively in conjunction with CAC and HP installations (97%). These participants were asked questions on the basis of the entire heating and cooling system project. As a result, these measures received the same NTG.

***Only five of the survey participants had installed air sealing and duct sealing measures; thus, the results are not statistically significant.

**** The M&V subtotal relative precision is calculated based on the savings and standard error of the M&V measure population, calculated as the square root of the sum of the squares of the CAC and DHP measure-level standard errors. See Appendix D for more details.

Table 1-8
Program Net Peak Demand Impacts

Measure	Measure Installations	Ex Post Gross Peak Demand Savings (kW)	NTGR	Ex Post Net Peak Demand Savings (kW)	Relative Precision at 90% Confidence*
CAC	2,646	901	0.52	469	36%
DHP	754	105	0.53	56	32%
M&V Subtotal	**3,400**	**1,006**	**0.52**	**525**	**32%*** **
Programmable thermostats	1,436	0	N/A	0	N/A
Furnace fans	274	0	N/A	0	N/A
Air sealing	97	15	N/A**	15	N/A
Duct sealing	5	1	N/A**	1	N/A
Total	**5,212**	**1,021**	**0.52**	**541**	**N/A**

* Relative precision is calculated at the 90% confidence level. The relative precision is not applicable for the measures that received only engineering review to verify savings rather than metering because it is conducted on a census of installations and no sampling error was introduced.

**Only five of the survey participants had installed air sealing and duct sealing measures; thus, the results are not statistically significant.

***The M&V subtotal relative precision is calculated based on the savings and standard error of the M&V measure population, calculated as the square root of the sum of the squares of the CAC and DHP measure-level standard errors. See Appendix D for more details.

1.3.4 Implications for the New York Technical Manual

The evaluation team produced metering results for a sample of CECONY program participants in New York City. The evaluation team extrapolated these results to apply to any unit using typical weather from New York City and Poughkeepsie for CECONY and Orange & Rockland Utilities (O&R), respectively.[14] The evaluation team recommends that these normalized values be adopted by the NYTM as applicable.

The evaluators recommend that the NYTM adopt the verified hours of use for both CECONY and O&R territories for CACs, as shown in Table 1-9, for use with the algorithms shown in Section 1.3.1 of this report and below. These revised EFLH values are not appropriate to use with the existing NYTM algorithms because they are EER-based values, and the existing NYTM algorithms require SEER-based values.[15] The NYTM should adopt the DHP savings per ton

[14] The O&R results represent a small addition to the project that will offer significant value to O&R in any future residential HVAC program planning efforts.

[15] To determine whether to use the single-stage or two-stage numbers, the unit's EER-to-SEER ratio can be calculated and used. A system with an EER-to-SEER ratio of 0.80 or less is a two-stage unit; a unit with an EER-to-SEER ratio greater than 0.80 is a single-stage unit.

values given in Table 1-11 with the algorithms shown in Section 1.3.1 of this report and below. The NYTM should also adopt a new coincidence factor of 0.52 for CACs and 0.47 for DHPs.[16]

For CACs, savings is determined from the run times in Table 1-3. To determine energy savings for an individual unit, use the following equation:

$$kWh_{Savings} = kWh_{Consumed,baseline} - kWh_{Consumed,\,efficient},$$

where,

$kWh_{Consumed,baseline}$ = The energy consumption of a baseline (SEER 13, EER 11.1) unit

$kWh_{Consumed,\,efficient}$ = The energy consumption of the efficient equipment installed

To determine $kWh_{Consumed,baseline}$ and $kWh_{Consumed,\,efficient}$, the following equation may be used:

$$kWh_{Consumed} = \left(\frac{EFLH_{High}}{EER} + \frac{EFLH_{Low}}{SEER}\right) \times Size\ (tons) \times 12$$

where,

$EFLH_{High}$ = The high-stage run time listed in Table 1-3

$EFLH_{Low}$ = The low-stage run time listed in Table 1-3

For single-stage units and DHPs, simply use 0 for the $EFLH_{Low}$ variable as listed in Table 1-9.

[16] There are no other comparable studies to check these numbers against. While the 30% relative precision on the coincidence factor is high, it still provides confidence that the actual coincidence factor is less than the currently-used value of 0.80. This is an area that should be continually researched to improve the precision. As other studies become available, the evaluation team recommends comparing the values.

Table 1-9
EER-Based EFLH for Use in NYTM

Measure and Location	EFLH*
CECONY – Single-stage CAC	
High stage	519
Low stage	0**
CECONY – two-stage CAC	
High stage	119
Low stage	449
Orange & Rockland*** – single-stage CAC	
High stage	415
Low stage	0**
Orange & Rockland*** – Two-stage CAC	
High stage	95
Low stage	358

*The EFLH listed in the tables already account for various unit efficiencies found within the program, and does not need to be further adjusted based on unit efficiency.

**Single-stage units do not have a low stage, and therefore the term of the equation that includes low-stage EFLH should be zero.

***O&R does not have an air conditioner program, but planning values are provided for O&R for completeness. The estimated EFLH in the O&R service territory is based on the CECONY metering study and adjusted to account for weather differences between the two service territories.

For comparison, the previously used EFLH values are shown in Table 1-10 with the evaluation verified SEER-based EFLH. The CECONY metering study (single-stage CAC) overall SEER-based EFLH shown in Table 1-10 differs from that shown in other tables because of the conversion from EER-based to SEER-based EFLH. The SEER-based EFLH of 608 in Table 1-10 is the correct value to use with the current NYTM equation.

Table 1-10
Comparison of Evaluated Values to Existing and Prior NYTM EFLH Values

Timeframe	EFLH	Savings Basis, Rated Load Factor (RLF)	Overall SEER-based EFLH
Prior to 2011 NYTM	837	SEER, 0.8 RLF	670
2011 NYTM	670	SEER, 1.0 RLF	670
CECONY metering study (single-stage CAC)	519	EER, 1.0 RLF	608

For DHPs, savings should be determined from the following equation.[17]

$$kWh_{Saved} = \frac{Capacity_{Cool}}{12} \times \frac{Savings}{Ton}_{Cool} + \frac{Capacity_{Heat}}{12} \times \frac{Savings}{Ton}_{Heat}$$

where,

> $Capacity_{Cool}$ = The nominal cooling capacity of the unit in kBtu/hr
>
> $Capacity_{heat}$ = The nominal heating capacity of the unit in kBtu/hr
>
> $Savings/ton_{Cool}$ and $Savings/Ton_{Heat}$ = The savings values found in Table 1-11

Table 1-11
DHP Savings Values for Use in NYTM

Stratum	Energy Savings per Ton (kWh/ton)
CECONY	
DHP cooling	271
DHP heating	51
Orange & Rockland*	
DHP cooling	102
DHP heating	58

*O&R does not have an air conditioner program, but planning values are provided for O&R for completeness. The estimated savings in the O&R service territory is based on the CECONY metering study and adjusted to account for weather differences between the two service territories.

1.4 Conclusions

The evaluation team's conclusions regarding the program resulting from the CECONY impact evaluation are provided below.

- **For DHP equipment, heating energy savings are much lower and cooling energy savings are much higher than expected for this program, while CAC hours of use are comparable to the current recommended value.** In general, there are three main things that technical manuals do not generally take into account that show up in metering studies:

[17] The cooling and heating EFLH are 922 and 234 hours, respectively. These should be used carefully, as they are only really applicable to a program with similar participating equipment, because DHP rated capacity and efficiency can be much different than full capacity and efficiency at full capacity.

a. Occupants using equipment less than expected due to large temperature setbacks[18]

b. Degree of oversizing typical in real AC equipment (sized to quickly cool house after daytime setback)

c. Availability and use of night cooling (people opening windows in lieu of AC)[19]

These reasons are likely dictators of the results in this study. However, each measure in this program has unique usage patterns among program participants. Participants use their CAC for cooling only slightly less than the previously used EFLH suggests. Therefore, the EFLH for CACs should remain effectively unchanged. Hours of use for DHPs in the cooling season are much higher than that of CACs. The evaluation team hypothesizes that the zonal nature of DHP installations is allowing people to focus on cooling the areas they use most with DHPs, which drives up the hours of use relative to a central system. DHP heating usage is lower than expected for this climate. This low heating usage is likely a result of DHPs being purchased primarily to provide central cooling.[20]

The effective coincidence factor is much lower than predicted for both CACs and DHPs. The verified peak demand savings of ductless systems (both AC and HP units) were lower than the deemed values primarily due to the systems running less during peak hours than predicted.. In addition, ductless systems are generally used to heat and cool a single space or portion of a home, and thus are used much more erratically and infrequently than central systems, which are typically used to meet a certain thermostat setpoint for most or all hours of the day.

NPSO is negligible for this program. Exploratory inquiry on NPSO found little evidence to warrant further investigation on this factor in the next round of evaluation of this program.

[18] Temperature setbacks are included in the prototype model utilized by the NY TM, but manual operation of the programmable thermostat systems is not included. These estimates could be refined.

[19] The evaluation team understands that natural ventilation (i.e. people opening windows in lieu of AC) is included in the residential models used to determine values used in the NYTM. The evaluation team believes that there is probably still some effect captured in the metered data that is not fully realized in the model.

[20] This conjecture is backed up by onsite data which shows that 88% of the metered participants use another source of heat either exclusively or in conjunction with their DHP. Of these, 73% have a gas furnace or boiler, 18% have an oil boiler, 5% have electric resistance heat, and 5% have another type of heating.

1.5 Recommendations

The evaluation team's recommendations for the program and technical manual resulting from the CECONY metering study are provided below.

1.5.1 Program Recommendations

The program has a relatively high cost per annual kWh of savings acquired. The evaluation team offers four recommendations for increasing program cost-effectiveness, which were requested by CECONY staff. These are listed below and then discussed in detail. The evaluation team's recommendations focus on driving participation toward higher energy savings per transaction or on lowering the cost of achieving savings. Some of them are based on findings from this evaluation's research. Others are based on program designs that the evaluation team has observed succeed for other administrators and believe could be incorporated into CECONY's program.

1. **Consider bundling expensive HVAC measures with other, lower cost measures.** By offering new equipment bundled with other lower cost measures, the incentive covers more savings. Bundling measures – regardless of the specific measures – reduces overhead and increases cost-effectiveness. For example, one measure to consider bundling with central systems is prescriptive duct sealing, which offers generous savings at a reduced cost.[21]

Consider incentivizing cold-climate DHPs[22] separately from other heat pumps and specifically targeting them at participants who will use them for heating. The ductless heat pump participants in this program had low heating savings because most program participants purchased the equipment primarily for cooling. Specifically, this evaluation found low run-time hours during the heating season while units were operating in heat pump mode. Cold climate heat pumps are a relatively new technology that offers much higher heating savings in colder climates, such as New York. The increased savings potential is due to their being more efficient and also more likely to be selected by dual-heat source customers, thanks to their high efficiency and warmer discharge air temperature. CECONY should explore programs targeting cold- climate DHPs at

[21] A source for prescriptive duct sealing savings and costs in the Pacific Northwest (as an example) is found at .

[22] Cold-climate ductless heat pumps are an emerging technology with the potential for large heating season savings relative to standard ductless heat pumps. They are being sold throughout the Northeast, including small numbers of units in the Con Edison program. Cold climate heat pumps use a higher compression ratio than standard heat pumps, allowing them to provide higher capacity and efficiency down to lower temperatures.

customers with existing electric heat and consider offering cold-climate heat pumps as the only eligible ductless heat pumps available for incentives. In addition to increasing gross savings, this would reduce FR, thereby increasing net savings.

Make forward-looking benefit-cost decisions. To accurately reflect the benefits and costs associated with HVAC measures, the inputs to the benefit cost test should be revisited to account for a forward-looking market. In particular, the incremental equipment costs, participation, and unit savings should be updated.

Consider fostering stronger relationships with contractors in order to influence their marketing to participants. In the interviews performed as part of this evaluation, customers showed that contractors have a large influence on participants, but contractors said the program does not have a substantial influence on their practices. CECONY should consider focusing more on developing partnerships with contractors. Contractors would be more likely to encourage their customers to participate in the program if the contractors understood better how the program could help their businesses. Strong relationships with contractors may in turn reduce FR by encouraging them to market the program better.

1.5.2 Recommendations for New York Technical Manual

The NYTM should adopt the verified hours of use for both CECONY and Orange & Rockland (O&R) territories, as shown in Tables 1-9 and 1-11, for use with the suggested algorithm in the Unit Run Time and Savings Results (Section 1.3.1) and Implications for NYTM (Section 1.3.4) sections. For comparison, the previously used EFLH values are shown in Table 1-10 and Table 4-6 in the Implications for NYTM section (Section 4.1.2).

1.5.3 Evaluation Recommendations

Upon completing this evaluation, the evaluation team has some recommendations for ways to improve future Residential Electric HVAC evaluations.

- **Design the metered sample differently.** Conduct the phone survey earlier to determine predicted run time before the field study begins and post-stratify based on predicted run time for CAC or on predicted savings for DHP.

  Ideally, the sample of metered sites from within the phone survey sites would have provided improved precision on the sites that were predicted to have high run times or savings by oversampling those substrata. This would have been implemented by pre-processing the phone survey before the field study started to determine predicted total run times for each site, and then post-stratifying each population density strata into high and low predicted run time or savings substrata. Upon starting the field study, the sample

– still nested within the phone sample – would have included more sites in the high run-time substrata within each population density stratum. Use of this method would require a larger phone sample size and an earlier survey start date relative to the summer peak metering period.

- **Use a higher coefficient of variation (CV) when sampling the metered sites from within the phone survey sample**. In this study, a coefficient of variation (CV) of 0.25[23] was used when sampling the metered sites from within the phone survey sample because the evaluation team assumed that the phone survey would accurately predict metered run time. A low CV assumes that there is little variation between the phone survey and metered samples and results in a low on-site metering sample. A higher CV should have been used and would have resulted in a larger on-site sample. The actual CVs achieved in this study for the CAC stratum were 0.53 and 0.46 for the first and second phases of the double ratio, respectively. The CVs were 0.57 and 0.80, respectively, for the DHP stratum.
- **Consider targeting 90/15 confidence and precision for future DHP metering studies.** Targeting 90/10 requires a large investment in metering for these technologies. A higher relative precision (higher uncertainty) target should be considered to keep evaluation costs down while still investigating changes in savings associated with future DHP technology iterations.
- **Future metering studies should consider alternatives for quantifying the precise in-situ capacity and efficiency of DHPs.** Given the nature of DHP's inverter-driven technology, the evaluation team could not sufficiently correlate the metered data with rated capacities and efficiencies. Future metering studies should dig deeper into the specific technology anomalies to determine a good algorithm for savings based on capacity and efficiency and consider metering baseline[24] DHPs as well.
- **Consider performing additional research to better understand the HVAC market dynamics.** The focus of the net impact evaluation research was to estimate and report program FR and SO rates. Limited research was performed to identify opportunities for program improvement to program processes that might impact the NTGR. In light of somewhat high FR estimates, the evaluation team recommends conducting additional

[23] This CV was chosen based on the evaluation team's previous experience metering CACs in other parts of the country.

[24] A baseline DHP is defined as a minimum efficiency (SEER 13) DHP. This is further explained in Section 3.1.1 of this report. The complete reasoning for this decision is detailed in Appendix C – Memo to DPS Regarding DHP Baseline.

research to identify opportunities for reaching and attracting participants who would not have installed high efficiency HVAC equipment without the program support, thus reducing FR. Additional research could include interviews with distributors and nonparticipating contractors. This research would provide information about the HVAC market in CECONY's service territory in terms of total number of installations taking place, equipment availability, and nonparticipating contractor sales practices. These findings can inform the most appropriate program intervention strategies, be it increased or selective contractor engagement, increasing the minimum program-qualifying SEER, or other approaches. This additional research can also shed light on the presence and magnitude of NPSO in the market.

2 INTRODUCTION

Consolidated Edison Company of New York (CECONY) and Orange & Rockland Utilities (O&R), collectively "the Companies," have completed the delivery of the first cycle (2009 – 2011) of a portfolio of Energy Efficiency Portfolio Standard (EEPS) Utility Administered programs, as ordered by the New York Public Service Commission. This document presents a detailed impact evaluation of the CECONY Residential HVAC program. This evaluation focused on the air conditioning and heat pump measures. Gas savings, including furnaces and boilers, are being covered by a separate joint statewide evaluation.

2.1 Program Background and Objectives

The Residential Electric HVAC program provides rebates to customers that install new HVAC energy efficiency measures, including CACs, heat pumps, furnaces, furnace fans, and programmable thermostats. CECONY implements this program via a network of contractors/trade allies that advise their customers of the availability of rebates. When the program was launched, CECONY required that the customer's installation contractor be enrolled in the program in order for the HVAC installation to be eligible for any equipment rebates except for programmable thermostats. CECONY's trade allies were required to attend a free training course, submit proof of contractor's license and appropriate insurance, and complete a program application in order to be approved as a participating contractor. The contractor training course included training on the program requirements and on the Air Conditioning Contractors of America (ACCA) Manual J load calculation for residential loads. Participating CECONY trade allies that submitted a Manual J load calculation for CAC and heat pumps received a $200 incentive. On October 1, 2010, CECONY dropped the requirement to attend the training course and submit the required documentation. However, the $200 contractor incentive for submitting a Manual J load calculation is still available to any contractor who is willing to provide this service.

2.2 Evaluation Objectives

The evaluation of the Residential Electric HVAC program has three desired outcomes:

1. First, the evaluation team is providing a general assessment of the Residential HVAC program's performance in total during the 2009 to 2011 period.

Second, the evaluation team is providing a focused and more robust assessment of the Residential HVAC measures based on primary data collection, including telephone surveys, customer bills, and on-site measurement and verification (M&V).

Third, the evaluation team is providing actionable recommendations for improving the program's implementation as a result of these assessments.

The evaluation team used a focused approach with on-site M&V for the CACs and ductless mini-split heat pump measures, because they contribute the majority of program ex-ante savings (73%), and they were identified as measures with significant opportunities for reduction in savings uncertainty. The results should better inform program and implementation staff about actual field performance and also provide input for revisions to the New York Technical Manual (NYTM) savings algorithms and factors.[25] Additionally, the evaluation team has provided forward-looking revised savings estimates and parameters for improvement of deemed savings for this program. The overall evaluation scope and objectives are identified in Table 2-1, as represented in the evaluation plan submitted for this program.

Table 2-1
Evaluation Scope and Objectives

Objective	Definition
Evaluation scope*	Primary data collection activities focused on CACs and DHPs, which account for 47% and 26% of the program's ex-ante savings, respectively.
Gross energy impacts	Report annual first-year gross electric (kWh) at the customer meter (gross savings) using tracking data inputs to a model developed from primary data collection. Results were weather-normalized to a typical year using TMY3 (typical meteorological year) weather data.
Gross demand impacts	Report the electrical demand impact at the customer meter defined as the energy reduction during the hottest day of the year between 4 p.m. and 5 p.m. using tracking data inputs to a model developed from primary data collection.
Program attribution	Estimate free ridership (FR) and participant spillover (SO) using self-reported responses from telephone surveys. In addition, nonparticipant spillover (NPSO) will be researched qualitatively through channel partners.
Precision	The sample designs will target 10% precision at the 90% confidence level for program energy savings as directed by the DPS Evaluation Guidelines. Subsector precisions will be less precise.

*The portion of claimed savings for CACs and DHPs in this table is different than that from the Evaluation Plan because the final data set was subsequently updated by CECONY after the Evaluation Plan was submitted.

[25] New York Department of Public Service's *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs*, October 10, 2010, (aka, the New York Technical Manual or NYTM).

3 Evaluation Methodology

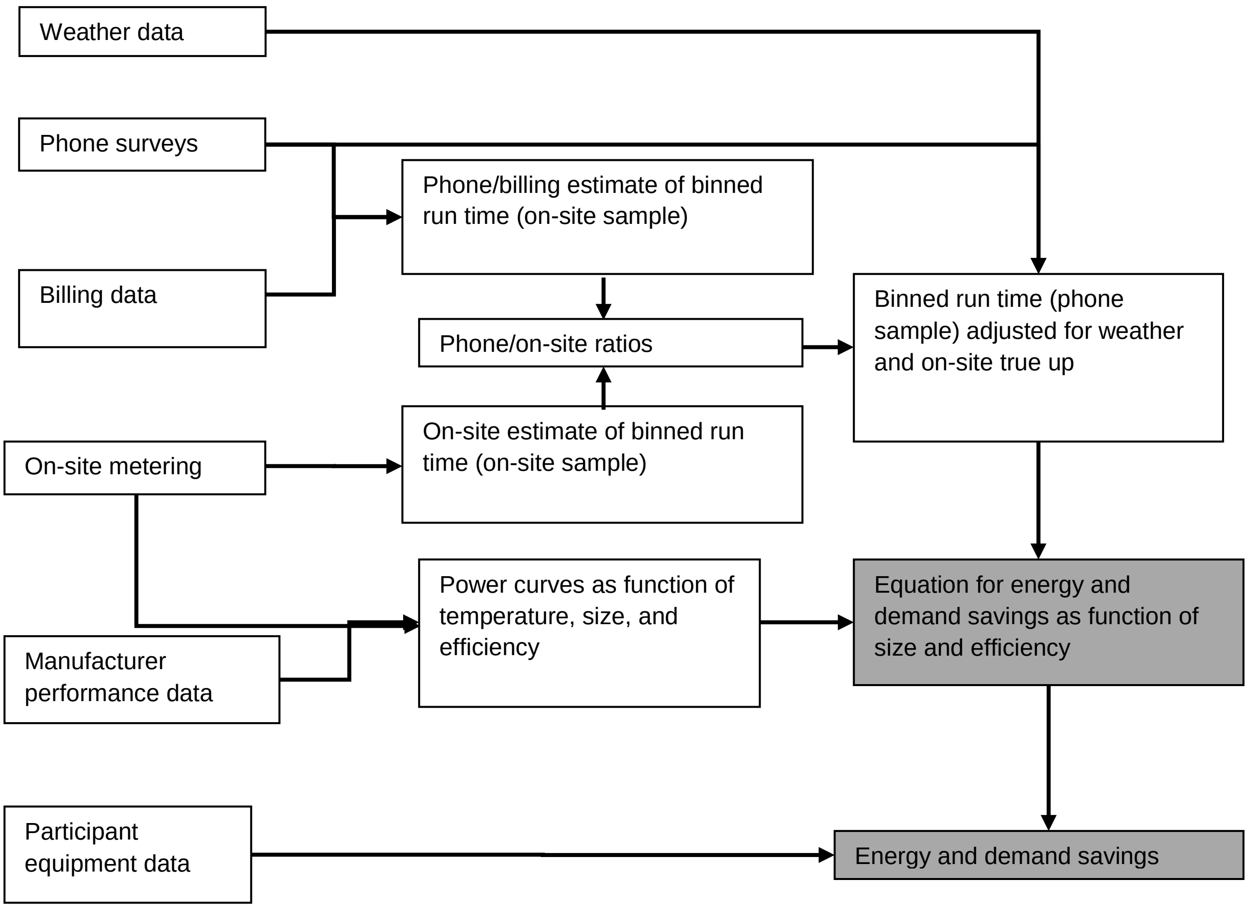
The following section gives a high level overview of the data collection and analysis methods used in this evaluation.

3.1 Gross Savings Evaluation Methods

The evaluation team calculated gross impacts by leveraging the program tracking data, program participants' billing data, phone survey data, and on-site metered data as well as other data collected on-site[26]. The use of a double-ratio estimation method for combining these various data sets ensured a high-quality result at a reasonable cost. Each segment of the evaluation method is discussed below briefly and more thoroughly in Appendix B. A schematic illustrating the general approach to the Residential HVAC gross impact evaluation is shown below in Figure 3-1.

[26] Other data collected included building characteristics (insulation, window area, building orientation and floor plan, etc.), equipment specifications, electrical spot measurements, and a customer interview about any other equipment onsite.

Figure 3-1
General Residential HVAC Impact Evaluation Approach



3.1.1 Baseline

The program design for the Residential Electric HVAC program and this evaluation assumes a replace-on-burnout baseline. This means that each piece of equipment is compared to a similar piece of equipment with code-minimum efficiency to derive savings. This hypothesis was not systematically tested during interviews due to concerns about survey duration. However, the investigators administering the telephone and on-site interviews judge this assumption to be valid. The baseline efficiency used to estimate energy and demand savings for CACs is SEER 13 and EER 11.1[27]. A low efficiency DHP with SEER 13 and EER 11.1 is used as the baseline for the

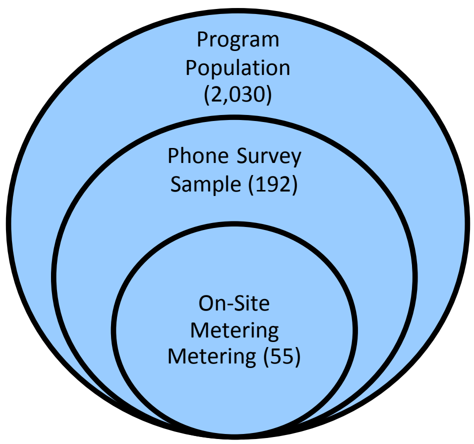
[27] The SEER basis is that of a minimally code-compliant system and matches the NYTM baseline. While ENERGY STAR has an EER performance specification, there is no federal requirement for minimum EER and EER data has not been required for the American Refrigeration Institute (ARI) publication since 2002; therefore, the baseline EER must be approximated to use this formula. The NYTM provides such a baseline, 11.09 EER value for a 13 SEER system. The NYTM estimate references the *2004–2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report*, Itron, Inc. Vancouver, WA. December, 2005,

high efficiency DHP measure because this represents the lowest-cost option of equipment with similar amenities. An explanation of the merits of using a low efficiency DHP as the baseline for high efficiency DHPs is given in Appendix C, Memo to DPS Regarding DHP Baseline.

3.1.2 Approach to Data Collection

The evaluation used a combination of phone surveys, billing data, and on-site metering to estimate equipment usage. The evaluation team used these combined data collection efforts to determine run-time hours, energy savings, and peak demand savings for a representative sample of program participants, utilizing the double-ratio estimation method.[28] The use of double-ratio estimation reduces uncertainty at a reasonable cost by leveraging the results of the low-cost, medium-accuracy phone surveys with the results from the high-rigor, higher-cost on-site metering. By nesting the on-site sample within the phone survey sample, the evaluators were able to achieve a more accurate estimate of the frequency of some outliers, which may include extremely high AC and heating usage participants or extremely low AC and heating usage participants. A schematic of the sampling strategy is shown below in Figure 3-2.

Figure 3-2
Nested Sampling Schematic



Sample Design Approach

The evaluation team designed the phone survey and on-site samples to meet a target of 90% confidence with 10% precision on program gross impacts. The sample designed for this study

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which in turn references data presented in *EER & SEER as Predictors of Seasonal Cooling Performance,* developed by Southern California Edison, prepared by J.J. Hirsh & Associates, October 2004, later updated August 2006. The data relating EER and SEER data came from the California Energy Efficiency database of approximately 13,000 unitary HVAC systems, presumably manufactured in 2002 or earlier when ARI published both parameters.

[28] Wright, Double Ratio Analysis: A New Tool for Cost-Effective Monitoring, 1994.

was stratified by measure. The sampled strata are shown in Table 3-1. The CAC and DHP strata were particularly stratified and chosen for metering because they had high participation and uncertain run times. Within the heat pump measure, 92% of the measure installations were DHPs. A more detailed description of the sampling approach as well as details on the targeted and achieved samples can be found in the Sample Design and Final Sample Disposition section of Appendix A.

Table 3-1
Sampled Strata

Stratum	2011 Program Population*	Target Phone Sample	Achieved Phone Sample	Target On-Site Sample	Achieved On-Site Sample**	Sites With Usable Data**
CAC	1,476	100	116	30	30	28
DHP	554	80	79	25	25	21/23
Total	**2,030**	**180**	**195**	**55**	**55**	**49/51**

*From Data Set of Record.

**Although the achieved on-site sample is the same as the targeted on-site sample, fewer than the achieved sites had usable data. The number of usable metered sites was 28 for CACs, 21 for DHPs during the cooling season, and 23 for DHPs during the heating season.

Data Collection Methods Overview

The general data collection effort consisted of the following three steps. The process is highlighted in the following sections and thoroughly detailed in corresponding sections in Appendix A.

1. The evaluation team conducted a phone survey to determine how customers report using their heating and cooling equipment on weekdays and weekends in different outdoor conditions.

The evaluation team disaggregated survey participant billing data in order to calibrate phone survey data.

Field technicians performed rigorous data collection and metering at a sample of phone survey participants. The technicians metered actual equipment energy consumption and indoor temperatures.

Phone Survey Approach

The evaluation team designed the phone survey with the primary intention of determining how the participant operated his or her rebated HVAC unit. The evaluation team asked each participant to provide a schedule of AC use depending on time of the day for hot, warm, and mild temperature types of days. The evaluation team determined different day types which were dictated by the high and average outdoor air temperature (OAT) for the day. For each day type, the participants provided a schedule with temperature setpoints for their unit.[29] The evaluation team used the phone survey responses to predict run time for sampled sites. The complete phone survey instrument can be found in Appendix E, the Residential HVAC and Room AC Program Participant Phone Survey.

On-Site Measurement and Verification Approach

The 30 sites included in the air conditioning on-site metering sample and the 25 sites included in the DHP on-site metering sample were metered from July 15th through October 1st. The 25 sites in the DHPs sample were metered additionally through March 1, 2013. At each site, the field technicians gathered data relating to site and building characteristics and equipment specifications. True power was metered at the indoor and outdoor units of CACs, and at the outdoor unit only for DHPs[30]. The indoor temperature was also metered for calibration purposes and to confirm run-time accuracy. Details about the meters used on-site can be found in the Metering Equipment Details of Appendix A. A list of information gathered at each metered site can be found in the On-site Survey section of Appendix A.

3.1.3 Approach to Data Analysis

The gross savings analysis for this evaluation included a combination of the phone survey results, billing data, and metered. The high- data level data analysis steps are listed below. A more detailed explanation of each of the analysis methods' steps can be found in Appendix B. The data analysis steps include:

1. Billing data disaggregation for each survey participant
    a. Determine monthly consumption for each site.
    b. Estimate lighting and domestic hot water (DHW) usage.
    c. Calculate the remaining consumption (HVAC and other electrical end use equipment).

[29] Final results of the analysis indicated that participants largely were not able to accurately report how they use their air conditioners beyond rough assessments of higher or lower usage. However, onsite metered data was used to correct the poor self-reported usage estimates. This was a major reason that the relative precision on the energy and demand savings estimates was higher than anticipated (higher uncertainty).

[30] DHPs' outdoor units act as a subpanel for any indoor units attached. Therefore, it was not necessary to meter the indoor units of the DHP measure.

d. Calculate all other electrical end use equipment consumption.[31]

e. Calculate HVAC consumption by subtracting lighting, DHW, and miscellaneous equipment consumption from the monthly total.

f. Split HVAC consumption into heating and cooling.

2. Phone survey processing for each survey participant

a. Create an hourly setpoint schedule for each participant for the monitored period as provided by each participant during the interview.

b. Determine whether or not the rebated unit is capable of fully meeting the cooling load when it is in use for extended periods of hot weather.

c. Generate a normalized power adjustment curve as a function of outdoor air temperature (OAT) to predict hourly energy consumption.

d. Model actual year cooling energy consumption using EnergyPlus.

e. Average actual year modeled monthly cooling energy with the corresponding billing-derived cooling energy consumption estimate to determine billing AFs.

f. Model cooling energy for a typical meteorological year (TMY) using a TMY3 in EnergyPlus.

g. Apply the monthly billing AFs to each hourly energy consumption value to generate billing-adjusted hourly run-time and energy consumption values for each participant for the actual year and for a typical year.

h. Stratify participants in each population density stratum into substrata based on phone-predicted run times.

i. For each of the five substrata, bin the billing-adjusted actual year results for the metering period and the billing-adjusted TMY results for the full year by time of day, OAT, and high temperature.

Benchmark power curves

a. For central systems, use manufacturers' performance data to derive input power (kW) as a function of OAT, rated efficiency, and size.

[31] The all other equipment electricity usage is calculated by subtracting a small assumed HVAC usage and the lighting usage estimate from the total usage in the minimum consumption month. See Appendix B.

b. For ductless AC and HP (DHP) units, use models from lab tests by Ecotope[32] to derive power, capacity and instantaneous efficiency as a function of OAT, part-load ratio (PLR), rated efficiency, and size.

Logger data processing

a. Assign each minute-long data point an operational mode.

b. Calculate total run time for each unit using the operational modes assigned and categorize run time by the OAT and the hour of the day for cooling, and additionally the average temperature for the day for heating.

    i. For DHP units, total kWh savings was calculated for each data point (using the benchmark power curve and assuming a SEER 13 baseline), because the concept of run time is not applicable to units with a fully-modulating compressor.

c. Summarize the data at the hourly level and average across all sites by stratum (CACs and DHPs).

d. Determine the entering wet-bulb value used in the equipment models from metered indoor temperatures and humidity.[33]

Ratio analysis

a. For each bin in each stratum, calculate the adjustment factor (AF) of billing-adjusted modeled run time for the metered period to the actual metered run time.

    i. For DHP units, the AF was calculated for kWh savings rather than run time.

b. Apply the bin and stratum-specific AFs to the hourly TMY results to get a typical cooling season hourly run-time shape for each stratum.

Equipment modeling

[32] "DHP Impact & Process Evaluation: Lab-Testing Report." Prepared by Ecotope, Inc., for the Northwest Energy Efficiency Alliance, Report No. E11-225, July 2011.

[33] The humidity conditions observed in the metered data were not analyzed with respect to manufacturer's SEER ratings or typical levels of humidity control with other types of equipment. This topic may warrant further research.

a. Start with the typical cooling season and heating season hourly run-time shape for each stratum from the phone survey model.

   i. For DHP units, start with hourly kWh savings instead of run times.

b. Determine adjusted normalized unit power for each hour from the adjusted power benchmark curve using OAT for each hour.

c. Calculate normalized energy consumption (in kWh-EER/ton) for each hour by multiplying adjusted run time by adjusted power for each stratum.

   i. For DHP units, calculate adjusted kWh savings (in kWh/ton) for each hour by multiplying kWh savings by the savings AF.

d. Calculate normalized peak demand during the hour from 4 to 5 p.m. on the single hottest day of the year.

e. Sum the hourly values of energy consumption over the entire cooling season to produce total normalized consumption for a typical year (in kWh-EER/ton).

   i. For DHP units, sum the hourly values of kWh savings to produce total kWh savings for a typical year (in kWh/ton).

f. Combine normalized total consumption and peak demand with baseline assumptions to derive energy and demand savings equations.

3.1.4 Engineering Review of Tracking System

A tracking system review was performed to understand how well the information in the tracking system is collected, checked for quality, and maintained by CECONY. The evaluation team initially reviewed the tracking system as a stand-alone document for clarity. The evaluators also reviewed it in conjunction with the data collected on-site for accuracy.

Additional measures within the Residential HVAC Electric program received an engineering review, which involved calculating savings for all participants based on database information and according to the algorithms in the existing NYTM. In this review, the savings for furnace fans, programmable thermostats, air sealing, and duct sealing were recalculated using the heating and cooling equivalent full-load hours (EFLH) determined from this metering study combined with the existing NYTM algorithms.

3.2 Attribution

Program attribution accounts for the portion of the gross energy savings associated with a program-supported measure or behavior change that would not have been realized in the absence of the program. The program-induced savings, indicated as a net-to-gross ratio (NTGR), is made up of free ridership (FR) and spillover (SO) and is calculated as $(1 - FR + SO)$. FR is the proportion of the program-achieved verified gross savings that would have been realized absent the program and its interventions. SO is generally classified into participant and nonparticipant spillover (NPSO). Participant spillover (PSO) occurs when participants take additional energy-saving actions that are influenced by the program interventions but did not receive program support. NPSO is the reduction in energy consumption and/or demand by nonparticipants because of the influence of the program.

As part of this evaluation, the evaluation team focused on the estimation of FR and PSO. The evaluation team also explored the presence of nonparticipant SO and whether additional research is justified to accurately quantify nonparticipant SO. Quantifying savings from NPSO activities is a challenging task that warrants a separate study and was outside of the scope of this evaluation effort.

The FR component of the NTGR was derived from self-reported information from telephone interviews with program participants and further adjusted through the interviews with participating trade allies. The PSO component of the NTGR was derived through participant interviews. The final NTGR was calculated as the percentage of gross program savings that can reliably be attributed to the program. NTG ratios were estimated separately for CACs and DHPs and then weighted by the relative contribution of each measure's evaluated savings to the overall program estimate.[34]

Below is a general overview of the method for developing an initial FR rate using participant survey results and then adjusting it using the results of trade ally interviews. The alternative methods for estimating FR through the trade ally interviews and PSO are also provided below.

Appendix B of this report contains further detail on the NTG estimation method.

3.2.1 Free Ridership

Free riders are program participants who would have implemented the incented energy efficient measure(s) even without the program. Free ridership represents the percent of savings that would have been achieved in the absence of the program. Telephone interviews with

[34] The overall program NTGR also includes the air sealing measure.

participants were used to develop the basis of the FR score. FR rates were estimated separately for CACs and DHPs.

As part of its activity in the market, the program can provide information, training, and other support to trade allies, thus potentially influencing the way trade allies recommend HVAC equipment to customers. This program outreach and interactions with trade allies might not necessarily be visible to program participants. As such, FR estimates based only on participant feedback might not accurately reflect the full credit that the program deserves. To address this gap, telephone interviews with trade allies were used to adjust the participant derived FR rates to account for broader influence of the program on the market that might not be visible to participants.

Participant Free-Ridership Score

Using the survey instrument developed for this evaluation, program participants were interviewed and asked a series of structured and open-ended questions about the influence of the program and its various components on the decision to purchase and install energy efficient cooling and heating equipment. More specifically, program participants were asked about any preexisting plans to implement the program measure(s), willingness to have installed the measure(s) even if there were no program incentives, and likelihood of taking the same action absent the program.

The evaluation team developed initial estimates of FR using a two-step approach:

Step 1 (FR1) – Identifying full free riders and nonfree riders and assigning FR values of 1 and 0, respectively

Step 2 (FR2) – Further estimating the magnitude of FR

As part of step 1, the evaluation team measured the timing of customer awareness of the program relative to equipment installation, as well as program influence on customers' mere decisions to purchase/install equipment.

As part of Step 2, the evaluation team explored the following areas of program influence:

1. Efficiency level of the purchased equipment (EI)

   a. Influence of individual program components (marketing and incentives) on the decision to install high efficiency HVAC equipment

   b. Likelihood to install the same efficiency equipment absent the incentives

Quantity of the high efficiency equipment purchased (QI)

a. (only for projects with more than one unit installed) Estimate of the scope of the high efficiency project absent the program

Timing of the purchase of high efficiency equipment (TI)

a. Estimate of the program influence on the timing of the high efficiency installation absent the program

Efficiency (EI), timing (TI), and quantity (QI) of the installation are distinct avenues of program influence. However, the timing of the installation and quantity of measures installed are conditional on efficiency. The program can only realize timing savings if the customer would have installed the efficient equipment on their own but the program caused the installation to happen earlier. The evaluation team measured each area as a distinct yet conditional method of program influence, calculated influence scores for each, and combined the scores multiplicatively.[35]

$$FR2 = EI \times QI \times TI$$

Each respondent's FR score was calculated using either Step 1 or Step 2 above (as they are mutually exclusive). If program attribution or lack thereof was determined through Step 1, the final FR value took the value from that Step. In all other cases, the final FR value was derived from the Step 2 estimate.

$$FR = FR1 \text{ OR } FR2$$

Trade Ally Free-Ridership Adjustment

The evaluation team used interviews with participating trade allies to determine if the program had any influence on trade ally recommendations of high efficiency equipment. As part of the

[35] It should be noted that following the approval and implementation of the Residential HVAC evaluation effort, the FR algorithm that multiplies the three program influence scores (EI, TI, and QI) has been questioned by the DPS as possibly being biased toward lower FR. The discussion among the New York Department of Public Service (DPS), CECONY, O&R, evaluators, and other stakeholders regarding an alternative calculation of the FR rate resulted in an algorithm that multiplies the EI and QI scores and averages them with the TI score, but only in cases where TI score does not exceed the product of EI and QI. In cases where the TI score exceeds the product of the EI and QI scores, the FR rate is based only on the EI and QI scores. Since the decision around alternative ways of calculating FR started after the NTG approach for the Residential HVAC Program was finalized, approved, and executed and this is a replace-on-burnout program with timing expected to be a low-influence factor, the evaluators followed the FR estimation approach that was initially proposed and did not estimate FR using an alternative method for this program. As the results will later note, the survey found negligible timing influence on partial participants (only four participants), making the concern over this methodological difference of small concern.

interviews, trade allies were asked a series of questions about their knowledge and interactions with the program, program influence on their stocking and sales practices, and the customer decision-making process. Based on the trade ally responses, participant FR score adjustment factors were calculated and applied to arrive at the final FR rate using the following three steps:

1. **Determining the trade ally attribution score.** We used participant survey results to determine the trade ally attribution score. While participants are unlikely to be aware of the program's influence on their contractor, they can fairly easily estimate and report their contractor's influence on their decision to install high efficiency HVAC equipment. Participants were asked to rate the influence of the trade ally recommendations on their decision to install high efficiency equipment.[36] FR scores of participants who were heavily influenced by trade ally recommendations were set to zero, giving the program full credit for the project. The evaluation team then recalculated the FR score using these adjusted values. This maximum trade ally-adjusted FR score effectively represents the maximum possible attribution that the program can claim and assumes that every trade ally was heavily influenced by the program in how they approach the recommendations and sales of the HVAC equipment. The differential between the two scores (i.e., the unadjusted participant FR score and the participant FR score adjusted for trade ally influence) is the trade ally attribution score, or the **maximum** possible decrease in the participant FR score due to program influence on trade ally recommendations that the program can claim.

Determining the influence of the program on participating trade allies. Though the program attempts to get trade allies to recommend more energy efficiency equipment, a number of factors influence trade ally recommendations. Therefore, only a portion of the trade ally attribution scores is due to the program influence on trade ally recommendations. We used the results of the trade ally interviews to determine the percentage of the trade ally attribution score the program truly deserves. Trade allies were asked questions about changes in trade ally knowledge of high efficiency options, their comfort level with recommending the high efficiency options, how frequently they recommend high efficiency equipment options, and their estimated degree of program influence on each of those areas. For each trade ally we developed and validated a trade ally program influence score.

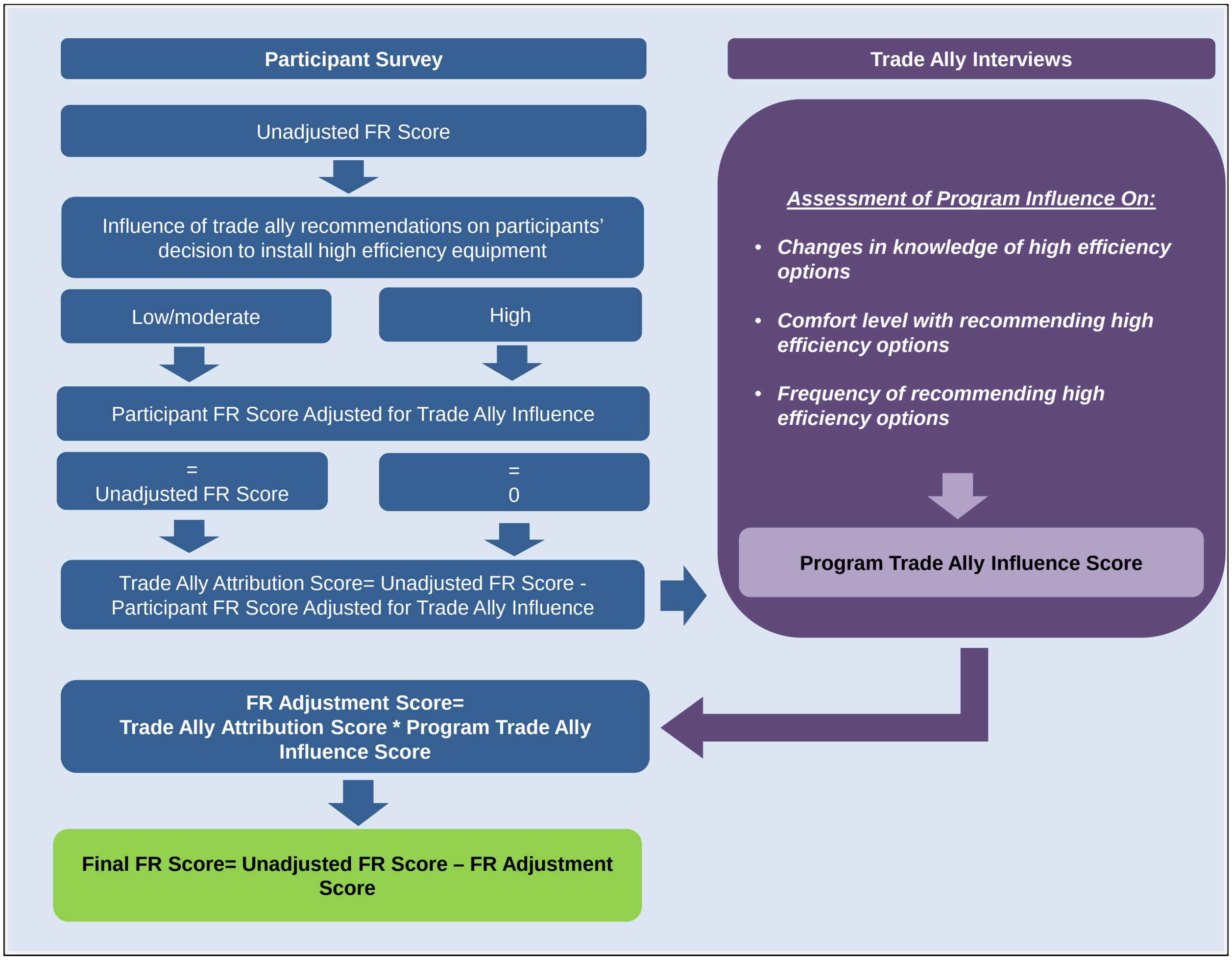
Determining the FR adjustment score and the final FR score. We combined the influence of the trade allies on participants and influence of the program on trade allies to arrive at the

[36] Participants were asked to provide a rating on a scale of 1 to 7, where 1 is not at all influential and 7 is very influential.

FR adjustment score. We then applied the adjustment score to the participant FR scores to arrive at the final FR rate.

Figure 3-3 provides a visual description of the algorithm at work.

Figure 3-3
Trade Ally Free-Ridership Adjustment Algorithm



Consistent with the participant research effort, FR adjustment scores were developed separately for CACs and DHPs and then weighted to the program-level score by known evaluated program savings associated with equipment that each trade ally installed through the program.

To supplement the FR adjustment approach described above, the interviews with trade allies also allowed the evaluators to calculate an independent estimate of FR. Exploring trade ally installations of CAC systems and DHPs and asking them to estimate the percentage of installations that would have happened absent the program allowed us to calculate FR.

The participant survey instrument can be found in Appendix E and the trade ally discussion guide can be found in Appendix F. Detailed, step-by-step algorithms for estimation of the NTGR can be found in Appendix B.

3.2.2 Spillover

SO represents additional savings (expressed as a percent of total program savings) that were achieved without program rebates but would not have happened in the absence of the program. Through this evaluation, the evaluators assessed participant SO through interviews with participating customers by asking about efficiency actions they took as a result of participating in the program but did not receive program support. The survey instrument contained checks to ensure consistency of response.

The program has not had a substantial marketing component that would promote energy efficiency in general or the installation of other measures aside from the ones rebated through the program. However, past experience suggests that, for some, the experience of using one type of energy efficient equipment can lead to looking for other ways to make one's home more energy efficient. If program-induced, those additional improvements can result in SO savings that the program could claim. As part of the participant survey, the evaluation team investigated whether participant SO existed and in cases where it existed, quantified it.

While participant SO can result from a variety of measures, survey length did not allow for estimation of SO across all possible scenarios. To avoid overburdening participants, the survey could only ask about a limited number of actions that might be taken outside the program. The evaluation team included measures that could be reasonably expected to be influenced by program participation and are more likely to have been implemented without program support. Participant SO was measured for attic insulation, ENERGY STAR clothes washers, and ENERGY STAR refrigerators.

Participants were asked if they made any of the above-listed improvements. Those who did were asked if the CECONY program influenced their actions and, if so, the degree of influence. Respondents were also asked to explain in their own words exactly how the program influenced their decision to make specific additional improvements.

As part of the evaluation, the evaluation team also investigated presence of NPSO in the market through trade ally interviews. The evaluation team used the information to qualitatively describe NPSO potential. Quantifying NPSO was outside the scope and budget of this evaluation effort.

4 Results

The gross and net results of the program evaluation are shown in the sections below.

4.1 Gross Savings Results

The following section presents the program level savings results, the run-time results, the peak coincidence factor results, and the tracking system results.

4.1.1 Program Level Savings Results

The program achieved a total of 1,891 MWh gross energy savings and 1,021 kW peak gross demand savings annually over the evaluation period. The realization rates for energy and peak demand savings are 0.87 and 0.76, respectively. Savings were calculated for each of two strata – one comprising CAC participants and one comprising DHP participants. DHP savings take into account both cooling and heating season savings. Of the savings achieved through the DHP program, 345 MWh (about 86%) were achieved from the cooling season savings.

The total verified gross energy savings and realization rates are shown by measure in Table 4-1. The total verified gross peak demand savings and realization rates are shown by stratum in Table 4-2.

Table 4-1
Program Gross Energy Impacts

Stratum	Measure Installations	Ex Ante Gross Energy Savings (MWh)	Ex Post Gross Energy Savings (MWh)	Gross Energy Realization Rate	Relative Precision at 90% Confidence*
CAC	2,646	1,015	800	0.79	17%
DHP	754	570	577	1.01	30%
M&V Subtotal	**3,400**	**1,585**	**1,377**	**0.87**	**15%****
Programmable thermostats	1,436	374	278	0.74	N/A
Furnace fans	274	170	201	1.18	N/A
Air sealing	97	29	32	1.12	N/A
Duct sealing	5	7	3	0.38	N/A
Total	**5,212**	**2,165**	**1,891**	**0.87**	**N/A**

*Relative precision is calculated at the 90% confidence level. The relative precision is not applicable for the measures that received only engineering review to verify savings rather than metering because the review is conducted on a census of installations and there is no sampling error to report.

**The M&V subtotal relative precision is calculated based on the savings and standard error of the M&V measure population, calculated as the square root of the sum of the squares of the CAC and DHP measure-level standard errors. See Appendix D for more details.

Table 4-2
Program Gross Peak Demand Impacts

Stratum	Measure Installations	Ex Ante Gross Peak Demand Savings (kW)	Ex Post Gross Peak Demand Savings (kW)	Gross Peak Demand Realization Rate	Relative Precision at 90% Confidence*
CAC	2,646	1,128	901	0.80	34%
DHP	754	185	105	0.57	29%
M&V Subtotal	**3,400**	**1,313**	**1,006**	**0.77**	**27%****
Programmable thermostats	1,436	0	0	N/A	N/A
Furnace fans	274	0	0	N/A	N/A
Air sealing	97	13.3	14.8	1.11	N/A
Duct sealing	5	10	0.6	0.06	N/A
Total	**5,212**	**1,336**	**1,021**	**0.76**	**N/A**

*Relative precision is calculated at the 90% confidence level. The relative precision is not applicable for the measures that received only engineering review to verify savings rather than metering because the review is conducted on a census of installations and there is no sampling error to report.

**The M&V subtotal relative precision is calculated based on the savings and standard error of the M&V measure population, calculated as the square root of the sum of the squares of the CAC and DHP measure-level standard errors. See Appendix D for more details.

The primary driver of the energy realization rate is the lower verified unit run time than the equivalent full-load hours (EFLH) used in the current NYTM for CACs. In particular, the heating season savings from the DHP measure are significantly lower than the ex-ante savings. While the cooling usage for DHPs was higher than found in the NYTM, the low heating usage drives overall lower savings for DHPs. The primary driver of the peak demand realization rate is a lower effective coincident factor than CECONY's current assumption.

For the remaining four measures, the primary driver of high and low realization rates is due to values in the database differing substantially from the savings calculated using the algorithms and assumptions found within the NYTM.

4.1.2 Run-Time Results and Implications for the NYTM

The evaluation team produced metering results for a sample of CECONY program participants in New York City. The evaluation team extrapolated these results to apply to any unit using typical weather from New York City and Poughkeepsie for CECONY and Orange & Rockland

Utilities (O&R), respectively.[37] The evaluation team recommends that these normalized values be adopted by the NYTM as applicable.

For CACs, savings is determined from the run times in Table 4-3. To determine energy savings for an individual unit, use the following equation:

$$kWh_{Savings} = kWh_{Consumed,baseline} - kWh_{Consumed,\,efficient},$$

where,

$kWh_{Consumed,baseline}$ = The energy consumption of a baseline (SEER 13, EER 11.1) unit

$kWh_{Consumed,\,efficient}$ = The energy consumption of the efficient equipment installed

To determine $kWh_{Consumed,baseline}$ and $kWh_{Consumed,\,efficient}$, the following equation may be used:

$$kWh_{Consumed} = \left(\frac{EFLH_{High}}{EER} + \frac{EFLH_{Low}}{SEER}\right) \times Size(tons) \times 12,$$

where,

$EFLH_{High}$ = The high-stage run time listed in Table 4-3

$EFLH_{Low}$ = The low-stage run time listed in Table 4-3

For single-stage units, simply use 0 for the $EFLH_{Low}$ variable as listed in Table 4-3.

[37] The O&R results represent a small addition to the project that will offer significant value to O&R in any future residential HVAC program planning efforts.

Table 4-3
EFLH for Use in NYTM

Measure and Location	EFLH
CECONY – Single-stage CAC	
High stage	519
Low stage	0**
CECONY – Two-stage CAC	
High stage	119
Low stage	449
Orange & Rockland*** – Single-stage CAC	
High stage	415
Low stage	0**
Orange & Rockland*** – Two-stage CAC	
High stage	95
Low stage	358

$$kWh_{Consumed} = \left(\frac{EFLH_{High}}{EER} + \frac{EFLH_{Low}}{SEER}\right) \times Size\ (tons) \times 12$$

*The EFLH listed in the tables already accounts for various unit efficiencies found within the program, and does not need to be further adjusted based on unit efficiency.

**Single-stage units do not have a low stage, and therefore the term of the equation which includes low-stage EFLH should be zero.

***O&R does not have an air conditioner program, but planning values are provided for O&R for completeness. The estimated EFLH in the O&R service territory is based on the CECONY metering study and adjusted to account for weather differences between the two service territories.

The evaluators recommend that the New York Technical Manual (NYTM) adopt the verified hours of use for both CECONY and O&R territories for CACs, as shown in Table 4-3, for use with the algorithms shown above. These revised EFLH values are not appropriate to use with the existing NYTM algorithms because they are EER-based values, and the existing NYTM algorithms require SEER-based values.[38] The SEER-based EFLH for use with the existing NYTM algorithm is 608. The evaluators prefer the updated CAC deemed savings equation because it can use both SEER and EER to approximate the performance of the equipment. For single stage equipment, there is little difference in accuracy between using a SEER-based and EER-based equation. The SEER, EER, and other performance condition efficiencies are generally correlated for single speed equipment. For two-speed equipment, the operating efficiency varies as a function of whether the equipment is in high or low stage of cooling capacity. The EER test generally reflects the high stage performance at an outdoor temperature of 95 degrees F. The SEER test mostly reflects the low stage performance at an outdoor temperature of 82 degrees F.

[38] To determine whether to use the single-stage or two-stage numbers, the unit's EER-to-SEER ratio can be calculated and used. A system with an EER-to-SEER ratio of 0.80 or less is a two-stage unit; a unit with an EER-to-SEER ratio greater than 0.80 is a single-stage unit.

In an ideal world, there would be rated data available at 82 and 95 degrees F in both high and low stage, because the equipment actually runs in both high and low stage at both moderate and high temperatures over the course of the year. The system will run in high stage at moderate temperatures in response to a large reduction in the thermostat setpoint. Conversely, the system will run in low stage at high temperatures when the thermostat is set up and loads are reduced. While the ideal four rating points are not available, the use of the two available rating points does do a better job of differentiating between the performance of two pieces of equipment with similar low stage and differing high stage efficiencies than the current NYTM algorithm. Because of this reason, the evaluators recommend changing to a SEER and EER-based equation like the one the evaluators used to calculate savings for this program.

For comparison, the previously used NYTM EFLH values are shown in Table 4-4 with the evaluation verified SEER-based EFLH. The CECONY metering study (single-stage CAC) overall SEER-based EFLH shown in table 4-4 differs from that shown in other tables because of the conversion from EER-based to SEER-based EFLH.

Table 4-4
Comparison of Evaluated Values to Existing and Prior NYTM EFLH Values

Timeframe	EFLH	Savings Basis, Rated Load Factor (RLF)	Overall SEER-based EFLH
Prior to 2011 NYTM	837	SEER,0.8 RLF	670
2011 NYTM	670	SEER, 1.0 RLF	670
CECONY Metering Study (single-stage CAC)	519	EER, 1.0 RLF	608

For DHPs, savings should be determined from the following equation.

$$kWh_{saved} = \frac{Capacity_{Cool}}{12} \times \frac{Savings}{Ton}_{cool} + \frac{Capacity_{Heat}}{12} \times \frac{Savings}{Ton}_{Heat}$$

where,

$Capacity_{Cool}$ = The nominal cooling capacity of the unit in kBtu/hr

$Capacity_{Heat}$ = The nominal cooling and heating capacity of the unit in kBtu/hr

$Savings/Ton_{Cool}$ and $Savings/Ton_{Heat}$ = The savings values found in Table 4-5

The NYTM should adopt the verified savings per ton given in Table 4-5 for DHPs for use with the DHP equations shown above. For the traditional SEER and HSPF-based equations in the NYTM, the resulting cooling EFLH is 922 and the resulting heating EFLH is 234. These values should be used carefully. Because of the complicated and variable methods in rating DHP equipment, these results are only applicable to a similar mix of equipment models. The savings per ton values have the same issues, but the connotation with savings per ton values is that they have limited applicability to similar program participation mixes. This seems like a fine distinction, but the evaluators would rather not see these values get misapplied in the future and the use of savings per ton values should make people pause before accepting them.

Table 4-5
DHP Savings Values for Use in NYTM

Stratum	Energy Savings per Ton (kWh/ton)
CECONY	
DHP cooling	271
DHP heating	51
Orange & Rockland*	
DHP cooling	102
DHP heating	58

*O&R does not have an air conditioner program so the estimated EFLH in the O&R service territory, provided for planning purposes, is based on the CECONY metering study and adjusted to account for weather differences between the two service territories.

4.1.3 Peak Demand Coincidence Factor

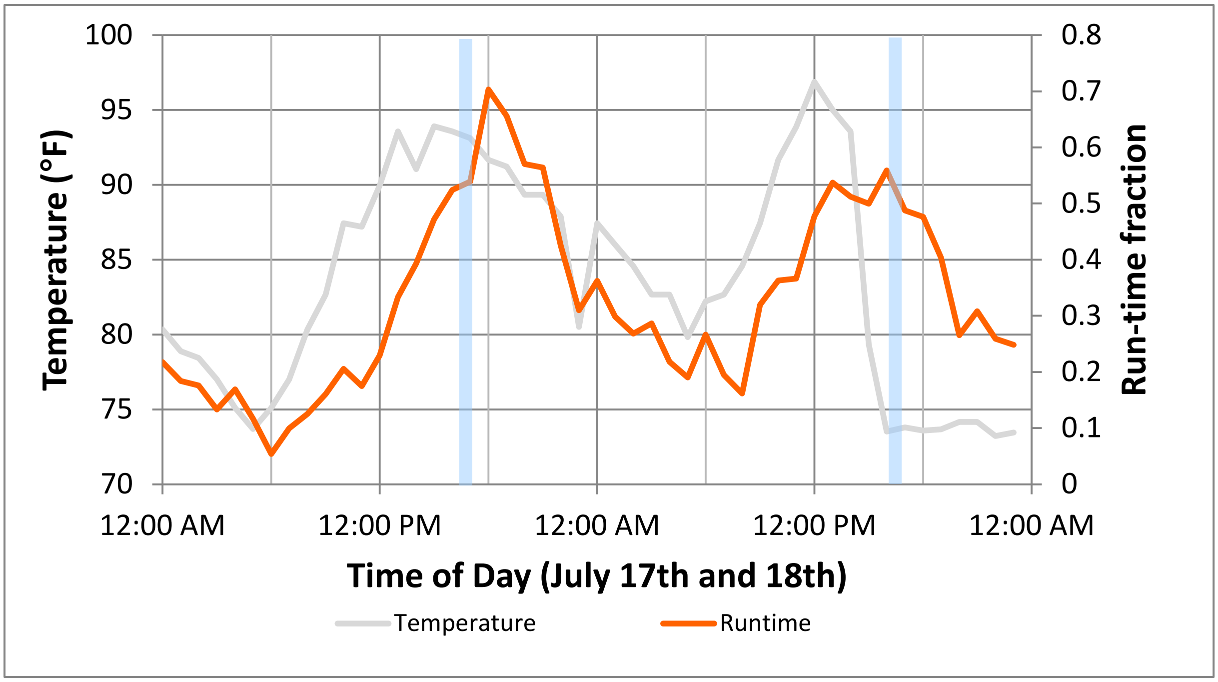
The coincidence factors by stratum are shown in Table 4-6. The evaluators recommend these values be adopted by the NYTM.

Table 4-6
Coincidence Factor Results by Stratum

Stratum	Coincidence Factor
CAC	0.52
DHP	0.47

Profiles of temperature and hourly run-time fraction (the average fraction of an hour that all participating units are cycling, or running) are shown in Figure 4-1. The two days shown in Figure 4-1 were the hottest days of 2012 in New York City.

Figure 4-1. Central Air Conditioning Run Time Fraction and Temperature Profile over Two Hottest Days in Summer 2012



4.2 Attribution

The section below provides the results of the net-to-gross assessment of the Residential HVAC program, including FR, SO, and any relevant support information.

4.2.1 Free Ridership

The evaluation team relied on telephone surveys with program participants as the core source of FR estimates. This approach was supplemented with research with participating trade allies to account for program influences on trade allies that are not visible to participants. Table 4-7 provides an overview of the results. The "Unadjusted Participant FR" column shows FR rates derived through participant research, while the "Trade Ally FR Adjustment Score" column shows a rate by which the participant FR score should be adjusted downward based on the program influencing contractor recommendations.

As can be seen in the table, final FR rates for CAC and DHP measures are very similar (48% and 47%), which is not surprising, given similarities in program design, marketing, and incentive levels.[39] Program influence on trade ally recommendations was limited and resulted in a

[39]Note that FR estimates were derived separately for CACs and DHPs. The evaluation team also estimated FR for a small sample (n=5) of the air sealing installations. While the results for air sealing

downward adjustment of the FR score by no more than 4%. Final FR for the program is at 48%. Appendix B contains greater detail on how each score was derived and the results from each intermediate calculation.

Table 4-7
Final FR Estimates

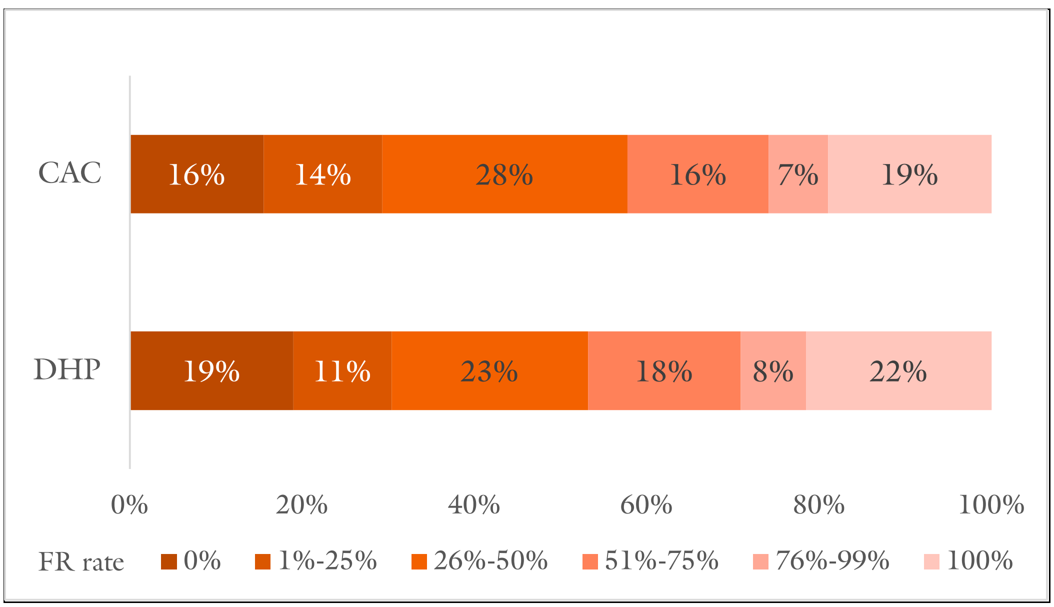
Stratum	Unadjusted Participant FR**	Trade Ally FR Adjustment Score**	Final FR*	Final FR Standard Error	Final FR Relative Precision (at 90% Confidence)
CAC	0.52	0.04	0.48	0.04	12%
DHP	0.50	0.03	0.47	0.04	15%
Total	**0.48**		**0.48**	**0.03**	**9%**

*The final FR estimate includes an estimate for the air sealing improvements. The contribution of the air sealing measure to the final FR is negligible and is based on a small number of participant interviews (five completed interviews out of the population of 47 participants).

**The measure-level FR scores and program trade ally influence scores are savings-weighted.

Program participants report high FR rates, indicating that a considerable number of installations would have happened absent the program. Figure 4-2 provides a distribution of FR rates.

Figure 4-2
FR Rate Distribution



are not presented separately due to the small number of cases, they were accounted for in the program-level calculation of FR.

An analysis of participant survey responses provides deeper insight into the reasons for the high FR rates. Some participants learned about CECONY's program after they installed high efficiency equipment (13% for CACs and 5% for DHPs). Overall, three-quarters of participants who installed CACs (72%) and two-thirds of participants who installed DHPs (66%) reported already having plans to install high efficiency HVAC systems when they learned about CECONY's program.

Furthermore, more than half of participants (57% for CACs and 59% for DHPs) reported receiving tax credits along with the program incentive for the installation of the high efficiency HVAC equipment. Those participants were asked to indicate the likelihood of installing a high efficiency system if both the tax credits and program incentives had not been available. More than half of participants who installed CACs (59%) and close to a half of participants who installed DHPs (44%) indicated high levels of likelihood to still proceed with the high efficiency system installation in the absence of any funding.[40]

As for trade allies, in-depth interviews revealed that there are multiple factors that drive trade ally recommendations of the HVAC equipment, including system cost, equipment availability, system's brand name, availability of warranty, customer requests for comfort and reliability, as well as availability of tax credits. During the interviews, most trade allies mentioned that they had always offered high efficiency options to customers. For some trade allies, high efficiency is at the core of their business. Other trade allies, however, mentioned that although they have always recommended high efficiency systems along with standard efficiency options, the program changed the emphasis they placed on the high efficiency option. Trade allies cite that the program, through incentives and marketing, somewhat increased their confidence and comfort level with recommending high efficiency equipment and made them more aggressive in their sales message.

In addition to the above-described estimates of FR, the evaluation team used trade ally interviews to arrive at an alternative estimate of FR. This estimate was designed to validate the final FR scores. These values are not used in any impact calculations, but were calculated for informational purposes. An alternative method of calculating FR using trade-ally reported sales resulted in higher FR rates, by measure and overall. These alternative estimates were developed by asking trade allies about their sales of high efficiency systems and what those sales would have been absent the program. As shown in Table 4-8, this alternate method suggests that 63% of program-rebated installations of CACs and DHPs would have happened absent the program. Relative precision associated with this estimate is 17% at 90% confidence.

[40] A rating of 6 or 7 on a scale of 1 to 7, where 1 is not at all likely and 7 is very likely.

Table 4-8
Alternative Residential Electric HVAC Program FR Values Using Trade Ally Research

Stratum	FR	Standard Error	Relative Precision (at 90% Confidence)
CAC	0.63	0.06	15%
DHP	0.64	0.16	42%
Total	**0.63**	**0.07**	**17%**

Many trade allies noted that the availability of the CECONY rebate made it easier to sell high efficiency systems to customers, but opinions were mixed on how much the program helped. Of the 20 interviewed trade allies, 13 indicated that the rebate was a primary driver for sales of high efficiency systems. When asked how CECONY helped with system installations between 2009 and 2011, one trade ally responded “I cannot survive without this program.” Other trade allies provided similar comments:

> “The program helps out immensely. It’s a big decision maker for the homeowner. It is a big incentive for them to upgrade or go high efficiency because they do get money back. It certainly does help.”

> “It’s become easier to sell the high efficiency [units] due to incentives that are available. Once you get the incentive, it brings the price close to or even with lower efficiency units. So it becomes a no brainer.”

Conversely, eight trade allies indicated that the rebate had little to no impact on their installations of high efficiency systems. Trade allies in this group found that the rebate is nice to have (calling it a “perk” or a “cherry on top”) but believed most customers would install the systems they chose regardless of the rebate. Comments from this group of trade allies included:

> “I don’t think that the rebate is a primary [driver of choosing high efficiency equipment]. It’s there, it’s maybe the fourth of fifth reason, but it is certainly not a primary reason.”

> “I wouldn’t say it’s a driving force. It’s nice, people love to hear [about] it, but generally with the price difference, it is not enough to sway them one way or another.”

Interestingly, some trade allies who believed that the program did not change the number of high efficiency systems installed indicated that the rebate might have influenced the customer in other ways. One contractor who focuses on heat pumps said that the rebate allows customers to work with better trade allies who perform quality installation. This contractor believes that most customers would get a high efficiency DHP no matter what and without the rebate they would just drop to a lower tier of installer. Two other trade allies noted that the rebate helps some customers speed up their purchase of a new system. Without the rebate, these trade allies believe, some customers would keep their existing equipment until total failure. [41]

4.2.2 Spillover

As part of the evaluation, the evaluation team estimated participant SO and looked at the presence of NPSO.

Participant Spillover

The evaluation team asked telephone survey respondents about SO associated with installing insulation, ENERGY STAR refrigerators, and ENERGY STAR clothes washers. The evaluation team found no SO savings that could be attributed to program activity.

Ten of the 192 survey respondents (three CAC participants and seven DHP participants) indicated that they installed either insulation, or ENERGY STAR refrigerators, or ENERGY STAR clothes washers after participation in the Residential Electric HVAC Program and gave the program an influence rating of six or seven, indicating the program influenced their actions.[42] When probed further to explain how the program influenced the decision to make those additional improvements, none of the ten respondents provided a response that indicated the program influenced the additional projects in a manner consistent with SO.

Nonparticipant Spillover

The evaluation team explored the overall impact of the Residential Electric HVAC program on the market and presence of NPSO through interviews with trade allies. Most contractors did not report doing work that would qualify as nonparticipant SO. Sixteen out of 20 trade allies stated that all systems that qualified for the CECONY program received a rebate. Of the four trade allies who did not report that the vast majority of qualifying systems received a rebate, three believed that the rebate was not a driving factor in their customers' decision and that many of their customers were looking for top of the line, efficient systems regardless of price.

NPSO may also occur due to changes in the products made and carried by manufacturers and distributors serving CECONY's service territory. Through the interviews with trade allies, the evaluation team explored program influence on the manufacturing and distribution trends.

[41] This might be indicative of the early retirement savings caused by the program. The topic however, was not explored sufficiently enough to make any conclusions.

[42] On a scale of 1 to 7, where 1 means no influence and 7 means a great deal of influence.

Many trade allies could not provide insight into the CECONY Residential HVAC program's influence on the equipment made and distributed by HVAC manufacturers and distributors, respectively. The trade allies that did provide feedback on the program's influence noted that the number of systems qualifying for the CECONY rebate has increased since the program's inception. However, trade allies' opinions on the influence of the program on this change is varied: several trade allies believed the program had no influence, some thought that the program absolutely influenced the market, and others believe there may be some influence along with other factors such as the federal tax credit for high efficiency systems. Trade allies who thought that the program influenced manufacturers and distributors believed it was due to the high sales of qualifying equipment and limits on stocking. According to one contractor, "it is very difficult now for manufacturers…or distributors to stock or produce so many different variations and if they can sell more of the high efficiency [systems] then it is definitely better for them to put more of that [level of efficiency] on the shelf."

These findings point to limited, if any, NPSO.

4.2.3 Net-to-Gross Ratio

Using the NTG formula of *(1-FR+SO)*, the evaluation team derived an overall NTG ratio of 0.52 for the program. At the program level, the evaluation results have 9% precision at the 90% confidence level. The final estimates of NTG by stratum are shown in Table 4-9.

Table 4-9
Final NTG Estimates

Stratum	Final FR**	Spillover	Final NTG*	Final NTG Standard Error	Final NTG Relative Precision (at 90% Confidence)
CAC	0.48	0	0.52	0.04	11%
DHP	0.47	0	0.53	0.04	13%
Total	**0.48**	**0**	**0.52**	**0.03**	**9%**

*The final NTG estimate includes an estimate for the air sealing improvements. The contribution of the air sealing measure to the final NTG is negligible and is based on a small number of participant interviews (five completed interviews out of the population of 47 participants).

**The measure-level FR scores are savings-weighted.

4.3 Net Program Level Results

The program level net impact results – taking the net to gross evaluation results into account – are presented in this section.

4.3.1 Evaluated Net Impacts

The net program results are calculated by multiplying the gross program results by the NTGR. The total program net energy impacts and total program net peak demand impacts are shown in Table 4-10 and Table 4-11, respectively.

Table 4-10
Program Net Energy Impacts

Measure	Measure Installations	Ex Post Gross Energy Savings (MWh)	NTGR	Ex Post Net Energy Savings (MWh)	Relative Precision*
CAC	2,646	800	0.52	416	20%
DHP	754	577	0.53	306	33%
M&V Subtotal	**3,400**	**1,377**	**0.52**	**722**	**18%******
Programmable thermostats	1,436	278	0.52**	145	N/A
Furnace fans	274	201	0.52**	105	N/A
Air sealing	97	32	N/A***	N/A	N/A
Duct sealing	5	3	N/A***	N/A	N/A
Total	**5,212**	**1,891**	**0.52**	**983**	**N/A**

*Relative precision is calculated at the 90% confidence level. The relative precision is not applicable for the measures that received only engineering review to verify savings rather than metering because the review is conducted on a census of installations and there is no sampling error to report.

** Furnace fans and programmable t-stats were installed almost exclusively in conjunction with CAC and HP installations (97%). These participants were asked questions on the basis of the entire heating and cooling system project. As a result, these measures received the same NTG.

***Only five of the survey participants had installed air sealing and duct sealing measures; thus the results are not statistically significant.

****The M&V subtotal relative precision is calculated based on the savings and standard error of the M&V measure population, calculated as the square root of the sum of the squares of the CAC and DHP measure-level standard errors. See Appendix D for more details.

Table 4-11
Program Net Peak Demand Impacts

Measure	Measure Installations	Ex Post Gross Peak Demand Savings (kW)	NTGR	Ex Post Net Peak Demand Savings (kW)	Relative Precision
CAC	2,646	901	0.52	469	36%
DHP	754	105	0.53	56	32%
M&V Subtotal	**3,400**	**1,006**	**0.52**	**525**	**32%***
Programmable thermostats	1,436	0	N/A	0	N/A
Furnace fans	274	0	N/A	0	N/A
Air sealing	97	15	N/A*	15	N/A
Duct sealing	5	1	N/A*	1	N/A
Total	**5,212**	**1,021**	**0.52**	**541**	**N/A**

*Relative precision is calculated at the 90% confidence level. The relative precision is not applicable for the measures that received only engineering review to verify savings rather than metering because the review is conducted on a census of installations and there is no sampling error to report.

**Only five of the survey participants had installed air sealing and duct sealing measures; thus the results are not statistically significant.

***The M&V subtotal relative precision is calculated based on the savings and standard error of the M&V measure population, calculated as the square root of the sum of the squares of the CAC and DHP measure-level standard errors. See Appendix D for more details.

5 Conclusions and Recommendations

The evaluation team presents several conclusions and recommendations for CECONY's Residential HVAC program. These are given in the following sections.

5.1 Conclusions

The evaluation team's conclusions regarding the program resulting from the CECONY impact evaluation are provided below.

1. **For DHP equipment, heating energy savings are much lower and cooling energy savings are much higher than expected for this program, while CAC hours of use are comparable to the current recommended value.** In general, there are three main things that technical manuals do not generally take into account that show up in metering studies:

   a. Occupants using equipment less than expected due to large temperature setbacks[43]

   b. Degree of oversizing typical in real AC equipment (sized to quickly cool house after daytime setback)

   c. Availability and use of night cooling (people opening windows in lieu of AC)[44]

   These reasons are likely dictators of the results in this study. However, each measure in this program has unique usage patterns among program participants. Participants use their CACs for cooling only slightly less than the previously used equivalent full-load hours (EFLH) suggests. Therefore, the EFLH for CACs should remain effectively unchanged from the current NY DPS guidance. Equivalent full load hours of use for DHPs in the cooling season are much higher than that of CACs. This is partially due to the fact that DHPs run for longer at a lower stage to meet the thermostat setpoints. DHP heating usage is lower than expected for this climate. This low heating usage is likely a result of DHPs being purchased primarily for central cooling.[45]

[43] Temperature setbacks are included in the prototype model utilized by the NY TM, but manual operation of the programmable thermostat systems is not included. These estimates could be refined.

[44] The evaluation team understands that natural ventilation (i.e. people opening windows in lieu of AC) is included in the residential models used to determine values used in the NYTM. The evaluation team believes that there is probably still some effect captured in the metered data that is not fully realized in the model.

[45] This conjecture is backed up by onsite data which shows that 88% of the metered participants use another source of heat either exclusively or in conjunction with their DHP. Of these, 73% have a gas

The effective coincidence factor is much lower than predicted for both CACs and DHPs. The verified peak demand savings of ductless systems were lower than the deemed values primarily due to the systems running less during peak hours than predicted. . In addition, ductless systems are generally used to heat and cool a single space or portion of a home, and thus are used much more erratically than central systems, which are typically used to meet a certain thermostat setpoint for most or all hours of the day.

NPSO is negligible for this program. Exploratory inquiry on NPSO found little evidence to warrant further investigation on this factor in the next round of evaluation of this program.

5.2 Recommendations

The evaluation team recommends the following for CECONY's program, the New York technical manual, and future evaluations.

5.2.1 Program Recommendations

The program has a relatively high cost per annual kWh of savings acquired. The evaluation team offers five recommendations for increasing program cost-effectiveness, which were requested by CECONY staff. These are listed below and then discussed in detail. The evaluation team's recommendations focus on driving participation toward higher energy savings per transaction or on lowering the cost of achieving savings. Some of these are based on findings from this evaluation's research. Others are based on program designs that the evaluation team has observed succeed for other administrators and believe could be incorporated into CECONY's program.

1. Consider bundling expensive HVAC measures with other, lower cost measures. By offering new equipment bundled with other lower cost measures, the incentive covers more savings. Bundling measures – regardless of the specific measures – reduces overhead and increases cost-effectiveness. For example, one measure to consider bundling with central systems is prescriptive duct sealing, which offers generous savings at a reduced cost[46].

furnace or boiler, 18% have an oil boiler, 5% have electric resistance heat, and 5% have another type of heating.

[46] A source for prescriptive duct sealing savings and costs in the Pacific Northwest (as an example) is found at .

Consider incentivizing cold-climate DHPs[47] separately from other heat pumps and specifically targeting them at participants who will use them for heating. The ductless heat pump participants in this program had low heating savings because most of them purchased the equipment primarily for cooling. Specifically, this evaluation found low run-time hours during the heating season while units were operating in heat pump mode. Cold climate heat pumps are a relatively new technology that offers much higher heating savings in colder climates, such as New York. The increased savings potential is due to their being more efficient and also more likely to be selected by dual-heat source customers, thanks to their high efficiency and warmer discharge air temperature. CECONY should explore programs targeting cold-climate DHPs at customers with existing electric heat and consider offering cold-climate heat pumps as the only eligible ductless heat pumps available for incentives. In addition to increasing gross savings, this would reduce FR, thereby increasing net savings.

Make forward-looking benefit-cost decisions. To accurately reflect the benefits and costs associated with HVAC measures, the inputs to the benefit cost test should be revisited to account for a forward-looking market. In particular, the incremental equipment costs, avoided costs, participation, and unit savings should be updated.

Consider fostering stronger relationships with contractors in order to influence their marketing to participants. In the interviews performed as part of this evaluation, customers showed that contractors have a large influence on participants, but contractors said the program does not have a substantial influence on their practices. CECONY should consider focusing more on developing partnerships with contractors. Contractors would be more likely to encourage their customers to participate in the program if the contractors understood better how the program could help their businesses. Strong relationships with contractors may in turn reduce FR by encouraging them to market the program better.

5.2.2 Recommendations for New York Technical Manual

The NYTM should adopt the verified run-time hours for both CECONY and Orange & Rockland (O&R) territories, as shown in Tables 4-3 and 4-4 for CECONY and Table 4-5 for Orange & Rockland. Both utilities should adopt the verified coincidence factors shown in Table

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[47] Cold-climate ductless heat pumps are an emerging technology with the potential for large heating season savings relative to standard ductless heat pumps. They are being sold throughout the Northeast, including small numbers of units in the Con Edison program. Cold climate heat pumps use a higher compression ratio than standard heat pumps, allowing them to provide higher capacity and efficiency down to lower temperatures.

4-6. These values should be used with the suggested algorithm in the Run-Time Results and Implications for NYTM section (Section 4.1.2). For comparison, the previously used EFLH values are shown in Table 4-4 of the same section.

5.2.3 Evaluation Recommendations

Upon completing this evaluation, the evaluation team has some recommendations for ways to improve future Residential Electric HVAC evaluations.

1. **Design the metered sample differently.** Conduct the phone survey earlier to determine predicted run time before the field study begins and post-stratify based on predicted run time for CAC or on predicted savings for DHP.

   Ideally, the sample of metered sites from within the phone survey sites would have provided improved precision on the sites that were predicted to have high run times or savings by oversampling those substrata. This would have been implemented by pre-processing the phone survey before the field study started to determine predicted total run times for each site, and then post-stratifying each population density strata into high and low predicted run time or savings substrata. Upon starting the field study, the sample – still nested within the phone sample – would have included more sites in the high run-time substrata within each population density stratum. Use of this method would require a larger phone sample size and an earlier survey start date relative to the summer peak metering period.

Use a higher coefficient of variation (CV) when sampling the metered sites from within the phone survey sample. In this study, a coefficient of variation (CV) of 0.25[48] was used when sampling the metered sites from within the phone survey sample because the evaluation team assumed that the phone survey would accurately predict metered run time. A low CV assumes that there is little variation between the phone survey and metered samples and results in a low on-site metering sample. A higher CV should have been used and would have resulted in a larger on-site sample. The actual CVs achieved in this study for the CAC stratum were 0.53 and 0.46 for the first and second phases of the double ratio, respectively. The CVs were 0.57 and 0.80, respectively, for the DHP stratum.

Consider targeting 90/15 confidence and precision for future DHP metering studies. Targeting 90/10 requires a large investment in metering for these technologies. A higher relative precision (higher uncertainty) target should be considered to keep evaluation

[48] This CV was chosen based on the evaluation team's previous experience metering CACs in other parts of the country.

costs down while still investigating changes in savings associated with future DHP technology iterations.

Future metering studies should consider alternatives for quantifying the precise in-situ capacity and efficiency of DHPs. Given the nature of DHP's inverter-driven technology, the evaluation team could not sufficiently correlate the metered data with rated capacities and efficiencies. Future metering studies should dig deeper into the specific technology anomalies to determine a good algorithm for savings based on capacity and efficiency and consider metering baseline DHPs as well.

Consider performing additional research to better understand the HVAC market dynamics. The focus of the net impact evaluation research was to estimate and report program FR and SO rates. Limited research was performed to identify opportunities for program improvement to program processes that might impact the NTGR. In light of somewhat high FR estimates, the evaluation team recommends conducting additional research to identify opportunities for reaching and attracting participants who would not have installed high efficiency HVAC equipment without the program support, thus reducing FR. Additional research could include interviews with distributors and nonparticipating contractors. This research would provide information about the HVAC market in CECONY's service territory in terms of total number of installations taking place, equipment availability (in terms of SEER), and nonparticipating contractor sales practices. These findings can inform the most appropriate program intervention strategies, be it increased or selective contractor engagement, increasing the minimum program-qualifying SEER, or other approaches. In addition, this additional research can shed light on the presence and magnitude of NPSO in the market.

APPENDIX A. DETAILED DATA COLLECTION METHODS

This appendix explains the detailed data collection methods of the evaluation.

Participant Survey Sample Design

A stratified random sample of program participants acquired in 2011 was pulled for the Residential Electric HVAC Program telephone survey and on-site M&V activities, with a single participating household as the sampling unit. The selection of customers from the most recent year reduced the time between customer decision-making and the attribution surveys and should improve customer recruitment rates. On-site samples were nested within the phone survey samples.

The Residential HVAC phone sample was stratified into CAC participants and DHP participants. After the phone survey was completed, the nested on-site sample of DHPs was further stratified into high and low users on the basis of predicted savings for both heating and cooling season savings. The results of the on-site metering were used to calculate an adjustment ratio on the phone survey and billing results. This method is known as double-ratio estimation.[1] The assumed coefficients of variation and resulting sample sizes and final confidence and relative precision are shown in Table A-1.

Table A-1
Residential HVAC Sample Design

Stratum	Total Acquired Participants in 2011	Reported Savings (kWh)	Phone CV	Phone Surveys	On-Site to Phone CV	On-Site M&V Surveys	Final Projected Precision at 90%
CAC	1,476	607,504	0.7	100	0.25	30	90/13
DHPs	554	445,549	0.7	80	0.25	25	90/15
Total	**2,030**	**1,053,053**		**180**		**55**	**90/10**

The coefficients of variation (CVs) for the phone survey and on-site surveys were estimated from other impact evaluations of Residential HVAC measures. However, since the programs

[1] The total relative precision in this double-ratio estimation case is calculated as the square root of the sum of the squares of the relative precision of the phone survey and the relative precision of the on-site survey. This method is described in detail in Wright, R. L. et al., "Double Ratio Analysis: A New Tool for Cost-Effective Monitoring," in *Proceedings of the 1994 ACEEE Summer Study on Buildings*.

have not been evaluated previously, the actual CVs were unknown at the time of sampling and were determined at the conclusion of the study. The actual program precision is a function of the CVs, and therefore the final precision attained varies from the projected precision shown in Table A-1 above.

Participant Survey Final Sample Disposition

The program participants were surveyed from June 26, 2012, through July 23, 2012. The evaluation team completed a total of 116 interviews with participants who installed CAC systems, 79 interviews with participants who installed DHPs, and 10 interviews with participants who installed air sealing.[2] The telephone interviews were conducted using a Computer-Assisted Telephone Interviewing (CATI) system. Table A-2 shows the final survey dispositions for the participant survey.

To minimize the measurement error, the survey was tested internally for comprehension. Additionally, it was pre-tested with several participants to ensure that survey questions are interpreted correctly and answered in a consistent manner.

[2] Note that the evaluation team completed a total of ten interviews with participants who installed air sealing, but five out of ten interviewees did not have any electric savings associated with their air sealing measures and as such were dropped from the analysis.

Table A-2
Residential Electric HVAC Program Participant Survey Dispositions

	CAC	DHP	Air Sealing
Disposition	**N**	**N**	**N**
Completed interviews	116	79	10
Eligible non-interviews	578	326	58
Refusals	211	142	21
Break off	10	8	0
Telephone answering device	180	44	16
Respondent never available	175	116	21
Language problem	2	16	0
Not eligible	83	64	11
Fax/data line	9	2	2
Nonworking	42	31	7
Wrong number	16	12	1
Business/government	12	12	0
No eligible respondent	3	7	1
Duplicate number	1	0	0
Unknown eligibility non-interview	628	93	8
Not dialed/worked	399	0	0
No answer	228	90	8
Busy	1	1	0
Call blocking	0	2	0
Total participants in sample	1,419	563	87

Table A-3 provides the response and cooperation rates. The survey response rate is the number of completed interviews divided by the total number of potentially eligible respondents in the sample. The evaluation team calculated the response rate (RR3) using the standards and formulas set forth by the American Association for Public Opinion Research (AAPOR).[3]

The evaluation team also calculated a cooperation rate, which is the number of completed interviews divided by the total number of eligible sample units actually contacted. The cooperation rate gives the percentage of participants who completed an interview out of all of the participants with whom the evaluation team actually spoke. This evaluation used AAPOR

[3] *Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys*, AAPOR, 2011. http://www.aapor.org/AM/Template.cfm?Section=Standard_Definitions2&Template=/CM/ContentDisplay.cfm&ContentID=3156

Cooperation Rate 1 (COOP1). The cooperation rates listed in Table A-3 are lower than what is seen in the evaluations of similar programs in other jurisdictions but are not unusual for New York. Downstate New York historically has had lower cooperation rates. Other participant survey efforts of similar programs that the evaluation team completed in the past few years in downstate New York feature similar cooperation rates.

Table A-3. Residential Electric HVAC Program Participant Survey Response and Cooperation Rates

AAPOR Rate	CAC	DHP	Air Sealing
Response rate (RR3)	9%	16%	13%
Cooperation rate (COOP1)	34%	35%	32%

No cash incentive was offered for completion of the telephone survey.

There are multiple sources of non-sampling error that can impact survey results, including non-response error and resulting coverage bias. This type of bias is usually overcome through comparing and, if needed, weighting the survey results to the observable characteristics (generally demographic or household) in the population of customers targeted by the survey effort. Since the demographic composition of the participant population is unknown and may have inherent differences from the overall customer population, the non-response bias could not be calculated. However, we tried to mitigate the non-response bias through the fielding process by taking the following steps:

- Calling participants multiple times at varying times of the day and week
- Extending the fielding process over a period of time to "work" the sample.

On-site visit participants were chosen from the telephone survey sample. They were offered gift card incentives of $50 associated with each of the two (CAC) or three (DHP) site visits for their assistance. The final number of completed on-site and telephone surveys of the on-site sample are shown below in Table A-4.

Table A-4
Residential HVAC Telephone and On-Site Sample Targets and Achieved Sample

Measure	On-Site Targets	On-Sites Complete	On-Sites with Usable Data Target	On-Site Surveys with Usable Data
CAC	30	30	27	28
DHP	25	25	23	23

Trade Ally Interviews

The evaluation team conducted interviews with twenty HVAC trade allies who participated in the Residential HVAC Electric program between 2009 and 2011. Interviews took place from May 14, 2013 through July 23, 2013.[4] The sample frame consisted of seventy-five trade allies with the highest number of rebated systems (CAC and DHP combined) between 2009 and 2011. The sample frame was drawn from the population of 284 trade allies who installed at least one program incented HVAC system.

To avoid respondent burden, the evaluation team focused the interviews on only one type of HVAC equipment – either CAC systems or heat pumps. With trade allies who installed only one type of program qualifying equipment (CACs or DHPs), the evaluation team focused the interview on that equipment. With trade allies who installed both, we prioritized one type of equipment based on the energy savings and sample needs. Based on these rules, the sample frame of seventy-five trade allies consisted of fifty-two in the CAC category (69%) and twenty-three in the DHP category (31%).[5]

The evaluation team completed a total of twenty interviews with fourteen CAC trade allies and seven DHP trade allies. The evaluation team was able to cover both CACs and DHPs in an interview with one trade ally.

Trade allies were offered a $100 incentive for completing an interview.

On-Site Survey

A list of all the information collected on-site at each sampled site is below under the categories of equipment information, logger information, customer interview, and site characteristics.

Equipment information

- ❑ HVAC manufacturer/model
- ❑ Unit size (Btu/h)
- ❑ SEER

[4] Although the evaluation team conducted interviews from May 14 to July 23, to maximize the number of interviews completed the amount of calls placed during that time varied from week to week as factors such as multiple heat waves in New York and the Fourth of July holiday limited contractor responsiveness during some weeks.

[5] These distributions are consistent with the distributions observed in the population of contractors, where about a third of program installations and gross savings resulting from the installation of DHPs.

Logger information

- ❑ Thermostat temperature logger details
- ❑ Power logger setup details

Customer interview

- ❑ Gift card number, signature
- ❑ Year home built
- ❑ Total conditioned floor area
- ❑ Floor space served by new unit
- ❑ Number of conditioned floors
- ❑ Number of AC units on-site

Site characteristics

- ❑ Home setting and type
- ❑ Average ceiling height
- ❑ Foundation information (if single-family home)
- ❑ Infiltration information
- ❑ Electric meter number and reading
- ❑ Wall information (photos of each side of house), construction, exterior finish
- ❑ Window information (photos of each side of house), shading, panes
- ❑ Detailed building sketch

Metering Equipment Details

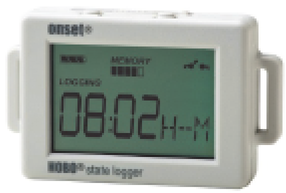
At each site, true power was metered at the indoor and outdoor units of CACs, and at the outdoor unit only for DHPs[6]. The indoor temperature was also metered for calibration purposes and to confirm run-time accuracy. The power logging setup used at each site consisted of two current transducers (CTs), a WattNode pulse output, and a HOBO UX90 data logger. The

[6] DHPs' outdoor units act as a subpanel for any indoor units attached. Therefore, it was not necessary to meter the indoor units of the DHP measure.

HOBO U12 logger, used to meter temperature and relative humidity, is a state logger. The specifications and pictures of each logger are shown in Figure A-1 and Figure A-2.

Figure A-1
HOBO UX90 Logger Data Sheet

HOBO® State Data Logger (UX90-001x) Manual



The HOBO State/Pulse/Event/Runtime data logger records state changes, electronic pulses and mechanical or electrical contact closures from external sensing devices. Using HOBOware®, you can easily configure the internal magnetic reed switch or the external sensor to monitor and record data in a wide variety of applications, such as energy consumption, mechanical equipment operation, and water and gas flow. This compact data logger also has a built-in LCD screen to monitor logging status, battery use, and memory consumption. There are two models of the HOBO state logger: the UX90-001 has 128 KB of memory while the UX90-001M has 512 KB.

HOBO State Data Logger

Models: UX90-001
UX90-001M

Included Items:

- 2.5 mm input cable
- Command™ strip
- Double-sided tape
- Hook & loop strap
- Magnet with 2 screws

Required Items:

- HOBOware 3.3 or later
- USB cable (included with software)

Accessories:

- Wattnode kWh transducers
- Power & Energy Meter (T-VER-E50B2)
- Water Flow Meter Sensor (T-MINOL-130)
- U-Shuttle (U-DT-1)

Additional sensors and accessories available at www.onsetcomp.com.

Specifications

Internal Sensor

Maximum State, Event, Runtime Frequency	1 Hz
Preferred Switch State	No magnet present (normally open)

External Input

External Contact Input	Electronic solid state switch closure or logic driven voltage output
Range	0 to 3 V DC (USB powered), 0 to 2.5 V DC (battery powered)
Maximum Pulse Frequency	50 Hz
Maximum State, Event, Runtime Frequency	1 Hz
Pulse, Event Lockout Time	0 to 1 second in 100 ms steps
Solid State Switch Closure	Input Low: < 10 KΩ; Input High: > 500 KΩ
Internal Weak Pull-Up	100 KΩ
Input Impedance	Solid state switch closure: 100 KΩ pull up

Logger

Resolution	Pulse: 1 pulse, Runtime: 1 second, State and Event: 1 State or Event
Logging Rate	1 second to 18 hours, 12 minutes, 15 seconds
Memory Modes	Wrap when full or stop when full
Start Modes	Immediate, push button, date & time, or next interval
Stop Modes	When memory full, push button, or date & time
Time Accuracy	±1 minute per month at 25°C (77°F) (see Plot A)
Battery Life	1 year, typical with logging intervals greater than 1 minute and normally open contacts
Battery Type	One 3V CR2032 lithium battery
Memory	UX90-001: 128 KB (84,650 measurements, maximum) UX90-001M: 512 KB (346,795 measurements, maximum)
Download Type	USB 2.0 interface
Full Memory Download Time	10 seconds for 128 KB; 30 seconds for 512 KB
Logger Operating Range	Logging: -20° to 70°C (-4° to 158°F); 0 to 95% RH (non-condensing) Launch/Readout: 0° to 50°C (32° to 122°F) per USB specification
LCD	LCD is visible from: 0° to 50°C (32° to 122°F); the LCD may react slowly or go blank in temperatures outside this range
Size	3.66 x 5.94 x 1.52 cm (1.44 x 2.34 x 0.6 in.)
Weight	23 g (0.81 oz)
Environmental Rating	IP50
CE	The CE Marking identifies this product as complying with all relevant directives in the European Union (EU).

Figure A-2. HOBO Temperature/Relative Humidity Logger Data Sheet

HOBO® U12 Temperature Data Logger (Part # U12-001)

Inside this package:

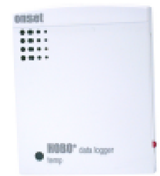
- HOBO U12 Temperature Data Logger
- Mounting kit with magnet, hook and loop tape, tie-wrap mount, tie wrap, and two screws

Doc # 7551-B, MAN-U12-001
Onset Computer Corporation

Thank you for purchasing a HOBO data logger. With proper care, it will give you years of accurate and reliable measurements.

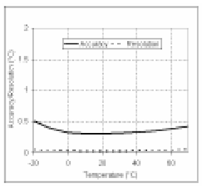
The HOBO U12 Temperature Data Logger is a single channel temperature logger with 12-bit resolution and can record up to 43,000 measurements or events. The logger uses a direct USB interface for launching and data readout by a computer.

An Onset software starter kit is required for logger operation. Visit www.onsetcomp.com for compatible software.

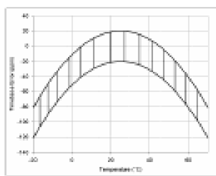


Specifications

Measurement range	-20° to 70°C (-4° to 158°F)
Accuracy	± 0.35°C from 0° to 50°C (± 0.63°F from 32° to 122°F), see Plot A
Resolution	0.03°C at 25°C (0.05°F at 77°F), see Plot A
Drift	0.1°C/year (0.2°F/year)
Response time	In airflow of 1 m/s (2.2 mph): 6 minutes, typical to 90%
Time accuracy	± 1 minute per month at 25°C (77°F), see Plot B
Operating temperature	Logging: -20° to 70°C (-4° to 158°F) Launch/readout: 0° to 50°C (32° to 122°F), per USB specification
Battery life	1 year typical use
Memory	64K bytes (43,000 12-bit measurements)
Weight	46 g (1.6 oz)
Dimensions	58 x 74 x 22 mm (2.3 x 2.9 x 0.9 inches)
CE	The CE Marking identifies this product as complying with all relevant directives in the European Union (EU).



Plot A



Plot B

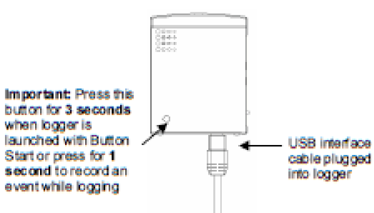
Accessories available

- White waterproof case (Part # SUBC2-WH)
- Gray waterproof case (Part # SUBSC2-GR)

Connecting the logger

The U-Family logger requires an Onset-supplied USB interface cable to connect to the computer. If possible, avoid connecting at temperatures below 0°C (32°F) or above 50°C (122°F).

1. Plug the large end of the USB interface cable into a USB port on the computer.
2. Plug the small end of the USB interface cable into the bottom of the logger as shown in the following diagram.



If the logger has never been connected to the computer before, it may take a few seconds for the new hardware to be detected. Use the logger software to launch and read out the logger.

Important: If you configure the logger to start with a button start, be sure to press and hold down the button on the front of the logger for at least three seconds when you want to begin logging.

You can read out the logger while it continues to log, stop it manually with the software, or let it record data until the memory is full. Refer to the software user's guide for complete details on launching, reading out, and viewing data from the logger.

Sample and event logging

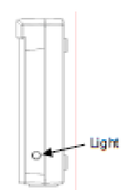
The logger can record two types of data: samples and events. Samples are the sensor measurements recorded at each logging interval (for example, the temperature every minute). Events are independent occurrences triggered by a logger activity. Examples of events recorded asynchronously during deployment include when the logger is connected to the host, when the battery is low, the end of a data file once the logger is stopped, and button pushes.

Press and hold down the button on the front of the logger for one second to record an event. Both a button up and down event will be recorded. This is useful if you want to mark the datafile at a particular point. For example, if the logger is located in an incubator, you might press the button each time the door is opened.

The logger stores 64K of data, and can record up to 43,000 samples and events combined.

Operation

A light (LED) on the side of the logger confirms logger operation.



The following table explains when the logger blinks during logger operation.

When:	The light:
The logger is logging	Blinks once every one to four seconds (the shorter the logging interval, the faster the light blinks); blinks when logging a sample.
The logger is awaiting a start because it was launched in Start At Interval, Delayed Start, or Button Start mode	Blinks once every eight seconds until launch begins.
The button on the logger is being pushed for a Button Start launch	Blinks once every second while pressing the button and then flashes rapidly once you release the button. The light then reverts to a blinking pattern based on the logging interval.

Part #: MAN-U12-001, Doc #: 7551-B

Billing Data

The evaluation team requested the billing data for the summer months from CECONY in mid-November to include all of May, June, July, August, September, and October for all customers who participated in the phone survey. The requested billing data encompassed the entire metering period as well as May and June, to ensure that the entire summer period was included in the billing data disaggregation.

Appendix B – Detailed Analysis Methods

This appendix details the analysis methods used in this evaluation.

Billing Data Disaggregation

In order to determine cooling consumption values to adjust the phone survey models, the evaluation team analyzed billing data from the phone survey participants. Data from CECONY was in the form of rows containing energy consumption for the past billing period, the billing date, and the number of days in the billing cycle. Data was cleaned and converted to energy consumption for each calendar month by the following process:

1. Determine the average consumption per day in each billing period by dividing total consumption by number of days.

Calculate consumption per day at the beginning and end of each billing period by assuming a constant slope between consumption per day of the previous period and that of the following period, and using that slope to adjust the average consumption per day of the current period.

Assign consumption values to each day of the billing period by assuming that consumption per day linearly follows the slope calculated in (2).

Determine consumption for each calendar month by summing the consumption per day for the appropriate days of the two billing periods that contain part of that month. [1]

End-Use Disaggregation

Once monthly consumption was determined for each site, those monthly total values were broken down by end use using the Navigant billing data end-use disaggregation method. This method is Navigant's standard practice, and it has been used in performing numerous residential evaluations nationwide. The basic steps are as follows:

[1] This method, while more complex than simply determining the portion of each billing period in each month and assigning a proportional amount of the consumption to that month, is a more accurate way of dividing consumption. The alternative method will tend to reduce the (real) split between the highest and lowest consumption months by assuming that consumption in a given billing period is constant; it is important to get an accurate value for the lowest-consumption month, since that drives the end-use disaggregation described below.

1. Determine monthly consumption for each site by splitting participant billing data into calendar months (described above).

Estimate lighting and DHW usage based on the U.S. DOE's Building America Research Benchmark.

Calculate the remaining consumption, which is attributable to HVAC and miscellaneous equipment,[2] by subtracting lighting and DHW consumption from the monthly total.

Calculate miscellaneous equipment consumption by:

   a. Identifying the base month, defined as the month with the lowest remaining consumption per day; assume that heating and cooling (HVAC) consumption accounts for a small fraction of the total in the base month (usually ~10%–15% in temperate climates with both heating and cooling).

   b. Subtracting the HVAC consumption in the base month from the remaining consumption; assume that this miscellaneous equipment consumption per day is constant throughout the year.

Calculate HVAC consumption by subtracting lighting, DHW, and equipment consumption from the monthly total.

Split HVAC consumption into heating and cooling by assigning all winter (Nov–March) HVAC consumption to heating and all summer (June–Sept) HVAC consumption to cooling; split swing-season HVAC consumption by assuming heating and cooling are proportional to the heating and cooling degree days in each month.[3]

Lighting and DHW Consumption

The first step in disaggregating monthly energy consumption into end uses is to break out the uses that can be reliably calculated using engineering algorithms and primary research: lighting and DHW.

Annual lighting consumption per household was estimated using an equation from the U.S. DOE's Building America Research Benchmark (BARB), which gives lighting consumption as a function of square footage of floor area:

[2] Miscellaneous consumption includes all electrical consumption for all end-uses other than lighting, DHW, and HVAC. This includes any plug loads including refrigerators, TVs, and computers.

[3] Heating and cooling degree days were taken from www.degreedays.net, a website that aggregates data from Weather Underground (www.wunderground.com).

$$Annual\ lighting\ consumption\ (kWh) = 0.737 \times Floor\ area\ (sq\ ft) + 467$$

Total annual lighting consumption was split into monthly consumption using the seasonal lighting load shape, also from BARB.

Square footage information was sourced from several Internet real estate databases (trulia.com and zillow.com). For the sites for which this information was unavailable, a modeled square footage was assigned by a simple linear regression of square footage as a function of total kWh consumption in July, for the sites that did have square footage information[4].

Hot water heater fuel was not a known value; however, a study by GDS Associates[5] indicates that only 4.5% of homes in the CECONY service territory have electric hot water. Based on this, the evaluation team assumed that DHW electric consumption was 0 for all homes.[6]

Miscellaneous Equipment Consumption

After subtracting the hot water and lighting end uses from the monthly household electricity consumption, the remaining consumption is composed of HVAC and miscellaneous equipment, which includes appliances and plug loads. To find the portion of the remaining consumption that is from miscellaneous equipment, remaining consumption per day was calculated for each month, and the month with the minimum daily remaining consumption was identified. This month is generally in the spring or the fall, and it corresponds to the time of lowest HVAC use. It was assumed that during this minimum-consumption month, HVAC accounted for either 0%, 3%, or 10% of total consumption, based on a visual QC of the data (past experience has shown this to be a reasonable assumption)[7]. Daily equipment consumption for this minimum month was then calculated as the total consumption per day minus the consumption of lighting, DHW,

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[4] While it would have been ideal to use a "base" month (i.e. a swing-season month with minimal HVAC usage, representing the baseload) for this step of the disaggregation, the end savings results are consistent regardless of which month is used because it is corrected for in the adjustment based upon the metering results.

[5] "Natural Gas Energy Efficiency Potential Study," GDS Associates, Inc. Nov 2007.

[6] For the small number of homes for which this is an incorrect assumption, the DHW consumption would be lumped in with the miscellaneous equipment consumption; overall impact on the resulting HVAC consumption is small.

[7] 10% was assigned to sites that appeared to have electric space heat, indicated by a large increase in total electric consumption during the heating months. 3% was assigned to sites that appeared to have gas space heat with an electric fan as the distribution system, indicated by a small increase in winter electric consumption. 0% was assigned to sites that appeared to have no electric consumption associated with heating, such as multi-family buildings with central steam heat, indicated by no increase in winter electric consumption.

and HVAC. This equipment consumption per day was assumed to remain constant throughout the year.

Heating and Cooling Consumption

Once the monthly lighting, DHW, and miscellaneous equipment consumptions were known, total HVAC consumption was calculated by subtracting these three end uses from the monthly totals. Next, HVAC consumption was split into heating and cooling energy. For November to March, all HVAC consumption was assumed to be heating, while for June to September, all HVAC use was assumed to be cooling. Shoulder month (April, May, and October) heating and cooling consumption was estimated using the relative proportions of heating and cooling degree days by the following steps:

1. Heating degree days (HDD) and cooling degree days (CDD), base 65°F (HDD65 and CDD65), were found for each month.[8]

A CDD-to-HDD weighting factor was determined as:

$$WF = \frac{HVAC\ kWh_{Jan} / HDD65_{Jan}}{HVAC\ kWh_{Jul} / CDD65_{Jul}}$$

This indicates the relative contributions of CDD and HDD to total HVAC consumption.

The fraction of total HVAC in each month that was cooling was calculated as

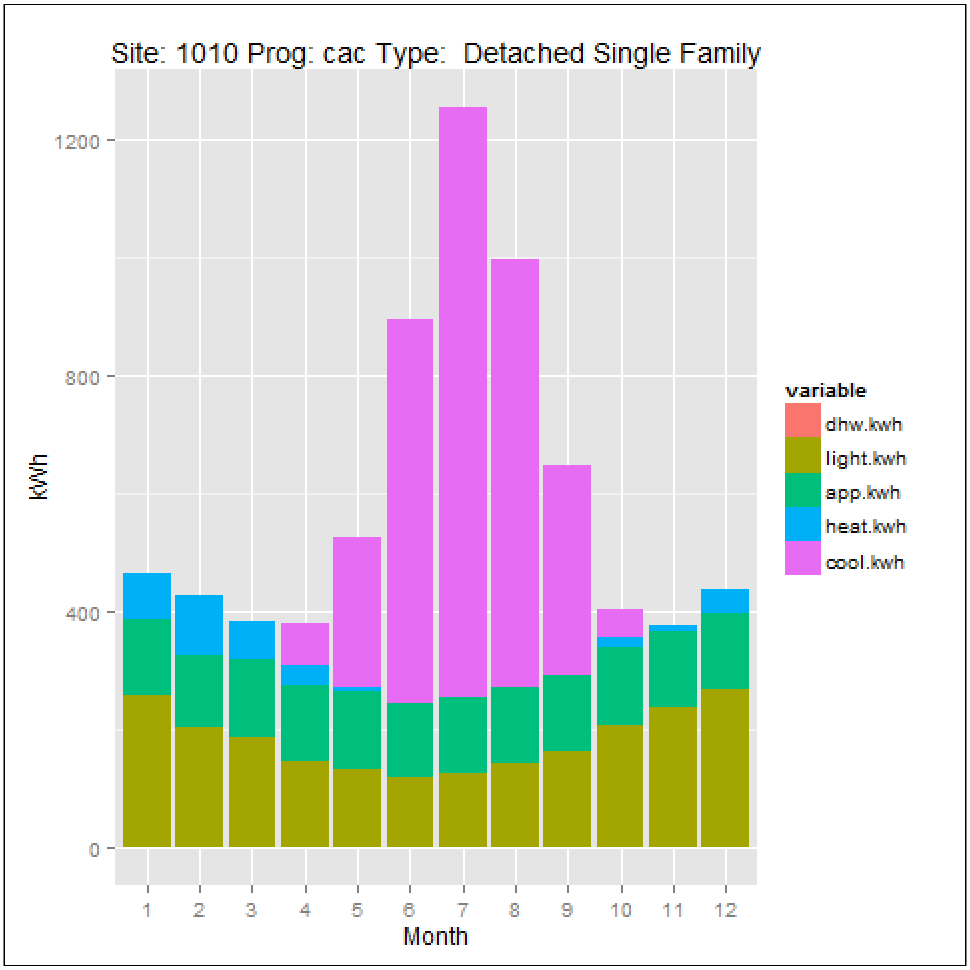
$$\frac{CDD65 / WF}{CDD65 / WF + HDD65}$$

Cooling consumption for each month was calculated as total HVAC consumption multiplied by the cooling fraction, with heating consumption accounting for the remainder of the HVAC energy.

An example of a completed end-use disaggregation is shown in Figure B-1.

[8] Heating and cooling degree days were taken from www.degreedays.net, a website that aggregates data from Weather Underground (www.wunderground.com).

Figure B-1
Example of End-Use Disaggregation



Quality Control

The initial disaggregation produced negative HVAC consumption for some sites, due to the error introduced by the uncertainty in the square footage numbers, which resulted in unreasonably high lighting consumption for some sites. To mitigate this error, the evaluation team iterated the disaggregation process for sites that had negative HVAC consumption, reducing the lighting consumption by 25% each time, until no further negative values existed.

A further QC step was completed to identify sites that did not have sufficient billing data for this method to produce a robust result; billing data is inherently subject to irregularities due to occupant behavior (vacations, etc.). Sixty-five sites (out of 338) were flagged as unreliable based on a visual QC. For these sites, the cooling consumption was determined by taking the average percent of total consumption due to cooling from the reliable sites, by month, and building type, and applying that percentage to the monthly consumption for each unreliable site.

Controlling for Multiple Units

The final step before the billing data could be compared to the phone survey model was to adjust cooling consumption to represent only a single unit at sites where there were multiple AC units. The adjustment was done in the following steps:

1. Determine total tons of rebated units at each site. Unit size was pulled from the tracking data and summed over all units for each site.

Determine total tons of ALL cooling units at each site. First, building square footage was divided by total tons of rebated units. If sq ft/ton was less than 700, it was assumed that the rebated units accounted for all of the cooling equipment at the site. If not, total tons of cooling equipment was calculated by assuming 600 sq ft/ton, and multiplying by the square footage.

Determine fraction of cooling attributable to the modeled unit. In all cases, the modeled unit was the largest rebated unit at the site. For sites in which the rebated units accounted for all of the cooling equipment at the site, the fraction attributed to the modeled unit was equal to the ratio of the size (tons) of the largest unit to the total tons of cooling equipment at the site. For sites in which the rebated units did not account for all of the cooling equipment, the same fraction was derived based on the fractional size of the equipment, but it was reduced by 20% to account for the new equipment being more efficient than the older equipment that was still operating.

Phone Survey Processing and Data Cleaning

The evaluation team conducted phone surveys with participants until the quotas were filled. The responses to the survey questions were compiled into an Excel spreadsheet and provided to the analysis team. The analysis team went through a series of steps to process the data, evaluate it for quality, and clean it before generating predicted run times. This section describes those steps.

Data Import and Quality Checks

Once the data was imported into Excel, the evaluation team visually inspected the responses to identify potential issues or incomplete answers. The evaluation team asked each participant at what outside temperature they typically operate their cooling system. The participants also provided a schedule of times during the day they typically operate their cooling system and what temperature setpoint their system is set to. Some participants responded that they have their system set to a particular setpoint for the entire cooling season and others responded that they turn it on or off depending on how hot of a day it is.

There were several cases where the participants could not recall or did provide times when they operated their cooling system or the setpoints that the system was set to. For these cases, the evaluation team calculated the average setpoint values for the participants that did respond and populated the schedules with the average values for those who didn't respond. If more than half of the respondents who provided an answer had their system running during a particular hour, the evaluation team assumed those who did not respond also had their system operating.

The evaluation team used the same logic for the heating season for participants who purchased a DHP. For the heating season, 22 of the 80 participants surveyed about their DHP indicated that they do not use their heat pump at all for heating.

Phone Survey Predicted Run Time

The evaluation team processed the survey responses from the participants to predict cooling system usage for the summer of 2012. The final output of the phone survey analysis for the CAC program was an hourly run-time prediction for each participant (who also participated in on-site metering) during the same period that the meter was installed. The final output for the DHP program was hourly energy consumption for each participant (who also participated in on-site metering). The general analysis steps are listed below.

1. The participants' responses to the times of day and outdoor air temperature (OAT) that they operate their cooling/heating system were used to create a setpoint schedule for each day of the year.
2. 2012–2013 (for heating) weather data[9] and the daily setpoint schedules were used to create an hourly setpoint schedule for each participant for the monitored period.
3. The evaluation team used the U.S. Dept. of Energy's whole building energy simulation program EnergyPlus to generate an hourly phone predicted cooling energy consumption profile for each participant using their survey responses and 2012–2013 weather data. An assumed oversize factor of 50%[10] was used to adjust the hourly loads generated by EnergyPlus.
4. Adjusted hourly load profiles were merged with the weather data; adjusted system capacity and energy input ratio as a function of outdoor dry-bulb temperature was

[9] The source of the weather data was the National Oceanic and Atmospheric Administration's National Climatic Data Center for Central Park, New York.

10 Long Island Residential New Construction Technical Baseline Study, Vermont Energy Investment Corporation, 2004.

calculated using AC performance curve coefficients[11]. For cooling, high-stage or low-stage operation is classified based on capacity ratio for each hour.

5. The monthly modeled energy consumption was computed and averaged with the billing cooling energy consumption in order to generate a monthly billing AF for each participant. The evaluation team applied the monthly AFs to each hourly energy consumption value to generate billing-adjusted hourly run-time and energy consumption values for each participant.[12] For the heating season, the billing data did not show enough heating usage to justify a billing adjustment factor. The percentage of overall home energy consumption due to heating was too small for the evaluation team to have confidence in the billing analysis.
6. The same general methodology was used for generating weather-normalized predicted run-time and energy consumption values for all of the phone survey participants for both heating and cooling. In this case, a typical weather file was used in the simulation to determine cooling and heating loads and the 2012 monthly billing AFs (for cooling) were used to calculate total run time and energy consumed.

Sample Post-Stratification

The evaluation team sorted the sampled sites in ascending order based on the phone-predicted run times for CAC and savings for DHPs for a typical meteorological year. The CAC stratum was left as one large stratum because there was less variation in phone-predicted run times. The DHP stratum was divided into two substrata for low and high phone-predicted run time for each the cooling and heating season. Many DHP survey respondents indicated that they use their heat pump very little or not at all for heating purposes. Ratio estimation works poorly on numbers that are zero or nearly zero. Therefore, a regression estimation adder – rather than the typical regression ratio estimation – was used for the phone-predicted low savings substratum in the DHP heating stratum. The method of using an adder creates an adjusted estimate that accounts for consumers who claim not to use their HVAC unit at all, but in fact have a low but non-trivial savings as indicated by the metered data.

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11 D. Cutler, J. Winkler, N. Kruis, C. Christensen, M. Brandemuehl. Improved Modeling of Residential Air Conditioners and Heat Pumps for Energy Calculations, NREL/TP-5500-56354, 2013.

12 In cases where the model predicted zero cooling energy consumption but the billing analysis showed non-zero cooling energy consumption, the average of zero and the non-zero value was assumed to be the cooling energy consumption. The evaluation team generated a monthly cooling load profile from the remaining participants, which was applied to the cooling load to generate an hourly cooling load profile for these cases.

Logger Data Processing and Cleaning

This section details the methods used for logger data processing and cleaning for use in the evaluation.

Data Import

The evaluation team began the logger data processing step by combining the list of logger files with the tracking spreadsheet to find missing loggers and catch data entry errors. Once each logger file was matched to a specific end use at the correct site, all the raw text files were read into SAS and converted to SAS datasets. Care was taken to custom read the different types of HOBO files, stored in four different configurations of text files, into a consistent format. The raw logger data was combined with contextual data, such as site identification and end use, by merging in the data in the tracking spreadsheet from the site visits.

Data Transformation

Next, the evaluation team transformed the data to get it into the format needed for analysis. The HOBO energy loggers were connected to WattNodes, which log a count for every time a certain amount of energy is consumed. Those counts were converted to kWh using the conversion for 50 A current transducers (0.00125 kWh/count). The data from the installation and retrieval dates for each logger were then deleted, because the installation and removal of the data logging equipment introduces some bad data into the logger file.

Since there were multiple logger files describing different end uses at the same site (e.g., outdoor unit energy, indoor unit energy, indoor temperature), all loggers for each site were combined into a single time series of data by rounding all time stamps to the nearest minute. Then, because the indoor temperature data was only logged every five minutes, the intermediate values were linearly interpolated. The final result was a single time series of data per site which contained outdoor unit energy, indoor unit energy (where there was a separate indoor unit), indoor temperature, and indoor relative humidity, all at one-minute intervals.

Finally, OAT was added from a NOAA weather file for Central Park (the same file used in the phone survey models) – this single weather station was chosen so that results could be extrapolated to a typical year using a Typical Meteorological Year (TMY) file for the same site. The NOAA temperature data, initially one measurement per hour, was also linearly interpolated to provide temperature readings for each minute.

Visual QC

After transforming the data, the evaluation team did one further round of quality control. The data from each site was plotted, one plot per day, and the plots were visually checked for irregularities. Five of the 55 logged sites were identified as having failed energy loggers, either with no energy consumption data or data that did not make sense, and deleted.

Logger Data Analysis

After processing and cleaning the logger data, the evaluation team analyzed the data to determine run times in different operational modes.

Assignment of Operational Mode

First, it was important to assign an operational mode to each data point. That is, during each logged point, what was the logged unit doing? The possible modes were:

- H – The unit ran in high-stage for the whole minute.
- L – The unit ran in low-stage for the whole minute.
- S – The unit split time between on and off, and ran for a partial minute.
- O – The unit was off for the whole minute.

Single-stage central systems were assigned "H" for all on points, while two-stage central systems had their operation further broken down into high and low stages.[13]

Because the power draw of a given unit is highly variable, it is difficult to determine what mode it is operating in at any given point. However, past experience has shown that the power draw of the outdoor unit of an AC is highly correlated to outdoor dry-bulb temperature. So as a starting point, the evaluation team ran a linear regression of logged energy to OAT for each month at each site. Site-specific multipliers were applied to the resulting equations to set a threshold separating partial points from full-on points, a threshold separating low points from high points for two-stage systems, and a predicted full-on point value for each point. Next, the evaluation team adjusted those multipliers through an iterative process of visual QC until the data from each site was split into modes.

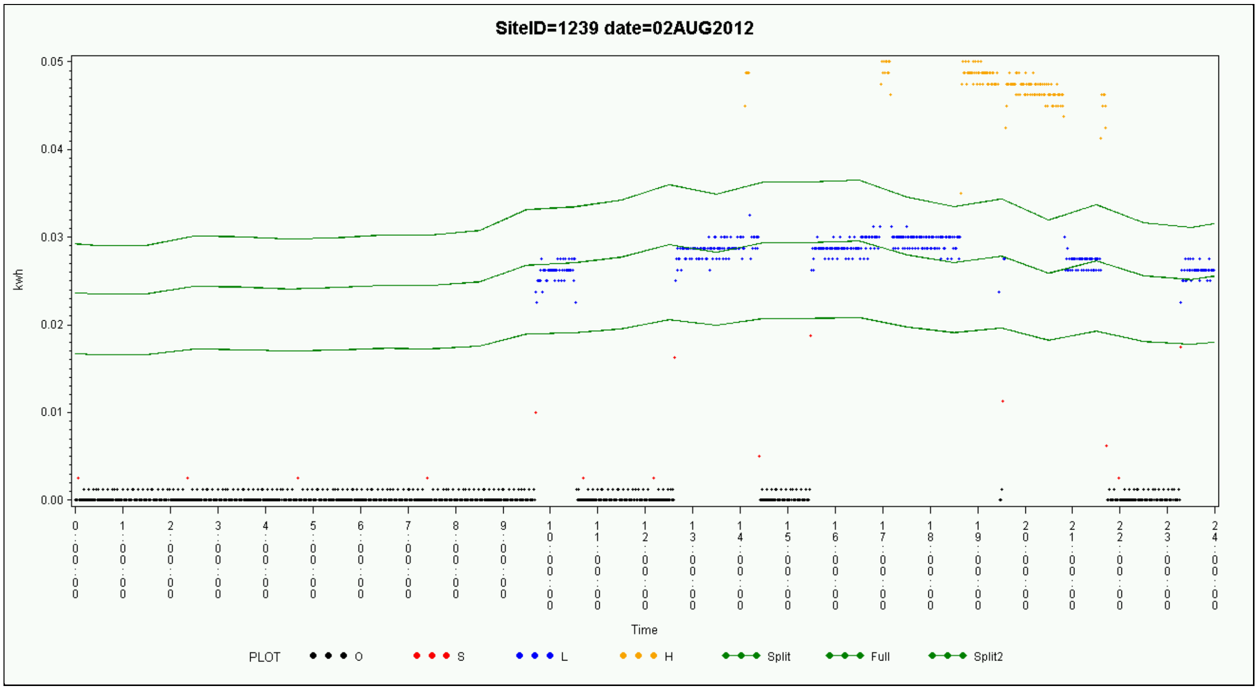
<u>Example – Visual QC Plot</u>

Figure B-2 shows an example of a QC plot used in the mode assignments. This plot shows a single day of data for a single site, with time of day on the x-axis and kWh on the y-axis. The colored dots represent individual logged data points, with the colors reflecting the mode which

[13] Note that for DHPs no mode was assigned; high-efficiency DHPs have a fully modulating compressor, so the idea of "high" or "low" stage does not apply. As a result, we chose to analyze those units differently. See the section on Unit Savings Equation Derivation.

the point has been assigned. The green lines are visual representations of the thresholds used to assign modes to each point; the lowest line splits “S” from “L” points, the middle line is the predicted “L” mode power (for assigning partial run times to the “S” points; see next section), and the top line splits “L” from “H” points.

Figure B-2
Example Visual QC Plot



By comparing the observed data to tracking data, the evaluation team determined that there were three two-stage CAC units that appeared to be operating in only a single stage. Whether they were operating all in high or all in low would have a big impact on the results. The evaluation team ran a comparison of the units exhibiting clear two-stage operation to determine how to sort out the others. First, predicted high power was calculated for each unit as P = Rated capacity / Rated EER. Then average power for each unit in high and low stage was found, and the ratios of AvgHi/Predicted and AvgLow/Predicted were calculated for the clear two-stage units. These ratios were averaged across all units, and the midpoint between them was found (0.77). The ratio of Avg/Predicted was calculated for the three units operating in only a single stage, and if it was above that threshold the unit was assumed to be running in high stage; otherwise it was running in low stage. One of the units was running in high, and two in low.

Run-Time Calculation and Data Summarization

Once the operational modes were assigned, the evaluation team calculated unit run time for each logged data point. High and low points were assigned a full minute of run time in their respective modes, while off points were assigned no run time. Split points were more difficult to assign. They were assigned a fractional minute each, equal to the ratio of the kWh logged to the modeled full-on-point kWh. This is a good approximation of what is happening in reality: the unit runs through a partial minute until the load is met, then turns off. And because the modeled kWh values were visually QC'ed for each site, the evaluation team is confident that this approximation gives a good result.[14]

For two-stage units the situation is more complicated. However, experience has shown that most units spend the bulk of the time operating in low stage, and often start a run period in low stage. Base on this, the evaluation team assumed that all split points that fell below the low-point threshold were partial run minutes in low stage, not high. Partial points that fell between the low-point and high-point threshold were assigned either low or high full points; there were few enough of these that the impact on the results is minimal.

The calculated run times for each site were summed up to the hourly level. Hourly run times were averaged across all sites, by stage (single, low, high) for CAC units. These average run-time values were then used to adjust the phone survey model results.

Indoor Temp Analysis

The logged data was also used to determine the entering wet-bulb value used in the equipment models. The evaluation team first converted the indoor temperature and relative humidity values to indoor wet-bulb temperature values using August-Roche-Magnus approximation. Next, the indoor wet-bulb values were averaged for all "on" points – considered the best approximation of conditions seen by the unit. The most representative value was 64°F. It was assumed that the air wet-bulb temperature would increase by 1°F on average, so 65°F was used in the model.

Equipment Modeling

The objective of the equipment modeling step was to produce generic tables that would predict the power draw of a generic unit at of a given efficiency at a given outdoor dry-bulb temperature. Because of the nature of the data available and the operational characteristics of the different units (single/two-stage CACs vs. fully modulating DHPs), this was done differently for CACs and DHPs.

CAC and HP Equipment Model

14 Again, this step was skipped for the DHP units, since the concept of run time is not useful in analyzing that data. See the section on Unit Savings Equation Derivation.

For central systems, there is extensive information published by manufacturers describing the performance of different units at a range of indoor and outdoor temperature conditions. The approach for these systems was to create a set of benchmark power curves, one for each stage (single-stage, two-stage low, and two-stage high), and to adjust those curves using our in situ logged data to get power predictions specific to the participant group.

Benchmark Power Curves

The evaluation team used Navigant's database of 216 model-size combinations, spanning the range of manufacturers and efficiencies in the current market, as a starting point for predicting unit power. The manufacturers' data was used to create benchmark power curves as a function of OAT, unit efficiency, and unit size. The steps for creating the benchmark curves were as follows:

1. Determine the indoor air conditions (80°F dry-bulb/65°F wet-bulb, from the logged data)

For each unit, use interpolation to find the power draw at one-degree increments of outdoor dry-bulb temperature, using those indoor air conditions.

Normalize the power draws for each unit by multiplying by (Efficiency / Size (tons)). For single-stage units and the high stage of two-stage units, the rated EER value was used as the efficiency, while for the low stage of two-stage units, the rated SEER value was used.[15]

Average the normalized power for each OAT across all units of the same stage (single, low, high) to produce benchmark curves by stage.

Smooth the curves by modeling a regression equation to each; it was found that a linear regression as a function of OAT gave an excellent fit, with R2 values of greater than 99.8% in each case.

To predict the power of a given unit at a given temperature, the generic power was determined by plugging the OAT into the regression equation; then, the specific power was determined by multiplying by (Size (tons) / Efficiency), using the rated values for the unit in question.

In-Situ Power Adjustment Factors

Once the benchmark curves were produced, the evaluation team used the logged data to derive in situ adjustment factors (AFs) that would be used to make the power curves specific to the

[15] The purpose of the normalization was to enable an "apples-to-apples" comparison across different units. The efficiency value use was the one thought to be most representative of the overall efficiency of the unit at its operating conditions; since the bulk of the low-stage operation of most two-stage units occurs at lower temperatures, SEER was chosen as the normalizing efficiency for low-stage data.

participant group. First, the kWh values from all logged data that was assigned "high" or "low" mode were converted to instantaneous power values.[16] Next, the predicted power was calculated for each data point using the regression equations and rated efficiency and size of each unit. The efficiency and size values were first verified by looking up each unit in the AHRI database. The instantaneous power adjustment factor was calculated for each data point by dividing the actual logged power by the predicted power.

These power adjustment factors were aggregated by averaging the instantaneous AFs of all data points in a given bin, using the same OAT and time-of-day bins that were later used to produce run-time adjustments.[17]

Ductless AC and HP Equipment Model

The analysis of ductless units (DHPs) was complicated by the fact that these units have fully modulating compressors, resulting in power being a function both of OAT and the part-load ratio (PLR) at which the unit is operating. For these units, a performance map was developed predicting power and efficiency at a range of OATs and part-load ratios. The base case was assumed to be a SEER 13 DHP, which generally has a single-speed compressor; a separate benchmark curve was developed predicting power as a function of OAT only.

Efficient Case Performance Map – Cooling

Manufacturers' data on unit performance was generally unavailable, so the evaluation team used lab test data for a representative Fujitsu unit[18] from a DHP evaluation by Ecotope[19] to derive a map of normalized cooling power and efficiency at a range of OATs and PLRs. The steps for deriving this performance map were as follows, using the cooling model from Appendix B:

[16] Because these are the data points judged to represent full-minute run times, they are the only ones in which the logged energy can reliably be converted to an average power value. They were converted by multiplying the kWh value by 60 (minutes / hour), since the logging interval was one minute.

[17] Averaging all data points individually (as opposed to averaging to the site level and then to the population level) implicitly weighted the results by the amount of run time each unit had in each bin. The evaluation team intentionally averaged this way, judging this to be the most representative way to combine the data.

[18] The lab test utilized was performed on a Fujitsu 12RLS, which has nominal cooling capacity of 12,000 BTU/h and nominal heating capacity of 16,000 BTU/h. It is a 12 HSPF, 25 SEER unit.

[19] "DHP Impact & Process Evaluation: Lab-Testing Report." Prepared by Ecotope, Inc. for the Northwest Energy Efficiency Alliance, Report No. E11-225, July 2011.

1. Calculate peak capacity and total power (both compressor and fan power) at one-degree increments of outdoor dry-bulb temperature, using the bi-quadratic equations (functions of outdoor dry-bulb and indoor wet-bulb, assuming indoor wet-bulb temperature of 67°F).[20]

Calculate capacity and power at 0.01 increments of PLR for each temperature, using the fractional power at part load bi-quadratic equation (functions of PLR and fan speed ratio, using assumed fan speeds by PLR from the report).[21]

Normalize the power values by multiplying by (Efficiency (EER) / Size (tons)) to allow the application of the values to units of any size and efficiency.

Calculate instantaneous normalized EER (instantaneous EER / rated EER) for each combination of outdoor dry-bulb and PLR, by dividing capacity by normalized power.

Efficient Case Performance Map – Heating

Data from the same DHP evaluation by Ecotope was used to derive a map of normalized heating power and efficiency at a range of OATs and PLRs. The steps for deriving this performance map were similar to those used in deriving the cooling performance map:

1. Calculate peak capacity and total power (both compressor and fan power) at one-degree increments of outdoor dry-bulb temperature, using the equations (functions of outdoor dry-bulb and indoor wet-bulb, assuming indoor WB of 60°F)

Calculate capacity and power at 0.01 increments of PLR for each temperature, using the fractional power at part-load equation (functions of PLR and fan flow rate, using assumed fan flow by PLR from the report)[22]

Normalize the power values by multiplying by (Efficiency (COP) / Size (tons)) to allow the application of the values to units of any size and efficiency

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[20] The model was only valid down to 66°F ODB; to accommodate the small number of points down to 55°F, the power values were linearly extrapolated using the power values at 66 and 67.

[21] The model was only valid down to PLR=0.35; to accommodate the small number of points down to PLR=0, power values were linearly extrapolated between the value at PLR=0.35 and 0 kW at PLR=0.

[22] The model was only valid down to PLR=0.25; to accommodate the small number of points down to PLR=0, COP values were assumed to be constant from PLR=0.25 down to PLR=0; below that point the unit would cycle at PLR=0.25, and cycling losses were assumed to be negligible. In reality, cycling losses would have an effect, however the number of data points in this range was minimal, and thus the error introduced by this assumption was small.

Calculate instantaneous normalized COP (instantaneous COP / rated COP) for each combination of outdoor dry-bulb and PLR, by dividing capacity by normalized power.

Base Case Benchmark Curve – Cooling

To derive the base case benchmark cooling power curve, the same method was used as for central systems, using only the SEER 13 units as a starting point. See the Benchmark power curve section for CACs above for further details. The main difference was that instead of using that data to produce power draw as a function of OAT, the power was combined with capacity to produce efficiency as a function of OAT.

Base Case Benchmark Curve – Heating

The base heating power curve was developed from the SEER 13 heat pump model used in the California Database for Energy Efficiency Resources (DEER).[23]

The equations used were:

$$Base\ COP = \frac{1}{(EIR_{Compressor} \times Temp\ adjustment + EIR_{Fan})}$$

$$\begin{aligned} &Temp\ adjustment \\ &= 0.853469 + 0.012033 \times EWB + 0.000033 \times EWB^2 - 0.015984 \times ODB \\ &+ 0.000153 \times ODB^2 + 0.000135 \times EWB \times ODB \end{aligned}$$

And the input parameters were:

$EIR_{Compressor}$	= The compressor energy input ratio, 0.3050099
EIR_{Fan}	= The indoor unit fan energy input ratio, 0.02800611
EWB	= The indoor unit entering wet-bulb temperature, assumed to be 60°F[24]
ODB	= The outdoor air dry-bulb temperature

Calculation of Run-Time Adjustment Factors

For each site in the on-site sample, the run time in each bin was calculated using the phone survey and on-site logging analysis. The results were then summed for each bin across all sites,

[23] See http://www.deeresources.com/.

[24] The humidity conditions observed in the metered data were not analyzed with respect to manufacturer's SEER ratings or typical conditions for other kinds of cooling systems. This topic may warrant further research.

giving a total phone-predicted run time and logged run time for the logged period across all logged sites in each stratum. The on-site logged run time was divided by the phone-predicted run time to derive the AF for each bin that contained 5 or more hours of logged time. Bins that contained fewer than 5 hours were combined with the next higher or lower bin until an aggregation of greater than 5 hours was available. For example, there might have only been 1 hour greater than 95°F between the hours of noon and 4 p.m. during the logged period. This bin would have been combined with the 90°F–95°F bin for noon to 4 p.m., creating a new 90°F-plus-between-noon-and-4-p.m. bin in place of the two original bins. The resulting AFs were then applied to typical year phone-predicted results.

Unit Savings Equation Derivation

The starting point for the savings equations was a file of hourly run times and temperatures for a typical cooling season, produced by the adjusted phone survey model, run with a Typical Meteorological Year (TMY) weather file. The following steps were taken to derive the energy and peak demand savings as a function of size and efficiency for a typical year:

1. Import TMY modeled hourly run times and temperatures. Separate run times were produced for each stratum. Both run times and outdoor dry-bulb temperatures were given for the entire cooling season (assumed to last from April to October).
2. Combine with run-time AFs by bin. Modeled run times were adjusted by multiplying by the run-time AF of the bin that corresponded to each hour, derived from the logged data. Run-time AFs were binned OAT, hour of day, and average daily temperature.
3. Determine adjusted normalized unit power for each hour. Adjusted power was derived from the adjusted power benchmark curve, using OAT for each hour. All power values were normalized (in units of kW-EER/ton), to allow them to represent units of generic size and efficiency.[25]
4. Calculate normalized energy consumption for each hour. Normalized energy consumption (in kWh-EER/ton) was calculated for each hour by multiplying adjusted run time by adjusted power. This was done separately for each stratum (high and medium) for RAC units.
5. Calculate normalized peak demand. The CECONY peak period is defined as the hour between 4 to 5 p.m. on the single hottest day of the year. For the TMY file, that hottest day was July 25th. The peak demand was thus calculated to be equal to the energy

[25] To determine the power of a specific unit, one would multiply that value by the size of the unit in tons, and divide by the rated EER.

consumption from step 4 during the 4–5 p.m. hour on 7/25, since average power is equal to total energy consumption for a given hour.

6. Find total normalized energy consumption. The hourly values of energy consumption were summed over the entire cooling season to produce total normalized consumption for a typical year (in kWh-EER/ton).
7. Derive savings equations. Normalized total consumption and peak demand were combined with baseline assumptions to derive energy and demand savings equations.
    a. Energy
        i. $Energy\ savings\ (kWh/ton)\ =\ Normalized\ total\ consumption\ (kWh - EER/ton)\ \times\ (1/EER_{Base} - 1/EER_{Eff})$.

Attribution Calculations

Program attribution accounts for the portion of the gross energy savings associated with a program-supported measure or behavior change that would not have been realized in the absence of the program. The program-induced savings, indicated as a net-to-gross ratio (NTGR), is made up of free ridership (FR) and spillover (SO) and is calculated as $(1 - FR + SO)$. FR is the portion of the program-achieved verified gross savings that would have been realized absent the program and its interventions. SO is generally classified into participant and nonparticipant spillover (NPSO). Participant spillover (PSO) occurs when participants take additional energy-saving actions that are influenced by the program interventions but did not receive program support. NPSO is the reduction in energy consumption and/or demand by nonparticipants because of the influence of the program.

As part of this evaluation, the evaluation team focused on the estimation of FR and PSO. Through interviews with trade allies, the evaluation team also explored the presence of nonparticipant SO and whether additional research is justified to accurately quantify nonparticipant SO. Quantifying savings from NPSO activities is a challenging task that warrants a separate study and was outside of the scope of this evaluation effort.

FR component of the NTGR was derived from self-reported information from telephone interviews with program participants and further adjusted through the interviews with participating trade allies. The evaluation team further validated the FR rates through our interviews with trade allies by asking trade allies to estimate equipment sales with and without the program.

The PSO component of the NTGR was derived through participant interviews. The final NTGR was calculated as the percentage of gross program savings that can reliably be attributed to the program. NTGRs were estimated separately for CACs and DHPs and then weighted by relative contribution of each measure's savings to the overall program estimate.[26]

Interviews with trade allies were used to assess the presence of NPSO. Quantifying savings from NPSO activities is a challenging task that warrants a separate study and was outside of the scope of this evaluation effort. As part of this evaluation the evaluation team assessed if NPSO activity was present and to the degree that would warrant such future study.

Below is a detailed overview of the method for developing FR and SO estimates, validating FR estimates, and assessing the presence of NPSO.

Free Ridership

Free riders are program participants who would have implemented the incented energy efficient measure(s) even without the program. In other words, free ridership (FR) represents the percent of savings that would have been achieved in the absence of the program.

The goal of most incentive-based energy efficiency programs is to influence customer decision-making regarding energy efficient improvements. Programs can do this by changing *what* customers install, *when* they install it, and *how much* they install. In other words, programs influence the *efficiency, timing,* and *quantity* of customers' energy-using equipment installations. The bulk of program savings is typically achieved by encouraging customers to install higher efficiency equipment than they would have installed on their own. Programs may also encourage early replacement of still functioning equipment that is less efficient, thus impacting the timing of the installation, so that savings can be realized earlier. The incentive may also make it more affordable for customers to install a greater number of high efficiency measures. As such, the FR algorithm outlined here combines the estimates of each of these concepts:

- Program influence on the efficiency level of the installed equipment (EI)
- Program influence on the timing of the installation of high efficiency equipment (TI)
- Program influence on the quantity of the high efficiency equipment installed (QI)

As part of its activity in the market, however, the program can provide information, training, and other support to trade allies, thus potentially influencing the way trade allies recommend HVAC equipment to customers. This type of program outreach to and interactions with trade

[26] The overall program NTGR also includes the air sealing measure.

allies might not necessarily be visible to program participants. As such, FR estimates based only on participant feedback do not accurately reflect the true credit that the program deserves. To address this gap, telephone interviews with trade allies were used to adjust the participant-derived FR rates to account for the broader influence of the program on the market that might not be visible to participants.

Initial Free-Ridership Estimation through Participant Research

Telephone interviews with participants were used to develop the basis of the FR score. The evaluation team based it on a series of questions designed to gather data on the customer's preexisting plans to implement the program measure, willingness to have installed the measure even if there had been no program incentive (i.e., to pay full cost), and likelihood of taking the same action in the absence of the program. The evaluation team developed initial estimates of FR using a two-step approach:

> Step 1 (FR1) – Identifying full free-riders and non-free riders and assigning FR values of 1 and 0 respectively
>
> Step 2 (FR2) – Further estimating the magnitude of FR

As part of step 1, the evaluation team measured the timing of customer awareness of the program relative to equipment installation, as well as program influence on customers' mere decision to purchase and install equipment.

As part of step 2 the evaluation team explored the following areas of program influence:

1. Efficiency level of the installed equipment (EI)

Quantity of the high efficiency equipment (QI)

Timing of the installation of high efficiency equipment (TI)

Each respondent's FR score was calculated using either step 1 or step 2 above (as they are mutually exclusive). If program attribution, or lack thereof, was determined through step 1, the final FR value took the value from that step. In all other cases, the final FR value was derived from step 2.

$$FR = FR1 \text{ OR } FR2$$

Below is a detailed description of each step which includes specifics on the questions, inputs, and formula.

Step 1 (FR1). Initial Determination of Full Free-Ridership and Non-Free Ridership

The questions below determined if a participant is a full free-rider. Participants who said that they had learned about program rebates *after* purchasing and installing program qualifying equipment were deemed full free-riders and were assigned a FR value of 1.

<u>*Questions:*</u>

B1a *When did you first learn that you could receive a rebate from Con Edison for installing new high efficiency heating and/or cooling equipment? Was it before or after you installed the equipment?*

[IF AFTER]

B1b *Just to be clear, did you install your new heating and/or cooling equipment and then later learn that you could receive a rebate from Con Edison?*

<u>*Calculation:*</u>

IF B1A= AFTER AND B1B=YES → FR1=1

On the other hand, participants who said that they would not have purchased and installed any equipment, regardless of its efficiency level, without the program were deemed non-free riders and assigned a FR value of 0. The following questions were used to determine non-FR.

<u>*Questions:*</u>

B3. *If the Con Edison rebate had not been available, would you have installed heating and/or cooling equipment at all?*

[IF VOLUNTARILY SAY THAT THE INSTALLATION WOULD NOT HAVE HAPPENED IN RESPONSE TO B5 ASKING ABOUT TIMING OF PURCHASE]

B6. *Just to confirm, if the Con Edison rebate had not been available, you would NOT have installed heating and/or cooling equipment at all, is that correct?*

<u>*Calculation:*</u>

IF B3=NO OR B6=YES → FR=0

Step 2 (FR2). Estimation of Free Ridership through Program Influences

The survey measured three distinct areas of program influence:

- ❑ Program influence on equipment efficiency (EI)
- ❑ Program influence on timing of the purchase/installation (TI)
- ❑ Program influence on quantity (QI)

Efficiency (EI), timing (TI), and quantity (QI) of the installation are distinct avenues of program influence. However, the timing of the installation and quantity of measures installed are conditional on efficiency. The program can only realize timing savings if the customer would have installed the efficient equipment on their own but the program caused the installation to happen earlier. Similarly, savings due to a quantity increase can only happen if a customer who was already installing some energy-efficient measures chooses to install additional ones because of the program.

The evaluation team believes that when the three concepts are measured as distinct yet conditional methods of program influence, it is appropriate to combine them by using multiplication. For example, if the program influences efficiency level of the purchased equipment as well as the quantity of the high efficiency equipment, overall FR score should be adjusted downward to account for both influences, and not for the largest or average of the two. Averaging or using some other calculation method would overestimate FR. As such, the formula to calculate FR through the program influences can be expressed as:

$$FR2 = EI \times QI \times TI$$

Given than the concepts of timing and quantity are conditional on efficiency, this multiplication only took place for participants who had a moderate to high probability installing the high efficiency equipment on their own. [27] For other participants where the probability of a high efficiency installation is low or none, the final FR score would default to the EI score.

$$\text{IF } EI \geq 0.50\text{, then } FR2 = EI \times QI \times TI$$

$$\text{All other cases, } FR2 = EI$$

It should be noted that following the approval and implementation of the Residential HVAC evaluation effort, the FR algorithm that multiplies the three program influence scores (EI, TI, and QI) has been questioned by the DPS as possibly being biased toward lower FR. The discussion among the New York Department of Public Service (DPS), CECONY, O&R, evaluators, and other stakeholders regarding an alternative calculation of the FR rate resulted in an algorithm that multiplies the EI and QI scores and averages them with the TI score, but only in cases where TI score does not exceed the product of the EI and QI multiplication[28]. In cases where the TI score exceeds the product of multiplying the EI and QI scores, the FR rate is based only on the EI and QI scores.

[27] The evaluation team multiplied the EI, TI, and QI scores only in cases where the EI score was 0.5 or higher (50% probability of the high efficiency installation happening absent the program)

[28] This is done in order to avoid penalizing the program for not influencing the timing to the same degree as efficiency and/or quantity.

Since the decision around alternative ways of calculating FR started after the NTG approach for the Residential HVAC Program was finalized, approved, and executed, the evaluation team followed the FR estimation approach that was initially proposed. The evaluation team estimated FR using an alternative algorithm and found that the resulting FR rate did not change for DHPs and increased 1% by CACs.

Below is further detail on the how each influence score was calculated as well as the survey questions measuring each area of influence.

Program Influence on Equipment Efficiency (EI)

Based on our knowledge of the program theory, the following program components can be of influence on the customer decision-making process to install high efficiency equipment:

- Program rebates (EI1)
- Program marketing (EI2)

A seven-point scale (1–7) was used to measure each of the program components. Opinions in the industry on the use of various rating scales vary. However, there is research providing evidence that seven-point scales yield more reliable and valid results.[29]

Survey responses to the efficiency influence questions were converted from the seven-point scale to a value between 0 and 1 using linear transformation. For example, a response of 3 on a seven-point scale became .33 or .66, depending on how the anchor points of the scale were defined to respondents.

The evaluation team does not have any reason to believe that linear transformations would yield results that are less reliable or valid than if the evaluation team were to use non-linear transformations of the scale responses. Linear transformation approach also seems intuitive, given the use of the scalars. The evaluation team therefore selected to use it in the calculations.

Since program rebates are considered the core program component, their influence was measured through more than one question to ensure reliability of results, with the results averaged to arrive at the overall influence of program rebates on equipment efficiency level.

29 Lozano, M., García-Cueto, E., Muñiz, J. 2008. "Effect of the Number of Response Categories on the Reliability and Validity of Rating Scales." European Journal of Research Methods for the Behavioral and Social Sciences 4(2): 73—79.

The score for program influence on efficiency level of the equipment (EI) was calculated by taking the minimum rating across overall program rebate score and program marketing score. This allowed for the program to claim the credit for the most influential of its components on the respondent decision-making process. The resulting score took a value from 0 to 1 expressed in terms of FR, with 1 being no influence and 0 being maximum influence.

Questions:

B4. *Using a scale of 1 to 7, where 1 means no influence and 7 means a great deal of influence, please rate the influence of the following on your decision to install the HIGH EFFICIENCY heating and/or cooling equipment.*

b. *Information from Con Edison marketing materials and/or website*

c. *Con Edison rebates*

B9. *Using a 1 to 7 point scale, where 1 is not at all likely and 7 is very likely, how likely is it that you would still have installed THE SAME EFFICIENCY heating and/or cooling equipment if you had not received a rebate from Con Edison?*

Calculation:

EI= MIN(EI1; EI2)

EI1= 1-((B4B-1)/6)

EI2= MEAN(1-(B4C-1)/6; (B9-1)/6)

Program Influence on Timing (TI)

Program influence on timing was measured by asking participants if the purchase and installation would have happened later in the absence of the program, and, if so, how much later, with the resulting score taking a value between 0 and 1. The timing score ranged from 0 to 1 based on when participants report the equipment installation would have taken place without the program. Similar to the efficiency score, the timing score was expressed in terms of FR, with 1 being no influence and 0 being maximum influence.

The timing of the installation is conditional on at least some probability of the high efficiency installation happening absent the program.

Questions:

B5. *Did the availability of the Con Edison rebate cause you to install your high efficiency heating and/or cooling equipment EARLIER than you were planning, or did the rebate have no influence on when you installed the equipment?*

[IF CAUSED TO INSTALL EARLIER]

B7. If the rebate had not been available. When would you have installed your high efficiency heating and/or cooling equipment?

Calculation:

TI=1 IF B5= YES AND B7= WITHIN 6 MONTHS

TI=0.66 IF B5= YES AND B7= 6 MONTHS TO YEAR LATER

TI=0.33 IF B5= YES AND B7= 1 TO 2 YEARS LATER

TI=0 IF B5= YES AND B7= MORE THAN 2 YEARS LATER

Program Influence on Quantity (QI)

Program influence on quantity was measured by asking participants who purchased/installed more than one piece of equipment if they would have purchased/installed fewer without the program. The quantity score was calculated by dividing the quantity that would have purchased absent the program by the program rebated quantity. As such, the score took a value between 0 and 1. Similar to the efficiency score, the timing score was expressed in terms of FR, with 1 being no influence and 0 being maximum influence.

Questions:

B8. *If the Con Edison rebate had not been available, would you still have installed <quantity> high efficiency CACs/heat pumps or would you have installed fewer?*

[IF FEWER]
B8a. How many high efficiency CACs/heat pumps would you have purchased if the rebate had not been available?

Calculation:

QI=1 IF B8=THE SAME QUANTITY

QI=B8A/PROGRAM QUANTITY IF B8=FEWER

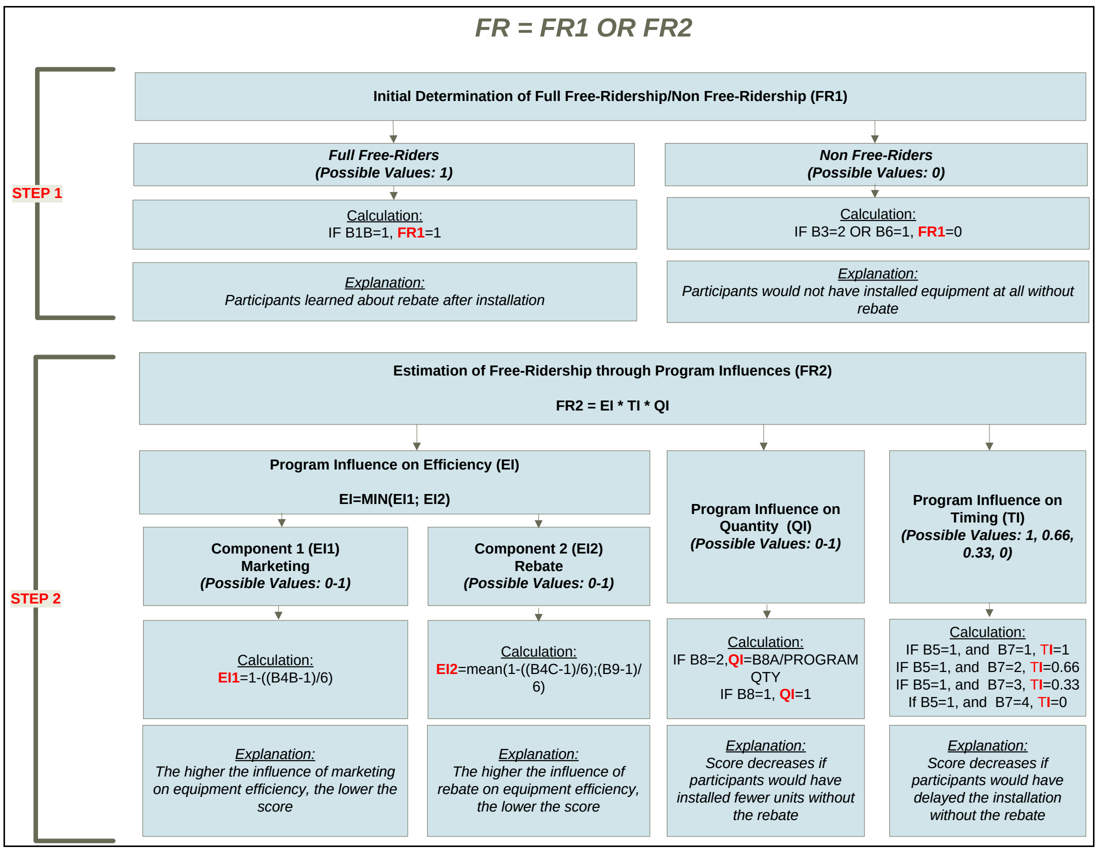
The scoring algorithm relied on responses from multiple questions to triangulate FR rate. Because respondents can sometimes give inconsistent answers, the survey instrument included consistency checks to clarify and validate these responses.

<u>*Question:*</u>

B10. *Just to make sure I understand, please explain the importance of the rebate you received from Con Edison on your decision to install the HIGH EFFICIENCY heating and/or cooling equipment instead of less efficient heating and/or cooling equipment?*

Figure B-3 provides a visual depiction of the FR score calculation.

Figure B-3
Initial Estimation of Free Ridership Rate Using Participant Survey



Free-Ridership Adjustment through Trade Ally Research

As part of its activity in the market, the program can provide information, training, and other support to trade allies, thus potentially influencing the way trade allies recommend HVAC equipment to customers. This program outreach to and interactions with trade allies are not necessarily visible to program participants. As such, FR estimates based only on participant feedback do not accurately reflect the true credit that the program deserves. To address this gap, telephone interviews with trade allies were used to adjust the participant-derived FR rates to account for the broader influence of the program on the market that is not visible to participants. Consistent with the participant research effort, FR adjustment scores were developed separately for CACs and DHPs.

Based on the trade ally responses, participant FR score adjustment factors were calculated and applied to arrive at the final FR rate using the following three steps:

1. **Determining the trade ally attribution score.** The evaluation team used participant survey results to determine the trade ally attribution score. While participants cannot see and estimate program influence on the trade ally they worked with, they can fairly easily estimate and report the influence that trade ally recommendations had on their decision to install high efficiency HVAC equipment. Using the survey question asking participants to rate, on a scale of 1 to 7, where 1 is not at all influential and 7 is very influential, the influence of the trade ally recommendations on their decision to install high efficiency equipment, the evaluation team estimated the trade ally attribution score by giving the program full credit[30] for participants who were heavily influenced by their trade allies[31] and recalculating the FR score to account for the influence that trade allies provided.

Determining the influence of the program on participating trade allies. Through our interviews with trade allies, the evaluation team estimated the influence the program had on their stocking and sales practices. Trade allies were asked questions about changes in trade ally knowledge of high efficiency options, their comfort level with recommending the high efficiency options, as well as recommendation practices (in terms of frequency of recommending high efficiency equipment options), and estimated the degree of program influence on each of those areas. For each trade ally, the evaluation team developed and validated the trade ally program influence score.

Determining the FR adjustment score and the final FR score. The evaluation team combined the influence of the trade allies on participants and influence of the program on trade allies to arrive at the FR adjustment score. The evaluators then applied the adjustment score to the participant FR scores to arrive at the final FR rate.

[30] This essentially means resetting the participant FR scores to 0.

[31] A score of 6 or 7 on a scale of 1 to 7, where 1 is not at all influential and 7 is very influential.

Determining the Trade Ally Attribution Score

The evaluation team relied on participant survey results to determine the trade ally attribution score. Using the survey question asking participants to rate, on a scale of 1 to 7, where 1 is not at all influential and 7 is very influential, the influence of the trade ally recommendations on their decision to install high efficiency equipment, the evaluation team estimated the trade ally attribution score by giving the program full credit[32] for participants who were heavily influenced by their trade allies[33] and recalculating the FR score to account for the influence that trade allies provided.

This newly calculated FR score effectively represents the maximum possible attribution that the program can claim and assumes that every trade ally was heavily influenced by the program in how they approach the recommendations and sales of the HVAC equipment. The differential between the two scores (i.e., the unadjusted participant FR score and the participant FR score adjusted for trade ally influence) is the trade ally attribution score, or the maximum possible decrease in the participant FR score due to program influence on trade ally recommendations. Calculations were performed by measure category.

$$\begin{aligned} &\textit{Trade ally attribution score} \\ &\qquad = \textit{Unadjusted participant FR score} \\ &\qquad - \textit{Participant FR score adjusted for trade ally influence} \end{aligned}$$

Determining the Influence of the Program on Participating Trade Allies

During this step, the evaluation team estimated the influence of the program on trade allies. Though the program attempts to get trade allies to recommend more energy efficiency equipment, a number of factors influenced contractor recommendations. The evaluation team used the results of trade ally interviews to determine the influence of the program on trade allies, and as a result, how much of the trade ally attribution score above the program can reasonably claim. In other words, during this step the evaluators determined the true rate of program influence on trade allies. The evaluators relied primarily on the following questions to determine program influence on trade allies:

Questions:

M4. Since your company became involved with the Con Edison Residential HVAC program, has any of the following changed? [IF NEEDED CLARIFY: BECOMING ACTIVE WITH THE PROGRAM MEANS STARTING TO INTERACT WITH PROGRAM

[32] This essentially means resetting the participant FR scores to 0.

[33] A score of 6 or 7 on a scale of 1 to 7, where 1 is not at all influential and 7 is very influential.

STAFF AND/OR WORK ON PROJECTS THAT APPLIED FOR CON EDISON'S INCENTIVES]

a. *Your knowledge of high efficiency options. [IF YES:] How influential was the program in this change on a scale of 1 to 7, where 1 means not at all influential and 7 means very influential? Why do you say that?*

b. *Your comfort level with discussing the benefits of high efficiency to your customers. [IF YES:] How influential was the program in this change on a scale of 1 to 7, where 1 means not at all influential and 7 means very influential? Why do you say that?*

c. *Your confidence level in recommending/selling high efficiency options. [IF YES:] How influential was the program in this change on a scale of 1 to 7, where 1 means not at all influential and 7 means very influential? Why do you say that?*

d. *The frequency with which you emphasize high efficiency options over less-efficient options when offering multiple equipment options. [IF YES:] How influential was the program in this change on a scale of 1 to 7, where 1 means not at all influential and 7 means very influential? Why do you say that?*

M5. *How, if at all, has the frequency with which you recommend high efficiency <CACs/Heat Pumps> changed since you became active with the program? [IF NEEDED, CLARIFY: BECOMING ACTIVE WITH THE PROGRAM MEANS STARTING TO INTERACT WITH PROGRAM STAFF AND/OR WORK ON PROJECTS THAT APPLIED FOR CON EDISON'S INCENTIVES] [PROBE FOR CHANGE IN PERCENTAGE CHANGE]*

If change noted:

a. *What are you doing more of – presenting only high efficiency options to customers instead of presenting both high- and less-efficient, or adding a high efficiency option to less-efficient option in more sales situations?*

b. *How influential was Con Edison's Residential HVAC program in this change on a scale of 1 to 7, where 1 means not at all influential and 7 means very influential? [PROBE FOR SPECIFIC PROGRAM COMPONENTS: INCENTIVES, TRAINING, ETC.]*

c. *How influential are other factors not related to the program? [ASK TO PROVIDE A RATING OF INFLUENCE ON A 1–7 POINT SCALE] What are* *these other factors? [PROBE FOR TAX CREDITS/GOVERNMENT REBATES, GENERAL EE AWARENESS, CHANGE IN CODES OR STANDARDS.]*

For each of the questions above, the evaluation team developed percentage of influence (I) by converting trade ally responses from a 1-to-7 point scale to a value between 0 and 1 using linear transformation.[34] A score of 0 means no influence, while a score of 1 means maximum influence. The conversion formulas are shown in Table B-1.

Table B-1. Conversion of Program Influence Responses from Trade Ally Interviews

Question	Conversion Formula
M4a	Ia= (M4a-1)/6
M4b	Ib= (M4b-1)/6
M4c	Ic= (M4c-1)/6
M4d	Id= (M4d-1)/6
M5b	Ie= (M5a-1)/6

Because each of these questions is conditionally similar, the evaluation team averaged the scores from the questions above to arrive at the overall influence score.

I=AVERAGE(IA, IB, IC, ID, IE)

This overall influence score served **as the basis** for the adjustment. Trade ally interviews are qualitative and in-depth in nature, providing an opportunity to obtain rich additional qualitative information on trade ally interactions and experiences with the program and, as such, better understand and evaluate the program influence on trade ally stocking and selling practices. The evaluation team used this qualitative information to validate and adjust, if needed, the overall influence score beyond the averages shown above. Two experts at Opinion Dynamics analyzed trade ally responses, validated the influence score for each trade ally, and arrived at an agreement on the final influence score (I). Along with the responses to the questions M4 and M5, the evaluation team relied on trade ally responses to other questions to support the program influence scores and adjust them, if needed. This included questions about trade ally knowledge of the program, frequency of their interactions with the program, their process of recommending heating and cooling equipment, etc.

[34] We do not have any reason to believe that linear transformations would yield results that are less reliable or valid than if we were to use non-linear transformations of the scale responses. The linear transformation approach also seems intuitive given the use of the scalars. We therefore selected to use it in our calculations.

The evaluation team developed influence scores as described above for each trade ally. The overall trade ally influence score is a weighted average of individual trade ally scores by known evaluated savings that each trade ally contributed to the program.

Determining the Free Ridership adjustment Score and the Final Free Ridership Score

To determine the trade ally FR adjustment score, the evaluation team scaled the trade ally influence scores to reflect a portion of the trade ally attribution score. To do that, the evaluation team multiplied the ***Program Trade Ally Influence Score*** by the ***Trade Ally Attribution*** score. The resulting product represents the percentage reduction to the participant FR score due to program influences on trade allies invisible to participants.

$$FR\ adjustment\ score = Program\ trade\ ally\ influence \times Trade\ ally\ attribution\ score$$

The final FR score is calculated by subtracting the trade ally FR adjustment score from the unadjusted participant FR score.

$$Final\ FR = Unadjusted\ FR - FR\ adjustment\ score$$

FR was estimated separately for CACs and DHPs. The evaluation team also estimated FR for a limited number of air sealing projects.[35] When calculating final measure-level FR scores, the evaluation team weighted individual scores by the evaluated savings associated with a given measure. Due to the small sample size, the air sealing results were not reported separately, but the air sealing FR estimates were integrated to arrive at the program-level FR rate. To develop the program level FR estimate, measure-level FR estimates were weighted by the contribution of the measure category savings to the overall evaluated program savings.

Independent Free-Ridership Estimation through Trade Ally Research

To supplement the approach described above, the interviews with trade allies allowed us to calculate an independent estimate of FR. Exploring trade ally installations of CAC systems and DHPs and asking them to estimate the percentage of installations that would have happened absent the program allows the evaluation team to calculate FR. Individual trade ally results were weighted by the evaluated energy savings.

[35] Note that for the air sealing measures we did not supplement participant self-report with trade ally research.

<u>Questions:</u>

PI1. *What is the approximate number of <CACs/Heat Pumps> installations that that your company performed in <Con Edison's service territory/downstate New York> between 2009 and 2011?*

PI2. *Now, if you were to divide all of your company's installations of the <Reference quantity from PI1> <CACs/Heat Pump> systems between 2009 and 2011 across the following SEER levels, what percent of the installations were..?*
[PROBE IF NEEDED: YOUR BEST ESTIMATE IS FINE]
[NOTE TO INTERVIEWER: PLEASE DO NOT INCLUDE DUCTLESS MINI SPLIT SYSTEMS. I WILL ASK YOU ABOUT THOSE SHORTLY.]
[MAKE SURE THAT RESULTS SUM UP TO 100%]

- *a.* *Lower than SEER 15*
- *b.* *SEER 15 and less than SEER 16*
- *c.* *SEER 16 and higher*

PI3. *What percent of the <CACs/Heat Pumps> systems with SEER 15 and higher received incentives through the program?*

PI4a. *Has Con Edison's program helped with <CACs/Heat Pump> system installations that your company performed between 2009 and 2011? [IF YES], How?*

PI5. *If Con Edison's Residential HVAC program incentives, marketing, and support had not existed, would your company have made fewer, more, or the same number of SEER 15 or greater <CACs/Heat Pump> system installations between 2009 and 2011?*

- *a.* *[IF FEWER] In percentage terms, how many fewer SEER 15 or greater <CACs/Heat Pump> systems do you think your company would have installed within the same time period if it hadn't been for the program? Why do you say that? [PROBE IF NEEDED: YOUR BEST ESTIMATE IS FINE]*

PI6. *If Con Edison's Residential HVAC program incentives, marketing, and support had not existed, what percent of the PROGRAM REBATED <CACs/Heat Pump> systems do you think you would still have installed? Why do you say that? [PROBE FOR THE INFLUENCE OF PROGRAM RELATED FACTORS, SUCH AS INCENTIVES, AND NON-PROGRAM RELATED FACTORS, SUCH AS TAX CREDITS, DISTRIBUTOR STOCKING PRACTICES, CUSTOMER DEMAND, ETC.]*

This alternative estimate of FR gave the evaluation team another vantage point to compare and validate the participant survey results.

Spillover

SO represents additional savings (expressed as a percent of total program savings) that were achieved without program rebates but would not have happened in the absence of the program.

Participant Spillover

While the program has not had a big marketing component that would promote energy efficiency in general or the installation of other measures aside from the ones rebated through the program, past experience suggests that for some, the experience of using one type of energy efficiency equipment can lead to them look for other ways they can make their homes more energy efficient. If program-induced, those additional improvements can result in the SO savings that the program could claim. As such, as part of the participant survey the evaluation team determined presence of and estimated participant SO.

While participant SO can result from a variety of measures, survey length did not allow for estimation of SO across all possible scenarios. In order not to overburden participants, the survey could only ask about a limited number of actions that might be taken outside the program. The evaluation team included measures that could reasonably be expected to be influenced by program participation and are more likely to have been implemented without program support. Participant SO was measured for the following equipment:

- ❑ Attic insulation
- ❑ ENERGY STAR clothes washers
- ❑ ENERGY STAR refrigerators

Participants were if they made any of the above-listed improvements. Those who did were asked if the CECONY program was of any influence and the degree of influence. Respondents were also asked to explain in their own words exactly how the program influenced their decision to make specific additional improvements. During the analysis, this allowed the evaluation team to screen out nonqualifying respondents. For respondents who passed all of these tests, the evaluation team verified the installations on-site for those who agree to the metering portion of the study.

Questions:

SO1. *SINCE your participation in the Con Edison program, have you made any of the following improvements for which you did NOT receive a rebate from Con Edison? Have you..?*

a. Insulated your home

c. Purchased an ENERGY STAR refrigerator

d. Purchased an ENERGY STAR clothes washer

[IF YES TO ANY]

SO2. Did your experience with the Con Edison program encourage you IN ANY WAY to make the improvement(s)?

SO3. Using a scale of 1 to 7, where 1 is no influence and 7 is a great deal of influence, how much influence did your experience with the Con Edison program have on your decision to…?

a. Insulate your home

c. Purchase an ENERGY STAR refrigerator

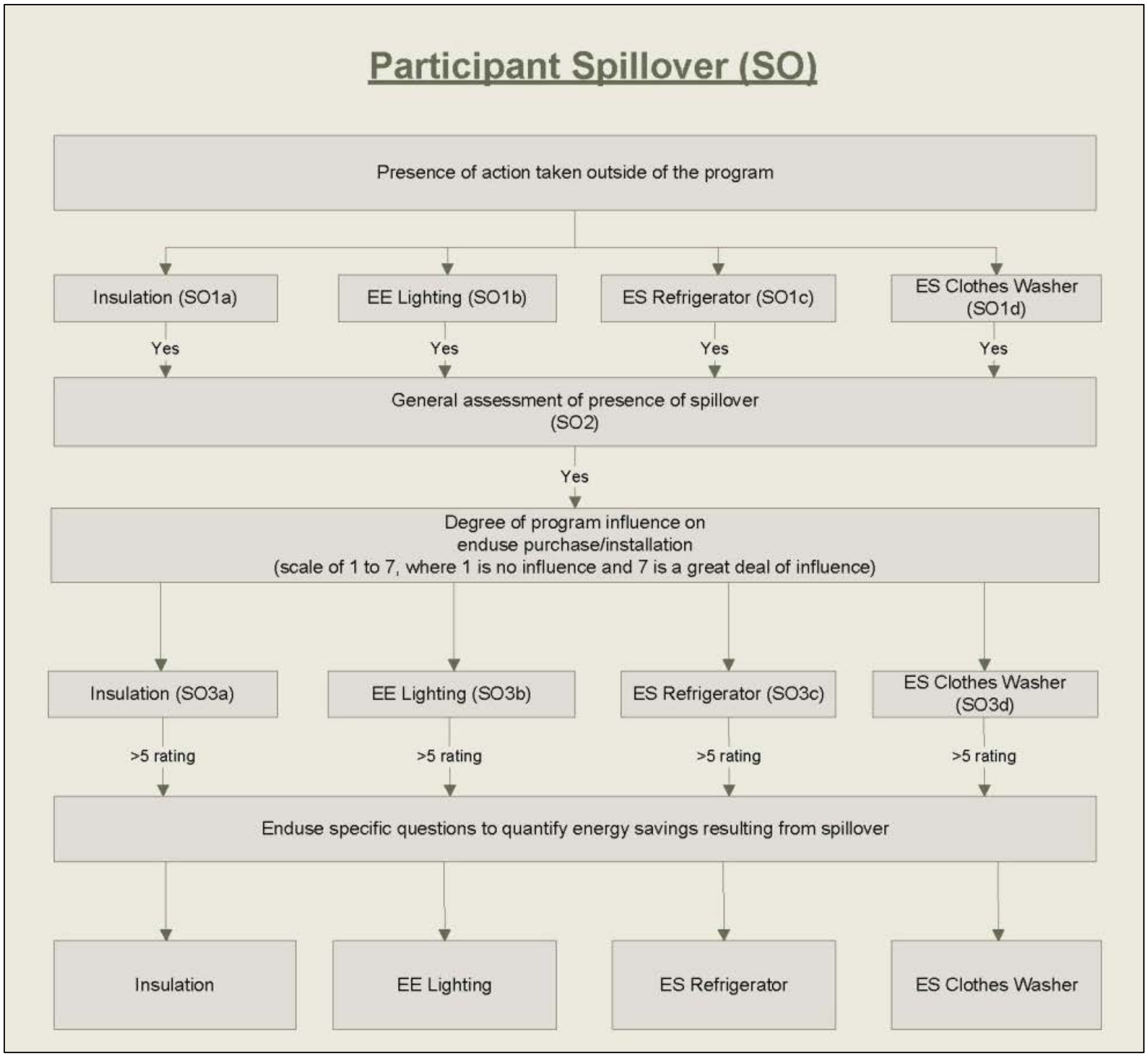
d. Purchase an ENERGY STAR clothes washer

SO4a/ /SO6a/SO7a. Can you explain how your experience with the Con Edison program influenced your decision to purchase a(n) <MEASURE> for your home?

If any energy efficient improvements were heavily influenced by the program[36], participants were asked a few equipment-specific questions that allowed for the calculation of savings associated with the installed equipment. The equipment details explored as part of the survey effort were limited by the survey length as well as by questions with reliable responses. Figure B-4 provides a graphical depiction of the participant SO approach.

[36] A rating of 6 or 7 on a scale of 1 to 7 where 1 is no influence and 7 is a great deal of influence.

Figure B-4
Participant Spillover Approach



Nonparticipant Spillover

The evaluation team investigated presence of nonparticipant spillover (NPSO) in the market through trade ally interviews. The evaluation team asked trade allies to estimate a percent of high efficiency systems that were installed during the course of 2009 and 2011 that did not receive incentives through the program and what that percentage would have looked like absent the program. The evaluation team also asked trade allies to provide an insight into how, if at all, CECONY Residential Electric HVAC program influences decisions made by HVAC manufacturers and distributors regarding their manufacturing, stocking, and distribution practices.

Questions:

[ASK IF PI3<100%]

PI7. Now thinking about the SEER 15 or greater <CACs/Heat Pump> systems that DID NOT receive incentives through the program, if the Con Edison's Residential HVAC program incentives, marketing, and support had not existed, what percent of those <CACs/Heat Pump> systems do you think you would still have installed? Why do you say that? [IF UNSURE, PROBE FOR BEST ESTIMATE]

PI8. Do you think Con Edison Residential HVAC program (and available rebates) influences decisions made by HVAC manufacturers about what equipment to carry? Why do you say that?

PI9. What about distributors, do you think that Con Edison Residential HVAC program influences their stocking and distribution practices? Why do you say that?

Additional Look at Free-Ridership Results

Using the participant FR algorithm described in Appendix B of this document, the evaluation team developed the FR estimates presented in Table B-2. These are participant reported FR rates unadjusted for any program influences that are not visible to participants.

As can be seen in the table, FR estimates are similar by measure category – 52 % for CAC systems and 50% for DHP systems.

Table B-2
Unadjusted Participant FR Rate

	CAC	DHP	Total Program*
Free ridership rate (FR)	0.52	0.50	0.52
Sample size	116	79	200
Population size	2,650	750	3,400
Variance	0.001	0.001	0.001
Standard error	0.031	0.038	0.02
T-value	1.645	1.645	1.645
Relative precision at 90% confidence	0.10	0.13	0.08
Confidence interval	0.05	0.06	0.04

*Please note that the measure-level FR scores are savings-weighted.

The evaluation team understands that Con Edison's Residential Electric HVAC program used various strategies to influence the way trade allies recommend HVAC equipment to customers. This included marketing and outreach, trade ally training, etc. An assessment of FR that relies just on participant research therefore does not credit the program for influences not visible to customers, primarily outreach to trade allies. The need to supplement participant research with trade ally perspectives is further corroborated by the fact that all trade allies interviewed stated that customers typically install what the contractor recommends as opposed to working with the contractor to make a decision or selecting the equipment on their own without the contractor's assistance. Over half of CAC participants (56%) and close to half of DHP participants (42%) report that their decision to install high efficiency equipment was heavily influenced by their trade ally.[37] Another quarter of participants report being moderately influenced by their trade ally (22% for CAC participants and 24% for DHP participants).

Therefore, the evaluation team utilized information from trade allies to supplement participant research and derive the final FR and NTG estimates. The evaluation team used the participant FR scores described above as the basis of the FR score and adjusted it downward to account for program influence on trade allies that might not necessarily be visible to participants.

Participants were asked to rate the influence of the trade ally recommendations on their decision to install high efficiency equipment.[38] FR scores of participants who were heavily influenced by trade ally recommendations were set to zero, giving the program full credit for the project. The evaluation team then recalculated FR score using these adjusted values. This newly calculated FR score (participant FR score adjusted for trade ally influence) effectively represents the maximum possible attribution that the program can claim and assumes that every trade ally was heavily influenced by the program in how they approach the recommendations and sales of the HVAC equipment. The differential between the two scores (i.e., the unadjusted participant FR score and the participant FR score adjusted for trade ally influence) is the trade ally attribution score, or the maximum possible decrease in the participant FR score due to program influence on trade ally recommendations. Calculations were performed by measure category. Table B-3 presents the results of the analysis. Trade ally attribution score is 25% for DHPs and 23% for CAC systems.

[37] A rating of 6 or 7 on a scale of 1 to 7, where 1 is not at all influential and 7 is very influential.

[38] Participants were asked to provide a rating on a scale of 1 to 7, where 1 is not at all influential and 7 is very influential.

Table B-3
Trade Ally Attribution Scores

Stratum	Unadjusted Participant FR	Participant FR Score Adjusted for Trade Ally Influence	Trade Ally Attribution Score	Standard Error - Trade Ally Attribution Score	Trade Ally Attribution Score Relative Precision (at 90% Confidence)
CAC	0.52	0.27	0.25	0.03	0.19
DHP	0.50	0.27	0.23	0.04	0.28

*Please note that the measure-level FR scores are savings-weighted.

Though the program encourages trade allies to recommend more energy efficiency equipment, a number of factors influence trade ally recommendations. Therefore, only a portion of the trade ally attribution scores of 25% and 23% for CACs and DHPs, respectively, would be due to the program influence on trade ally recommendations. The evaluation team used the results of the trade ally interviews to determine the percentage of the trade ally attribution score the program actually deserves (program trade ally influence score).

As part of the trade ally interviews, the evaluation team asked trade allies questions about how their approach to recommending and selling HVAC equipment may have changed because of the program. The evaluation team explored program influence on their knowledge around high efficiency HVAC equipment, comfort level with discussing and promoting the benefits of high efficiency equipment, confidence level in recommending/selling high efficiency equipment, frequency with which trade allies emphasize high efficiency equipment, and frequency of recommending high efficiency equipment. Along with the influence of the program on the above-mentioned areas, the evaluation team also explored the influence of other factors, not related to the program, such as tax credits, general awareness of energy efficiency, company practices, etc. The evaluation team also explored trade ally interactions with and knowledge of the program. (See Appendix F for the full trade ally discussion guide).

Overall, we found limited program influence on trade ally sales and recommendations – 14% for DHPs and 17% for CACs. Error bounds around those two estimates are high (68% and 90% relative precision for CACs and DHPs respectively), as expected given small sample sizes and variance in responses. It should be noted that because of the limited program influence on trade allies, the contribution of these error bounds to the overall uncertainty around the FR estimates is negligible. The program influence on trade allies is shown in Table B-4.

Table B-4.
Program Trade Ally Influence Scores

Stratum	Program Trade Ally Influence Score	Standard Error	Relative Precision (At 90% confidence)	Trade Ally Sample Size
CAC	0.17	0.07	0.68	14
DHP	0.14	0.08	0.90	7

*Note that the program trade ally influence scores are savings-weighted.

To determine the trade ally FR adjustment score, the evaluation team scaled the trade ally influence scores to reflect a portion of the trade ally attribution score. To do that, the evaluation team multiplied the program trade ally influence score by the trade ally attribution score. The resulting product represents the percentage reduction to the participant FR score due to program influences on trade allies that is invisible to participants. The final FR score is calculated by subtracting the trade ally FR adjustment score from the unadjusted participant FR score. Table B-2 above presents the results of the analysis, as well as the final FR scores. As can be seen in the table, trade ally research resulted in only a slight downward adjustment of the participant-derived FR rates. Overall FR for the program is 48% and is consistent across measure categories. These details are shown in Table B-5.

Table B-5
Final FR Estimates

Stratum	Unadjusted Participant FR**	Trade Ally Attribution Score**	Program Trade Ally Influence Score	Trade Ally FR Adjustment Score	Final FR*	Final FR Standard Error	Final FR Relative Precision (At 90% confidence)
CAC	0.52	0.25	0.17	0.04	0.48	0.04	0.12
DHP	0.50	0.23	0.14	0.03	0.47	0.04	0.15
Total	**0.48**				**0.48**	**0.03**	**0.09**

*The final FR estimate includes an estimate for the air sealing improvements. The contribution of the air sealing measure to the final FR is negligible and is based on a small number of participant interviews (five completed interviews out of the population of 47 participants).

**Please note that the measure-level FR scores and program trade ally influence scores are savings-weighted.

APPENDIX C – MEMO TO DPS REGARDING DHP BASELINE

To: Steve Mysholowsky and Rosanna Jimenez, Con Edison

From: Justin Spencer and Steve Hastie, Navigant

CC: Lucy Neiman and Jon Maxwell, ERS

Date: March 27, 2013

Re: Proposed Baseline for DHP

Background/Objective: To estimate savings from DHPs installed through Con Edison's Residential HVAC program, it is necessarily to determine a general baseline representing what the customer would have done in the absence of the program. DHPs are a relatively new entrant to the residential HVAC market. Con Edison's Residential Electric HVAC program incented high efficiency equipment, including DHPs, and saw significant numbers of DHPs installed. These units are typically installed as retrofits in older homes where there is no room for ducts, or as small increments to existing systems, e.g., to serve an addition, or improve comfort in one part of the house. Most DHPs sold utilize variable speed compressors, which allows them to get extremely high efficiencies. However, there are also inexpensive, single speed DHPs available with code-minimum efficiency. Customer rationale for installing DHPs varies. Possibilities include:

- They desire to have a central cooling amenity (including comfort, sound, and aesthetics), but they have no place to put ducts for a traditional system.
- They have electric resistance heat, do not have gas available as a heating fuel in their location, and are looking to save energy/money by installing a higher efficiency electricity-based heating system.
- They have room air conditioners and are looking to save energy/money by installing a higher efficiency cooling system.
- They desire greater comfort and are looking to add a zoned system for heating and cooling.

Proposed Baseline: Navigant believes that the simplest solution is likely the best solution in this case: **Use a code-minimum DHP as the baseline.**

Rationale:

1. Our belief is that DHPs offer significant non-energy benefits over the room AC alternative.
   a. Quiet.
   b. No need to remove seasonally.
   c. Aesthetics.

   d. Large area, multi-room cooling and comfort. With a sufficient number and placement of ductless units, an effect similar to that of central air conditioning can be achieved.

2. Further, we believe that participants in the Con Edison program make the decision to buy a DHP first, primarily on the basis of the non-energy benefits, such as those noted above, and then decide which efficiency level to purchase.

3. The Con Edison program was not marketed as a DHP program, but rather as promoting high efficiency CAC and heat pump equipment in general.

4. As a result, the program was unlikely to incent people into a retrofit purchase decision by itself, but did offer incentives to purchase equipment that met the program requirements.

5. The lowest-cost option offering similar amenities to a variable speed DHP is a code-minimum single speed DHP.

6. We assume that the proper baseline here is then the lowest-cost option offering the same amenities, which is a SEER 13 single speed DHP.

APPENDIX D – DOUBLE-RATIO ESTIMATION

In ratio estimation, instead of measuring the mean of an uncertain variable, the evaluator measures the ratio between the measured values and some prior estimate of the values on a site-specific basis. Ratio estimation is used widely in evaluation of custom projects, but it may be applied to many other sampling problems where there is some prior estimate of savings available. The use of the double-ratio estimation technique depends on there being a lower-cost way of collecting data that is indicative of the final results but is not accurate enough to use on its own. By nesting more rigorous on-site measurements inside a large sample of lower rigor data collection, such as billing data or phone survey results, a rigorous result can be achieved with fewer resources.

Double-ratio estimation is especially effective when large outliers (sites with realization rates much higher or much lower than one) may be the primary drivers of the overall results, provided the first stage can effectively find these large outliers. The large sample in the first stage effectively measures the frequency of the large outliers, while the second stage acts to calibrate the results of the first stage to a more accurate set of results for a subsample, while using a much smaller sample than would be required if only the second-stage data collection techniques were being used. Evaluators facing highly rigorous evaluation requirements should incorporate double-ratio estimation more often, in order to maximize value and rigor and reduce risk of not meeting confidence and precision targets. For example, in custom programs, the ultimate confidence and precision are highly dependent on the quality of the ex ante estimates, which can vary widely from project to project and even year to year, as program participation changes. There is always a risk that the actual CV will be significantly higher than was assumed.

A useful metaphor for double-ratio estimation is the process used for extracting gold from river sediments. Prospectors are trying to separate gold from a bunch of gravel and have multiple methods available to them. Some methods are cheaper but offer lower accuracy – there will be other objects of similar density extracted with the gold. Panning is the most accurate method, in that the gold can be extracted in a pure form, but the process is labor-intensive. What modern prospectors do is to combine a first stage of sluicing with a second stage of panning. In the first stage, huge volumes of river sediment are pumped through a sluice, which separates everything that has a similar density to gold from the other contents. This process is very efficient at sorting through high volumes, but the results are not pure gold. In the second stage, the extracted high-density materials are panned to separate the gold from the other high-density material. The result is pure gold. In double-ratio estimation for evaluation, the first stage of information extraction is to perform a set of file reviews or phone verifications, which can be performed inexpensively on a large sample. This is equivalent to sluicing the river sediments to get high-density material. In the second stage, a more accurate method (like on-site metering) is performed on a nested subsample of sites. This is equivalent to the panning method, where the results are pure gold.

Calculating Realization Rates with Double-Ratio Estimation

In a double-ratio estimation, there are three sets of numbers being compared:

1. *xjh* is defined as the tracking data estimate for a given sample point *j* in stratum *h*
2. *yjh* is defined as the first stage (phone or file review) estimate of savings for a given sample point *j* in stratum *h*
3. *zjh* is defined as the second stage (on-site metering or verification) estimate of savings for a given sample point *j* in stratum *h*

A double-ratio estimation calculates two ratios, between the first stage and tracking and between the second stage and first stage. In some cases, it may be preferable to calculate statistics on the mean in the first stage, rather than use a ratio. The same general double-sampling method applies, except for the use of standard statistics on the first stage. The first-stage realization rate for the sample point, measuring the realization rate between the tracking and phone/file review estimate, RR_{jh1} is then calculated:

$$RR_{jh1} = \frac{y_{jh}}{x_{jh}}$$

The second-stage realization rate for the sample point, measuring the realization rate between the phone/file review estimate and the on-site metering/verification estimate, RR_{ih2} is then calculated:

$$RR_{jh2} = \frac{z_{jh}}{y_{jh}}$$

The overall sample point realization rate RR_{jh} is then calculated as the product of the two stages:

$$RR_{jh} = RR_{jh1} \times RR_{jh2}$$

The stratum first-stage sample realization rate of stratum *h* is the sum of all phone/file-verified ex post savings in the sample of stratum h divided by the sum of all tracked ex ante savings in the sample (*n* = *j*) of stratum *h*, given by:

$$RR_{h1} = \frac{\sum_1^j y_{jh}}{\sum_1^j x_{jh}}$$

In the second stage, only a subsample of the sites in the first stage sample are used.[1] The stratum second-stage sample realization rate of stratum h is the sum of all the on-site-verified ex post savings in the on-site subsample of stratum h divided by the sum of all the phone/file-verified ex post savings in the on-site subsample ($n = i$) of stratum h, given by:

$$RR_{h2} = \frac{\sum_1^i z_{ih}}{\sum_1^i y_{ih}}$$

The overall stratum realization rate, RRh, is then calculated as the product of first- and second-stage realization rates:

$$RR_h = RR_{h1} \times RR_{h2}$$

The verified total savings estimate for stratum h is the sum of all tracked ex ante estimates in stratum h multiplied by the stratum realization rate, given by:

$$TS_h = RR_h \times \sum x_{kh}$$

The verified total savings for the program is the sum of the total savings in the individual strata:

$$TS_p = \sum TS_h$$

The overall realization rate for the program is then calculated by dividing the total verified savings by the total tracked savings:

$$RR_p = \frac{TS_p}{TS'_p}$$

Calculating Confidence and Precision with Double-Ratio Estimation

In ratio estimation, an estimate for each member of stratum h can be made by multiplying the sample stratum realization rate by the prior estimate. A residual error can then be calculated for each sample point in stratum h by taking the difference between the ratio estimate and verified ex post savings for the point. In double-ratio estimation, the first-stage error at each sample point is calculated by taking the difference between the first-stage verified savings and the first-stage realization rate times the tracked value:

$$e_{1jh} = y_{jh} - RR_{h1} \times x_{jh}$$

[1] There are k members of the population, j members out of k in the first-stage phone/file review sample, and i members out of j in the second-stage on-site sample.

The sample variance of the first-stage verified total savings in stratum h is derived from the stratum first-stage residuals:

$$V_{h1} = \frac{1}{n_{h1} - 1} \sum_{1}^{j} e_{1jh}^{2}$$

The first-stage finite population correction factor for stratum h, FPC_{h1}, is calculated using Nh, the stratum population and n_{h1}, the first-stage sample size:

$$FPC_{h1} = \sqrt{\frac{N_h - n_{h1}}{N_h - 1}}$$

The first-stage standard error for stratum h, SE_{h1}, is calculated using:

$$SE_{h1} = FPC_{h1} \times \frac{\sqrt{V_{h1}}}{\sqrt{n_{h1}}} \times N_h$$

The first stage relative precision for stratum h, RP_{h1}, is then calculated using the first-stage total savings, TS_{h1}, standard error, $\mathrm{SE}_{\mathrm{h1}}$, and t-value, t_1, based on the first stage sample size, n_{h1}:

$$RP_{h1} = t_1 \times \frac{SE_{h1}}{TS_h} \times 100\%$$

In the case where the first stage estimates a mean value, rather than a ratio, the statistics calculation for the first stage is exactly the same as above, except that the individual error terms are calculated using:

$$e_{1ih} = y_{ih} - \frac{\sum_{i}^{n_{h1}} y_{ih}}{n_{h1}}$$

The second-stage error at each sample point is calculated by taking the difference between the second-stage verified savings and first-stage verified savings:

$$e_{2ih} = z_{ih} - RR_{h2} \times y_{ih}$$

The sample variance of the second-stage verified total savings in stratum h is derived from the stratum second-stage residuals:

$$V_{h2} = \frac{1}{n_{h2} - 1} \sum_{1}^{i} e_{2ih}^{2}$$

The second-stage finite population correction factor for stratum h, FPC_{h2}, is calculated using N_h, the stratum population and n_{h1}, the first-stage sample size:

$$FPC_{h2} = \sqrt{\frac{N_h - n_{h2}}{N_h - 1}}$$

The second-stage standard error for stratum h, SE_{h2}, is calculated using:

$$SE_{h2} = FPC_{h2} \times \frac{\sqrt{V_{h2}}}{\sqrt{n_{h2}}} \times N_h$$

The second-stage relative precision for stratum h, RP_{h2}, is then calculated using the second-stage total savings, TS_{h2}, standard error, SE_{h2}, and t-value, t_2, based on the second-stage sample size, n_{h2}:

$$RP_{h2} = t_2 \times \frac{SE_{h2}}{TS_h} \times 100\%$$

The overall relative precision for stratum h, RP_{ht}, is then calculated as the square root of the sum of the squares of the relative precisions for the two stages:

$$RP_{ht} = \sqrt{{RP_{h1}}^2 + {RP_{h2}}^2}$$

The total standard error for stratum h, SE_{ht}, is then calculated using the first-stage t-value, t_1, and the stratum total savings, TSh:

$$SE_{ht} = \frac{RP_{ht} \times TS_h}{t_1}$$

The standard error on the total program, SEp is given by:

$$SE_p = \sqrt{\sum_h {SE_{ht}}^2}$$

The relative precision on the total program, RP_t, is calculated using the program total standard error, savings, and t-value, based on the total sample size across all strata:

$$RP_t = t \times \frac{SE_p}{TS_p} \times 100\%$$

References:

- Wright, R.L., et al., "Double Ratio Estimation: A New Tool for Cost-Effective Monitoring," 1994 ACEEE Summer Study on Building Energy Efficiency, 1994.
- Lohr, S. L., *Sampling: Design and Analysis, 2nd Edition*, 2010.

Appendix E – Residential HVAC and Room AC Program Participant Phone Survey

Sample Variables
1. Measure Flags
<ROOMAC>
<CENTRALAC>
<HEAT_PUMP>
<ECM_FAN>
<AIR_SEALING>
<DUCT_SEALING>
<WATER_HEATER>
<THERMOSTAT>

2. Measure Quantities
<ROOMAC_QTY>
<CENTRALAC_QTY>
<HEATPUMP_QTY>
<ECMFAN_QTY>
<WATERHEATER_QTY>
<THERMOSTAT_QTY>

3. <INCENTIVE> (Incentive Amount for Main Measure)

4. <PROGRAM> (Residential Room Air Conditioner Program or Residential HVAC Program)

INTRODUCTION
Hi, May I please speak with <NAME FROM DATABASE>

My name is ____ and I'm calling from Opinion Dynamics, an independent research company, on behalf of Con Edison. We're speaking with Con Edison customers who have participated in the <PROGRAM>, which gives rebates to customers who install high efficiency air conditioning or heating equipment.

I would like to ask you some questions about your experience with the <PROGRAM>, as this information will help Con Edison understand how the program may be improved. The questions that I have will only take about 15 minutes and your responses will be kept strictly confidential.

Are you the person who is most knowledgeable about your participation in the Con Edison program?

1. Yes [CONTINUE WITH DECISION MAKER]
2. No [ASK TO SPEAK WITH THE DECISION MAKER]

C1. Are you currently talking to me on a regular landline phone or a cell phone?
1. Regular landline phone
2. Cell Phone
8. (Don't know)
9. (Refused)

[ASK IF C1 = 2; ELSE GO TO SURVEY START]

C2. Are you currently in a place where you can talk safely and answer my questions?
1. Yes
2. No [SCHEDULE CALL BACK]
3. No [DO NOT CALL BACK]
8. (Don't know) [SCHEDULE CALL BACK]
9. (Refused) [SCHEDULE CALL BACK]

[ASK IF ROOMAC=1]

EQUIPMENT VERIFICATION – ROOM AC

EV1. Our records show that you received a rebate from Con Edison for purchasing <ROOMAC_QTY> room air conditioner(s) in 2011. Is this correct?
1. Yes
2. (Yes – but different number)
3. No, did not
8. (Don't know)
9. (Refused)

[SKIP IF EV1 <> 2]

EV1a. How many units did you purchase and received a rebate for? [NUMERIC OPEN END]

[CALCULATE ROOMAC_QTY_VERIFIED USING EV1 & EV1A]

[ASK IF ROOMAC_QTY_VERIFIED=1]

EV1b. Did you purchase this room air conditioner to use in your home or in someone else's home?
1. My home
2. Someone else's home
8. (Don't know)
9. (Refused)

[ASK IF ROOMAC_QTY_VERIFIED>1]

EV1c. Did you purchase these room air conditioners to use them both in your home, to use just one of them in your home and use the other in someone else's home, or to use both of them in someone else's home?

1. Both in my home
2. One in my home and one in someone else's home
3. Both in someone else's home
8. (Don't know)
9. (Refused)

[ASK IF EV1B=2 OR EV1C=2 OR 3]

EV1d. Does Con Edison provide electricity to the home where you plan to use [IF EV1B=2 "THE AIR CONDITIONER", IF EV1C=2, "ONE OF THE AIR CONDITIONERS", IF EV1C=3, "THE AIR CONDITIONERS"] for which you received a rebate from Con Edison?

1. Yes
2. No
8. (Don't know)
9. (Refused)

[ASK IF CENTRALAC=1]

EQUIPMENT VERIFICATION – CAC

EV2. Our records show that you received a rebate from Con Edison for installing <CENTRALAC_QTY> CAC unit(s) in your home during 2011. Is this correct?

1. Yes
2. (Yes – but different number)
3. No, did not
8. (Don't know)
9. (Refused)

[SKIP IF EV2 <> 2]

EV2a. How many units did you install? [NUMERIC OPEN END]

[CALCULATE CENTRALAC_QTY_VERIFIED USING EV2 & EV2A]

[ASK IF AIR_SEALING =1]

EQUIPMENT VERIFICATION – AIR SEALING

EV3. Our records show that you received a rebate from Con Edison for having air sealing done in your home during 2011. Is this correct? [READ IF NEEDED: THIS IS THE PROCESS OF IDENTIFYING AND FILLING HOLES IN THE FLOORS, WALLS AND CEILINGS OF A HOME TO PREVENT WARM AIR LEAKAGE]

1. Yes
2. No, did not
8. (Don't know)
9. (Refused)

[ASK IF DUCT_SEALING =1]

EQUIPMENT VERIFICATION – DUCT SEALING

EV4. Our records show that you received a rebate from Con Edison for having your air ducts sealed during 2011. Is this correct? [READ IF NEEDED: THIS IS THE PROCESS OF IDENTIFYING AND ELIMINATING AIR LEAKS IN THE HOME'S DUCT SYSTEM]

1. Yes
2. No, did not
8. (Don't know)
9. (Refused)

[ASK IF HEAT_PUMP =1]

EQUIPMENT VERIFICATION – HEAT PUMP

EV5. Our records show that you received a rebate from Con Edison for installing <HEATPUMP_QTY> heat pump(s) in your home during 2011. Is this correct?

1. Yes
2. (Yes – but different number)
3. No, did not
8. (Don't know)
9. (Refused)

[SKIP IF EV5 <> 2]

EV5a. How many units did you install? [NUMERIC OPEN END]

[CALCULATE HEATPUMP_QTY_VERIFIED USING EV5 & EV5A]

[ASK IF WATERHEATER =1]

EQUIPMENT VERIFICATION – WATER HEATER

EV6. Our records show that you received a rebate from Con Edison for installing <WATERHEATER_QTY> water heater(s) in your home during 2011. Is this correct?

1. Yes
2. (Yes – but different number)
3. No, did not
8. (Don't know)
9. (Refused)

[SKIP IF EV6 <> 2]

EV6a. How many units did you install? [NUMERIC OPEN END]

[CALCULATE WATERHEATER_QTY_VERIFIED USING EV6 & EV6A]

[ASK IF THERMOSTAT=1]
EQUIPMENT VERIFICATION – PROGRAMMABLE THERMOSTAT
EV7. Our records show that you received a rebate from Con Edison for purchasing <THERMOSTAT_QTY> programmable thermostats in your home during 2011. Is this correct?
1. Yes
2. (Yes – but different number)
3. No, did not
8. (Don't know)
9. (Refused)

[SKIP IF EV7 <> 2]
EV7a. How many units did you install? [NUMERIC OPEN END]

[CALCULATE THERMOSTAT_QTY_VERIFIED USING EV7 & EV7A]

[ASK IF ECM_FAN=1]
EQUIPMENT VERIFICATION – ECM FANS

EV8. Our records show that you received a rebate from Con Edison for installing <ECMFAN_QTY> ECM fan(s) during 2011. Is this correct?
1. Yes
2. (Yes – but different number)
3. No, did not
8. (Don't know)
9. (Refused)

[SKIP IF EV8 <> 2]
EV8a. How many units did you install? [NUMERIC OPEN END]

[CALCULATE ECM_FAN_QTY_VERIFIED USING EV8 & EV8A]

[THANK AND TERMINATE IF ALL EV1-EV8=3,8,9,SYSMIS OR EV1B=2,8,9. OR EV1C=3,8,9]

PROGRAM MARKETING AND INTERACTIONS

Q1. How did you first learn about the Con Edison's <PROGRAM>?
- 01. (Contractor)
- 02. (Con Edison mailing/letter)
- 03. (Bill insert)
- 04. (Con Edison website)
- 05. (Family/friends/word of mouth)
- 06. (Retailer/Store)
- 00. (Other, please specify)
- 98. (Don't know)
- 99. (Refused)

[ASK Q2a IF Q1 <> 1 AND (CENTRALAC_QTY_VERIFIED>0 OR HEATPUMP_QTY_VERIFIED>0)]

Q2a. Did your contractor talk to you about the Con Edison's Residential HVAC program and available rebates?
- 1. Yes
- 2. No
- 8. (Don't know)
- 9. (Refused)

Q2b. Did you receive any materials from Con Edison about the benefits of [IF ROOMAC_QTY_VERIFIED>0, READ "ENERGY STAR ROOM AIR CONDITIONERS"; IF CENTRALAC_QTY_VERIFIED>0, READ "ENERGY EFFICIENT COOLING EQUIPMENT"; IF HEATPUMP_QTY_VERIFIED>0, READ "ENERGY EFFICIENT HEATING AND COOLING EQUIPMENT "] or available rebates?
- 1. Yes
- 2. No
- 8. (Don't know)
- 9. (Refused)

Q2c. Did you visit Con Edison's website to learn more about the benefits of [IF ROOMAC_QTY_VERIFIED>0, READ "ENERGY STAR ROOM AIR CONDITIONERS"; IF CENTRALAC_QTY_VERIFIED>0, READ "ENERGY EFFICIENT COOLING EQUIPMENT"; IF HEATPUMP_QTY_VERIFIED>0, READ "ENERGY EFFICIENT HEATING AND COOLING EQUIPMENT "] or available rebates?
- 1. Yes
- 2. No
- 8. (Don't know)
- 9. (Refused)

[ASK IF ROOMAC_QTY_VERIFIED>0, ELSE SKIP TO Q3]

Q2d. Where did you purchase your [IF ROOMAC_QTY_VERIFIED=1, "ROOM AIR CONDITIONER"; IF ROOMAC_QTY_VERIFIED>1, "ROOM AIR CONDITIONERS"]? Was it online, at a store, through a contractor or through another source?

01. Store
02. Online
03. Contractor
00. Other source – specify
98. (Don't know)
99. (Refused)

[ASK IF Q2D=1]

Q2h. When shopping to buy your [IF ROOMAC_QTY_VERIFIED=1, "ROOM AIR CONDITIONER"; IF ROOMAC_QTY_VERIFIED>1, "ROOM AIR CONDITIONERS"], did you see any signs, labels, or print materials from Con Edison about the benefits of ENERGY STAR room air conditioners or available rebates?

1. Yes
2. No
8. (Don't know)
9. (Refused)

[ASK Q3 IF CENTRALAC_QTY_VERIFIED>0 OR HEATPUMP_QTY_VERIFIED>0]

Q3. Did you receive a tax credit or rebate from the government for the [IF HEATPUMP_QTY_VERIFIED>0, "HEATING AND COOLING"; ELSE "COOLING"] equipment that you installed?

1. Yes
2. No
8. (Don't know)
9. (Refused)

[ASK IF ROOMAC_QTY_VERIFIED>0, ELSE SKIP TO NEXT SECTION]
FREE RIDERSHIP: ROOM AIR CONDITIONER

Next I have a few questions about the decision-making process that led you to purchase your new ENERGY STAR [IF ROOMAC_QTY_VERIFIED=1, "ROOM AIR CONDITIONER"; IF ROOMAC_QTY_VERIFIED>1, "ROOM AIR CONDITIONERS"]

As you may know, ENERGY STAR room air conditioners are air conditioners that have been certified as energy efficient and have an ENERGY STAR label as an indicator of high efficiency.

[ASK IF ROOMAC_QTY_VERIFIED=1]
A0a. Did your new room air conditioner replace an old air conditioner or was it not a replacement?
1. Replacement
2. Not a replacement
8. (Don't know)
9. (Refused)

[ASK IF ROOMAC_QTY_VERIFIED>1]
A0aa. Did both of your new room air conditioners replace old units, did neither of them replace old units, or did only one of them replace an old unit?
1. Both replaced old units
2. Only one replaced an old unit
3. Neither replaced old units
8. (Don't know)
9. (Refused)

[ASK IF A0A=1 OR A0AA=1 OR A0AA=2]
A0b. Why did you replace your old [IF A0AA=1 "ROOM AIR CONDITIONERS"; ELSE "ROOM AIR CONDITIONER"]? [DO NOT READ; MULTIPLE RESPONSE; ACCEPT UP TO 3]
01. (Old air conditioner(s) was/were broken)
02. (Old air conditioner(s) wasn't/were not performing well/wanted improved performance)
03. (Wanted a more energy efficient air conditioner(s)/wanted to save energy)
04. (Wanted a different size air conditioner(s))
00. (Other)
98. (Don't know)
99. (Refused)

A1a. When did you first learn that you could receive a rebate from Con Edison for purchasing [IF ROOMAC_QTY_VERIFIED=1, "A NEW HIGH EFFICIENCY ROOM AIR CONDITIONER"; IF ROOMAC_QTY_VERIFIED>1, "NEW HIGH EFFICIENCY ROOM AIR CONDITIONERS"]? Was it before or after you purchased the [IF ROOMAC_QTY_VERIFIED=1, "AIR CONDITIONER"; IF ROOMAC_QTY_VERIFIED>1, "AIR CONDITIONERS"]? [INTERVIEWER NOTE: IF LEARNED ABOUT THE REBATE WHILE SHOPPING AT THE STORE, RECORD RESPONSE AS #3]

1. Before
2. After
3. (While in the store shopping for air conditioner(s))
8. (Don't know)
9. (Refused)

[IF A1a <>2 SKIP TO A2A]

A1b. Just to be clear, did you buy your [IF ROOMAC_QTY_VERIFIED=1, "HIGH EFFICIENCY ROOM AIR CONDITIONER"; IF ROOMAC_QTY_VERIFIED>1, "HIGH EFFICIENCY ROOM AIR CONDITIONERS"] and then later learn that you could receive a rebate from Con Edison?

1. Yes [SKIP TO A4]
2. No
8. (Don't know)
9. (Refused)

A2a. Were you already planning to purchase [IF ROOMAC_QTY_VERIFIED=1, "A NEW AIR CONDITIONER"; IF ROOMAC_QTY_VERIFIED>1, "NEW AIR CONDITIONERS"] when you learned that you could receive a rebate from Con Edison?

1. Yes
2. No
8. (Don't know)
9. (Refused)

[ASK IF A2a=1]

A2b. Were you already planning to purchase [IF ROOMAC_QTY_VERIFIED=1, "A HIGH EFFICIENCY AIR CONDITIONER"; IF ROOMAC_QTY_VERIFIED>1, "HIGH EFFICIENCY AIR CONDITIONERS"] when you learned that you could receive a rebate from Con Edison?

1. Yes
2. No
8. (Don't know)
9. (Refused)

A3. Our records show that you received a rebate of $30 from Con Edison for [READ 'EACH' IF 'ROOMAC_QTY_VERIFIED>1; READ 'THE' IF 'ROOMAC_QTY_VERIFIED =1] room air conditioner you purchased. If the Con Edison rebate had not been available, would you have purchased [IF ROOMAC_QTY_VERIFIED=1,"ROOM AIR CONDITIONER"; IF ROOMAC_QTY_VERIFIED>1,"ROOM AIR CONDITIONERS"] at all?

1. Yes, would have purchased
2. No, would not have purchased [SKIP TO SO1]
3. (Maybe)
8. (Don't know)
9. (Refused)

A4. Using a scale of 1 to 7, where 1 means no influence and 7 means a great deal of influence, please rate the influence of the following on your decision to purchase the HIGH EFFICIENCY [IF ROOMAC_QTY_VERIFIED=1, "ROOM AIR CONDITIONER"; IF ROOMAC_QTY_VERIFIED>1, "ROOM AIR CONDITIONERS"]...

a. [ASK IF Q2B=1 OR Q2C=1 OR Q2H=1] Information from Con Edison's marketing materials [IF Q2C=1, READ "AND WEBSITE"]
b. [SKIP IF A1B=1] Con Edison rebates

[SKIP TO SO1 IF A1B=1]

A5. If the Con Edison rebate had not been available, would you have purchased the HIGH EFFICIENCY [IF ROOMAC_QTY_VERIFIED=1,"ROOM AIR CONDITIONER"; IF ROOMAC_QTY_VERIFIED>1,"ROOM AIR CONDITIONERS"] BEFORE the fall of 2011 or would you have purchased [IF ROOMAC_QTY_VERIFIED=1, "IT"; IF ROOMAC_QTY_VERIFIED>1, "THEM"] DURING OR AFTER the fall of 2011?

1. Would have purchased BEFORE the fall of 2011
2. Would have purchased DURING OR AFTER the fall of 2011
3. (Would not have purchased a room air conditioner(s) at all without rebate)
8. (Don't know)
9. (Refused)

[ASK IF A5=3]

A6. Just to confirm, if the Con Edison rebate had not been available, you would NOT have purchased [IF ROOMAC_QTY_VERIFIED=1, "A ROOM AIR CONDITIONER"; IF ROOMAC_QTY_VERIFIED>1, "ROOM AIR CONDITIONERS"] at all, is that correct?

1. Yes [SKIP TO SO1]
2. No
8. (Don't know)
9. (Refused)

[ASK IF ROOMAC_QTY_VERIFIED>1]

A8. If the Con Edison rebate had not been available, would you still have purchased two HIGH EFFICIENCY air conditioners or would you have purchased one?

1. Two
2. One
8. (Don’t know)
9. (Refused)

A9. Using a 1 to 7 point scale where 1 is “not at all likely” and 7 is “very likely” how likely is it that you would still have purchased THE SAME EFFICIENCY [IF ROOMAC_QTY_VERIFIED=1, “ROOM AIR CONDITIONER”; IF ROOMAC_QTY_VERIFIED>1, “ROOM AIR CONDITIONERS”] if you had not received a rebate from Con Edison? [RECORD 1-7; 98=DON'T KNOW; 99=REFUSED]

[ASK IF (A9<3 AND A4C>5) OR (A9>5 AND A4C<3)]

A10. Just to make sure I understand, please explain the importance of the rebate you received from Con Edison on your decision to purchase the [IF ROOMAC_QTY_VERIFIED=1, “HIGH EFFICIENCY ROOM AIR CONDITIONER”; IF ROOMAC_QTY_VERIFIED>1, “HIGH EFFICIENCY ROOM AIR CONDITIONERS”] instead of less efficient [IF ROOMAC_QTY_VERIFIED=1, “AIR CONDITIONER”; IF ROOMAC_QTY_VERIFIED>1, “AIR CONDITIONERS”].

00. [OPEN END]
98. (Don’t know)
99. (Refused)

[ASK IF CENTRALAC_QTY_VERIFIED>0 OR HEATPUMP_QTY_VERIFIED>0, ELSE SKIP TO NEXT SECTION]

FREE RIDERSHIP: RESIDENTIAL HVAC

Next I have a few questions about the decision-making process that led you to install [IF HEATPUMP_QTY_VERIFIED>0, "HEATING AND COOLING"; ELSE "COOLING"] equipment.

B0a. Did you have a central cooling system in your home before you installed new [IF HEATPUMP_QTY_VERIFIED>0, "HEATING AND COOLING"; ELSE "COOLING"] equipment?

1. Yes
2. No
8. (Don't know)
9. (Refused)

B1a. When did you first learn that you could receive a rebate from Con Edison for installing new [IF HEATPUMP_QTY_VERIFIED>0, "HEATING AND COOLING"; ELSE "COOLING"] equipment? Was it before or after you installed the equipment?

1. Before
2. After
8. (Don't know)
9. (Refused)

[IF B1a <>2 SKIP TO B2A]

B1b. Just to be clear, did you install your new [IF HEATPUMP_QTY_VERIFIED>0, "HEATING AND COOLING"; ELSE "COOLING"] equipment and then later learn that you could receive a rebate from Con Edison?

1. Yes [SKIP TO B4A]
2. No
8. (Don't know)
9. (Refused)

B2a. Were you already planning to install new [IF HEATPUMP_QTY_VERIFIED>0, "HEATING AND COOLING"; ELSE "COOLING"] equipment when you learned that you could receive a rebate from Con Edison?

1. Yes
2. No
8. (Don't know)
9. (Refused)

[ASK IF B2A=1]
B2b. Were you already planning to install HIGH EFFICIENCY [IF HEATPUMP_QTY_VERIFIED>0, “HEATING AND COOLING”; ELSE “COOLING”] equipment when you learned that you could receive a rebate from Con Edison?
1. Yes
2. No
8. (Don’t know)
9. (Refused)

B3. Our records show that you received a rebate of <INCENTIVE> from Con Edison for installing your new [IF HEATPUMP_QTY_VERIFIED>0, “HEATING AND COOLING”; ELSE “COOLING”] equipment. If the Con Edison rebate had not been available, would you have installed [IF HEATPUMP_QTY_VERIFIED>0, “HEATING AND COOLING”; ELSE “COOLING”] equipment at all?
1. Yes, would have installed new equipment
2. No, would not have installed new equipment [SKIP TO SO1]
3. (Maybe)
8. (Don’t know)
9. (Refused)

B4. Using a scale of 1 to 7, where 1 means no influence and 7 means a great deal of influence, please rate the influence of the following on your decision to install the high efficiency [IF HEATPUMP_QTY_VERIFIED>0, “HEATING AND COOLING”; ELSE “COOLING”] equipment?
a. Contractor recommendations
b. [ASK IF Q2B=1 OR Q2C=1 OR Q2E=1] Information from Con Edison’s marketing materials and [IF Q2C=1, READ “AND WEBSITE”]
c. [SKIP IF B1B=1] Con Edison rebates

B5. Did the availability of the Con Edison rebate cause you to install your HIGH EFFICIENCY [IF HEATPUMP_QTY_VERIFIED>0, “HEATING AND COOLING”; ELSE “COOLING”] equipment EARLIER than you were planning, or did the rebate have no influence on when you installed the equipment?
1. Installed earlier
2. Did not change when installed
3. (Would not have installed the equipment at all without rebate)
8. (Don't know)
9. (Refused)

[ASK IF B5=3]
B6. Just to confirm, if Con Edison rebate had not been available, you would NOT have installed [IF HEATPUMP_QTY_VERIFIED>0, “HEATING AND COOLING”; ELSE “COOLING”] equipment at all, is that correct?
1. Yes [SKIP TO SO1]
2. No
8. (Don’t know)
9. (Refused)

[ASK B5=1]

B7. If the rebate had not been available, when would you have installed your HIGH EFFICIENCY [IF HEATPUMP_QTY_VERIFIED>0, "HEATING AND COOLING"; ELSE "COOLING"] equipment? Would you say…

1. Within 6 months of when you did
2. 6 months to a year later
3. 1 to 2 years later
4. or more than 2 years later
8. (Don't know)
9. (Refused)

[ASK IF CENTRALAC_QTY_VERIFIED OR HEATPUMP_QTY_VERIFIED>1]

B8. If the Con Edison rebate had not been available, would you still have installed <CENTRALAC_QTY_VERIFIED OR HEATPUMP_QTY_VERIFIED> [IF HEATPUMP_QTY_VERIFIED>0, "HIGH EFFICIENCY HEAT PUMPS"; ELSE "HIGH EFFICIENCY CENTRAL AIR CONDITIONING UNITS"] or would you have installed fewer?

1. Same number
2. Fewer
8. (Don't know)
9. (Refused)

[ASK B8=2]

B8a. How many [IF HEATPUMP_QTY_VERIFIED>0, "HIGH EFFICIENCY HEAT PUMPS"; ELSE "HIGH EFFICIENCY CENTRAL AIR CONDITIONING UNITS"] would you have installed if the rebate had not been available? [NUMERIC OPEN END, 98=DK, 99=REF]

B9. Using a 1 to 7 point scale where 1 is "not at all likely" and 7 is "very likely" how likely is it that you would have installed THE SAME EFFICIENCY [IF HEATPUMP_QTY_VERIFIED>0, "HEATING AND COOLING"; ELSE "COOLING"] equipment if you had not received a rebate from Con Edison? [RECORD 1-7; 98=DK; 99=REF]

[ASK IF (B9<3 AND B4C>5) OR (B9>5 AND B4C<3)]

B10. Just to make sure I understand, please explain the importance of the rebate you received from Con Edison on your decision to install the HIGH EFFICIENCY [IF HEATPUMP_QTY_VERIFIED>0, "HEATING AND COOLING"; ELSE "COOLING"] equipment instead of less efficient equipment.

00. [OPEN END]
98. (Don't know)
99. (Refused)

[ASK IF Q3=1, ELSE SKIP TO SO1]

You mentioned earlier that you received a rebate from Con Edison AND a government tax credit or rebate for the installation of high efficiency [IF HEATPUMP_QTY_VERIFIED>0, "HEATING AND COOLING"; ELSE "COOLING"] equipment.

B11. Using a 1 to 7 point scale where 1 is "not at all likely" and 7 is "very likely" how likely is it that you would have installed THE SAME EFFICIENCY [IF HEATPUMP_QTY_VERIFIED>0, "HEATING AND COOLING"; ELSE "COOLING"] equipment had neither tax rebates and credits nor Con Edison rebate been available? [RECORD 1-7; 98=DK; 99=REF]

SPILLOVER

SO1. SINCE your participation in the <PROGRAM>, have you made any of the following improvements for which you did NOT receive a rebate from Con Edison? Have you..?

a. Insulated your home
b. Installed energy efficient lighting, such as CFLs or LEDs
c. Purchased an ENERGY STAR refrigerator
d. Purchased an ENERGY STAR clothes washer

1. Yes
2. No
8. (Don't know)
9. (Refused)

[ASK IF ANY IN SO1=1, ELSE SKIP TO NEXT SECTION]

SO2. Did your experience with the Con Edison <PROGRAM> encourage you IN ANY WAY to make [IF ONLY ONE IN SO1, "THIS IMPROVEMENT"; IF MORE THAN ONE IN SO1, "ANY OF THESE IMPROVEMENTS"]?

1. Yes
2. No [SKIP TO NEXT SECTION]
8. (Don't know) [SKIP TO NEXT SECTION]
9. (Refused) [SKIP TO NEXT SECTION]

SO3. Using a scale of 1 to 7, where 1 is no influence and 7 is a great deal of influence, how much influence did your experience with the Con Edison <PROGRAM> have on your decision to...?

a. [ASK IF SO1A=1] Insulate your home
b. [ASK IF SO1B=1] Install high efficiency lighting, such as CFLs or LEDs
c. [ASK IF SO1C=1] Purchase an ENERGY STAR refrigerator
d. [ASK IF SO1D=1] Purchase an ENERGY STAR clothes washer

[ASK IF SO3A>5, ELSE SKIP TO SO5A]

SO4a. Can you explain how your experience with the Con Edison <PROGRAM> influenced your decision to insulate your home?

00. [OPEN END]
98. (Don't know)
99. (Refused)

SO4b. What parts of your home did you insulate?

01. Attic
02. Walls
00. (Other, specify)
98. (Don't know)
99. (Refused)

[ASK IF S04B=1, ELSE SKIP TO S05A]

S04c. What type of insulation did you use to insulate your attic? Was it..?

01. Blown in insulation
02. Layer or batting insulation
03. Spray foam insulation
00. or some other type?
98. (Don't know)
99. (Refused)

S04d. Did you have any insulation in your attic before this insulation project?

1. Yes
2. No
8. (Don't know)
9. (Refused)

[ASK IF S04D=1]

S04e. Approximately, how many inches of insulation did you have in your attic before the insulation project? [NUMERIC OPEN END, 98=DK, 99=REF] [PROBE FOR BEST ESTIMATE]

S04f. Approximately, how many inches of insulation were added as a result of your project? [NUMERIC OPEN END, 98=DK, 99=REF] [PROBE FOR BEST ESTIMATE]

[ASK IF S04E=98, 99 AND S04D=1]

S04g. What was the R-value of the insulation that you had in your attic before the insulation project? [NUMERIC OPEN END, 98=DK, 99=REF] [PROBE FOR BEST ESTIMATE]

[ASK IF S04F=98, 99]

S04h. What is the R-value of the insulation that was added as a result of your project? [NUMERIC OPEN END, 98=DK, 99=REF] [PROBE FOR BEST ESTIMATE]

[ASK IF S03B>5, ELSE SKIP TO S06A]

S05a. Can you explain how your experience with the Con Edison <PROGRAM> influenced your decision to install energy efficient light bulbs in your home?

00. [OPEN END]
98. (Don't know)
99. (Refused)

S05b. Did you install CFLs, LEDs or both?

1. CFLs
2. LEDs
3. Both
4. (Neither) [SKIP TO S06A]
8. (Don't know) [SKIP TO S06A]
9. (Refused) [SKIP TO S06A]

[ASK IF SO5B=1 OR 3]
SO5c. How many CFLs did you install in your home? [RECORD NUMBER; 98=DON'T KNOW; 99=REFUSED]
[ASK IF SO5B=2 OR 3]
SO5d. How many LEDs did you install in your home? [RECORD NUMBER; 98=DON'T KNOW; 99=REFUSED]

[ASK IF SO3C>5, ELSE SKIP TO SO7A]
SO6a. Can you explain how your experience with the Con Edison <PROGRAM> influenced your decision to purchase an ENERGY STAR refrigerator for your home?
00. [OPEN END]
98. (Don't know)
99. (Refused)

SO6b. What type of ENERGY STAR refrigerator did you get? Does it have..?
1. A top-mounted freezer
2. A bottom-mounted freezer or
3. A side-by-side freezer
8. (Don't know)
9. (Refused)

[ASK IF SO3D>5, ELSE SKIP TO NEXT SECTION]
SO7a. Can you explain how your experience with the Con Edison <PROGRAM> influenced your decision to purchase an ENERGY STAR clothes washer for your home?
00. [OPEN END]
98. (Don't know)
99. (Refused)

[ASK IF EV1B=1 OR EV1C=1 OR 2]
ROOM AIR CONDITIONER

I would like to ask you a few more questions about room air conditioners.

RAC1. How many total room air conditioners do you have in your home?
[NUMERIC OPEN END]
98. (Don't know)
99. (Refused)

[READ IF ROOMAC_QTY_VERIFIED=1 AND EV1B=1]:
When answering the following questions, please think about the room air conditioner for which you received a rebate through Con Edison.

[READ IF ROOMAC_QTY_VERIFIED>1 AND EV1C=2]:
When answering the following questions, please think about the room air conditioner for which you received a rebate through Con Edison that you purchased to use in YOUR home.

[READ IF ROOMAC_QTY_VERIFIED>1 AND EVC1C=1 AND BTUS FOR BOTH UNITS ARE NOT THE SAME]:
When answering the following questions, please think about the room air conditioner that is rated at [BTU VALUE] Btus for which you received a rebate from Con Edison. That's the largest room air conditioner that was rebated.

[READ IF ROOMAC_QTY_VERIFIED>1 AND EVC1C=1 AND BTUS FOR BOTH UNITS ARE THE SAME]:
When answering the following questions, please think about just one room air conditioner for which you received a rebate from Con Edison.

RAC2a. In what room is this room air conditioner usually installed?
01. Bedroom
02. Living room/family room
03. Office
04. Kitchen
05. Dining Room
00. (Other)
98. (Don't know)
99. (Refused)

RAC2b. Does this room have a door?
1. Yes
2. No
8. (Don't know)
9. (Refused)

[ASK RAC2C IF RAC2B=1; ELSE SKIP TO RAC3]

RAC2c. When the room conditioner is ON, do you usually keep the doors to this room shut or do you usually keep the doors open?

1. Shut
2. Open
8. (Don't know)
9. (Refused)

RAC3. Is this air conditioner installed year round or do you install it just for cooling season?

01. Installed year round
02. Install it just for cooling season
00. (Other, specify)
98. (Don't know)
99. (Refused)

[ASK RAC4A AND RAC4B IF RAC3=1; ELSE SKIP TO RAC5A]

RAC4a. What month do you typically install this air conditioner for the season?

01. March
02. April
03. May
04. June
05. July
00. Other (specify)
98. (Don't know)
99. (Refused)

RAC4b. What month do you typically remove this air conditioner for the season?

01. August
02. September
03. October
04. November
05. December
00. Other (specify)
98. (Don't know)
99. (Refused)

RAC5a. When you are running this air conditioner, what temperature is the air conditioner's thermostat usually set to?

[NUMERIC OPEN END]

97. (No temperature setting; just dial)
98. (Don't know)
99. (Refused)

[ASK RAC57B IF RAC5A=97; ELSE SKIP TO RAC6]
RAC5b. What number is the dial set to?
[NUMERIC OPEN END]
97. (No temperature setting; just dial)
98. (Don't know)
99. (Refused)

[ASK IF RAC5B=97]
RAC5c.What is the coldest setting on the dial?
[NUMERIC OPEN END]
98. (Don't know)
99. (Refused)

RAC5d.When you use this room air conditioner in the summer, do you usually use it on the high cool setting, the low cool setting, or just the fan setting?
01. High cool or cooling high
02. Low cool or cooling low
03. Fan setting
00. (Other, specify)
98. (Don't know)
99. (Refused)

RAC5e.On the hottest summer WEEK DAYS, with outside high temperature higher than 90 degrees, between 4 and 5 pm, are you typically running this room air conditioner?
1. Yes
2. No
3. (Sometimes/occasionally)
8. (Don't know)
9. (Refused)

The next set of questions is about how you use this air conditioner at different outside temperatures. When answering, please ONLY THINK ABOUT SUMMER WEEK DAYS.

First, please think about summer WEEK DAYS when the outside high temperature is between 70 and 80 degrees...

RAC6. On WEEK DAYS like this, do you use this room air conditioner at all? [IF RESPONDENT SAYS IT VARIES, PROBE FOR A TYPICAL DAY]
1. Yes
2. No
8. (Don't know)
9. (Refused)

[ASK IF RAC6=1, ELSE SKIP TO RAC7]

RAC6a. And do you typically keep the air conditioner on all the time, or do you turn it on and off depending on the time of the day?

1. Keep on all the time
2. Turn on and off
8. (Don't know)
9. (Refused)

[ASK IF RAC6A=2]

RAC6b. Between what hours do you TYPICALLY have the air conditioner running?

[IF RESPONDENT SAYS IT DEPENDS, PROBE FOR A TYPICAL DAY WHEN THE TEMPERATURES ARE BETWEEN 70 AND 80]

[FOR EACH RESPONSE, RECORD FROM AND TO TIMES, AS WELL AS AM/PM]

[AFTER EACH RESPONSE PROBE: DO YOU TURN THE ROOM AIR CONDITIONER BACK ON AT ANY OTHER TIME OF DAY OR NIGHT?]

a.	Period 1	From [OPEN END] AM/PM	To [OPEN END] AM/PM
b.	Period 2	From [OPEN END] AM/PM	To [OPEN END] AM/PM
c.	Period 3	From [OPEN END] AM/PM	To [OPEN END] AM/PM

Now, think about summer WEEK DAYS when the outside high temperature is between 80 and 90 degrees…

RAC7. On WEEK DAYS like this, do you use this room air conditioner at all? [IF RESPONDENT SAYS IT VARIES, PROBE FOR A TYPICAL DAY]

1. Yes
2. No
8. (Don't know)
9. (Refused)

[ASK IF RAC7=1, ELSE SKIP TO RAC8]

RAC7a. And do you typically keep the air conditioner on all the time, or do you turn it on and off depending on the time of the day?

1. Keep on all the time
2. Turn on and off
8. (Don't know)
9. (Refused)

[ASK IF RAC7A=2]

RAC7b.Between what hours do you TYPICALLY have the air conditioner running?

[IF RESPONDENT SAYS IT DEPENDS, PROBE FOR A TYPICAL DAY WHEN THE TEMPERATURES ARE BETWEEN 80 AND 90]

[FOR EACH RESPONSE, RECORD FROM AND TO TIMES, AS WELL AS AM/PM]

[AFTER EACH RESPONSE PROBE: DO YOU TURN THE ROOM AIR CONDITIONER BACK ON AT ANY OTHER TIME OF DAY OR NIGHT?]

a.	Period 1	From [OPEN END] AM/PM	To [OPEN END] AM/PM
b.	Period 2	From [OPEN END] AM/PM	To [OPEN END] AM/PM
c.	Period 3	From [OPEN END] AM/PM	To [OPEN END] AM/PM

Now, think about hot summer WEEK DAYS when the outside high temperature is 90 degrees or higher…

RAC8. On WEEK DAYS like this, do you use this room air conditioner at all? [IF RESPONDENT SAYS IT VARIES, PROBE FOR A TYPICAL DAY]

1. Yes
2. No
8. (Don't know)
9. (Refused)

[ASK IF RAC8=1, ELSE SKIP TO NEXT SECTION]

RAC8a.And do you typically keep the air conditioner on all the time, or do you turn it on and off depending on the time of the day?

1. Keep on all the time
2. Turn on and off
8. (Don't know)
9. (Refused)

[ASK IF RAC8A=2]

RAC8b.Between what hours do you TYPICALLY have the air conditioner running?

[IF RESPONDENT SAYS IT DEPENDS, PROBE FOR A TYPICAL DAY WHEN THE TEMPERATURE IS 90 DEGREES OR HIGHER]

[FOR EACH RESPONSE, RECORD FROM AND TO TIMES, AS WELL AS AM/PM]

[AFTER EACH RESPONSE PROBE: DO YOU TURN THE ROOM AIR CONDITIONER BACK ON AT ANY OTHER TIME OF DAY OR NIGHT?]

a.	Period 1	From [OPEN END] AM/PM	To [OPEN END] AM/PM
b.	Period 2	From [OPEN END] AM/PM	To [OPEN END] AM/PM
c.	Period 3	From [OPEN END] AM/PM	To [OPEN END] AM/PM

[ASK IF CENTRALAC_QTY_VERIFIED>0, ELSE SKIP TO NEXT SECTION]
CAC

I wanted to ask you a few more questions about the central air conditioning system for which you received a rebate from Con Edison.

[READ IF CENTRALAC_QTY_VERIFIED>1]:
When answering the next set of questions, please focus on just one cooling zone. A cooling zone is an area of your home with its own thermostat.

[ASK IF THERMOSTAT_QTY_VERIFIED=0]
CAC1a. Is your thermostat programmable? That is, can you program it to change temperature settings automatically at different times of the day and night?

1. Yes
2. No
8. (Don't know)
9. (Refused)

CAC1b. Do you turn your air conditioner on and off depending on the outdoor temperature, or do you turn it on and leave it on for the season?

1. Turn AC off and on depending on temperature
2. Turn AC and leave it on for the season
8. (Don't know) [SKIP TO NEXT SECTION]
9. (Refused) [SKIP TO NEXT SECTION]

[ASK IF CAC1B=2 AND CAC1A=1 OR THERMOSTAT_QTY_VERIFIED>0]
CAC1c.Do you program your thermostat to automatically change temperatures of your central air conditioning system at different times or do you adjust it manually based on your comfort level?

1. Thermostat is programmed
2. Adjust manually
8. (Don't know)
9. (Refused)

[ASK IF CAC1C=1]
CAC1d. What are your thermostat settings for a TYPICAL SUMMER WEEK DAY?

[IF RESPONDENT SAYS IT DEPENDS, PROBE FOR A TYPICAL DAY IN THE SUMMER]
[FOR EACH RESPONSE, PROBE FOR AND RECORD FROM AND TO TIMES, AS WELL AS AM/PM AND TEMPERATURES]
[AFTER EACH SETTING PROBE: "IS YOUR THERMOSTAT SET TO ADJUST TEMPERATURE AT ANY OTHER TIMES DURING THE DAY OR NIGHT?"]

a.	Setting 1	From [OPEN END] AM/PM	To [OPEN END] AM/PM	Temp [OPEN END]
b.	Setting 2	From [OPEN END] AM/PM	To [OPEN END] AM/PM	Temp [OPEN END]
c.	Setting 3	From [OPEN END] AM/PM	To [OPEN END] AM/PM	Temp [OPEN END]
d.	Setting 4	From [OPEN END] AM/PM	To [OPEN END] AM/PM	Temp [OPEN END]

[ASK IF CAC1B=1]
CAC1e. What is the outside high temperature at which you are typically using your CAC?

1. 75 degrees
2. 80 degrees
3. 85 degrees
4 90 degrees
5. 95 degrees
8. (Don't know)
9. (Refused)

[ASK IF CAC1B=1 OR CAC1B=2 AND CAC1C<>1]
CAC1f.When you use your CAC, between what hours do you TYPICALLY have the CAC running ON SUMMER WEEK DAYS?
[IF RESPONDENT SAYS IT DEPENDS, PROBE FOR A TYPICAL SUMMER WEEK DAY]
[FOR EACH RESPONSE, PROBE FOR AND RECORD FROM AND TO TIMES, AS WELL AS AM/PM]
[AFTER EACH RESPONSE PROBE: DO YOU TURN THE CAC BACK ON AT ANY OTHER TIME OF DAY OR NIGHT?]

a.	Period 1	From [OPEN END] AM/PM	To [OPEN END] AM/PM
b.	Period 2	From [OPEN END] AM/PM	To [OPEN END] AM/PM
c.	Period 3	From [OPEN END] AM/PM	To [OPEN END] AM/PM
d.	Period 4	From [OPEN END] AM/PM	To [OPEN END] AM/PM

[ASK IF CAC1B=1 OR CAC1B=2 AND CAC1C<>1]
CAC1g. At what temperature do you set your thermostat during each of the periods that you just mentioned? Let's start with… [READ TIME PERIODS FROM BELOW]?
[IF RESPONDENT SAYS IT DEPENDS, PROBE FOR A TYPICAL SUMMER WEEK DAY]

a.	Period	From READ IN	To READ IN	Temp [OPEN END]
b.	Period	From READ IN	To READ IN	Temp [OPEN END]
c.	Period	From READ IN	To READ IN	Temp [OPEN END]
d.	Period	From READ IN	To READ IN	Temp [OPEN END]

CAC1h.On the hottest summer WEEK DAYS with outside high temperature above 90 degrees, between 4 and 5 pm, are you typically running the CAC?
1. Yes
2. No
3. (Sometimes/occasionally)
8. (Don't know)
9. (Refused)

[ASK IF HEATPUMP_QTY_VERIFIED>0]
HEAT PUMPS

We are interested in learning about how you use the heat pump(s) you purchased through the Con Edison <PROGRAM>.

[READ IF HEATPUMP_QTY_VERIFIED>1]:
When answering the next set of questions, please focus on just one heating and cooling zone. A heating or cooling zone is an area of your home with its own thermostat.

[ASK IF THERMOSTAT_QTY_VERIFIED=0]
HP1. Is your thermostat programmable? That is, can you program it to change temperature settings automatically at different times of the day and night?
1. Yes
2. No
8. (Don't know)
9. (Refused)

HP1a. Which of the following modes have you used on your heat pump? Have you used..?
[1=YES; 2=NO; 8=DK; 9=REF]
a. Cooling mode
b. Heating mode
c. Dry mode
d. Fan mode

For the next set of questions, please think about using your heat pump during the summer months for cooling.

HP1b. Do you TYPICALLY turn your heat pump on and off depending on the outdoor temperature, or do you turn it on and leave it on for the season?
1. Turn heat pump off and on depending on temperature
2. Turn heat pump and leave it on for the season
8. (Don't know) [SKIP TO NEXT SECTION]
9. (Refused) [SKIP TO NEXT SECTION]

[ASK IF HP1B=2 AND HP1=1 OR THERMOSTAT_QTY_VERIFIED>0]
HP1c. Do you program your thermostat to automatically change temperatures of your heat pump at different times of the day and night or do you adjust it manually based on your comfort level?
1. Thermostat is programmed
2. Adjust manually
8. (Don't know)
9. (Refused)

[ASK IF HP1C=1]
HP1d. What are your thermostat settings for a TYPICAL SUMMER WEEK DAY?

[IF RESPONDENT SAYS IT DEPENDS, PROBE FOR A TYPICAL SUMMER WEEK DAY]
[FOR EACH RESPONSE, PROBE FOR AND RECORD FROM AND TO TIMES, AS WELL AS AM/PM AND TEMPERATURES]
[AFTER EACH SETTING PROBE: "IS YOUR THERMOSTAT SET TO ADJUST TEMPERATURE AT ANY OTHER TIMES DURING THE DAY OR NIGHT?"]

a.	Setting 1	From [OPEN END] AM/PM	To [OPEN END] AM/PM	Temp [OPEN END]
b.	Setting 2	From [OPEN END] AM/PM	To [OPEN END] AM/PM	Temp [OPEN END]
c.	Setting 3	From [OPEN END] AM/PM	To [OPEN END] AM/PM	Temp [OPEN END]
d.	Setting 4	From [OPEN END] AM/PM	To [OPEN END] AM/PM	Temp [OPEN END]

[ASK IF HP1B=1]
HP1e. What is the outside high temperature at which you start using your heat pump for cooling?

1. 75 degrees
2. 80 degrees
3. 85 degrees
4 90 degrees
5. 95 degrees
8. (Don't know)
9. (Refused)

[ASK IF HP1B=1 OR HP1B=2 AND HP1C<>1]

HP1f.When you use your heat pump, between what hours do you TYPICALLY have the heat pump running ON WEEK DAYS?

[IF RESPONDENT SAYS IT DEPENDS, PROBE FOR A TYPICAL SUMMER WEEK DAY WHEN THE HEAT PUMP IS ON]

[FOR EACH RESPONSE, PROBE FOR AND RECORD FROM AND TO TIMES, AS WELL AS AM/PM]

[AFTER EACH RESPONSE PROBE: DO YOU TURN THE HEAT PUMP BACK ON AT ANY OTHER TIME OF DAY OR NIGHT?]

a.	Period 1	From [OPEN END] AM/PM	To [OPEN END] AM/PM
b.	Period 2	From [OPEN END] AM/PM	To [OPEN END] AM/PM
c.	Period 3	From [OPEN END] AM/PM	To [OPEN END] AM/PM
d.	Period 4	From [OPEN END] AM/PM	To [OPEN END] AM/PM

[ASK IF HP1B=1 OR HP1B=2 AND HP1C<>1]

HP1g. At what temperature do you set your thermostat during each of the periods that you just mentioned? Let's start with… [READ TIME PERIODS FROM BELOW]?

[IF RESPONDENT SAYS IT DEPENDS, PROBE FOR A TYPICAL SUMMER WEEK DAY]

a.	Period	From READ IN	To READ IN	Temp [OPEN END]
b.	Period	From READ IN	To READ IN	Temp [OPEN END]
c.	Period	From READ IN	To READ IN	Temp [OPEN END]
d.	Period	From READ IN	To READ IN	Temp [OPEN END]

HP1h. On the hottest summer WEEK DAYS with outside high temperature higher than 90 degrees, between 4 and 5 pm, are you typically running the heat pump?

1. Yes
2. No
3. (Sometimes/occasionally)
8. (Don't know)
9. (Refused)

For the next set of questions, please think about using your heat pump during the winter months for heating.

HP2b. Do you TYPICALLY turn your heat pump on and off depending on the outdoor temperature, or do you turn it on and leave it on for the season?

1. Turn heat pump off and on depending on temperature
2. Turn heat pump and leave it on for the season
8. (Don't know)
9. (Refused)

[ASK IF HP2B=2 AND HP2A=1 OR THERMOSTAT_QTY_VERIFIED>0]
HP2c.Do you program your thermostat to automatically change temperatures of your heat pump at different times of the day and night or do you adjust it manually based on your comfort level?

1. Thermostat is programmed
2. Adjust manually
8. (Don't know)
9. (Refused)

[ASK IF HP2C=1]
HP2d. What are your thermostat settings for a TYPICAL WINTER WEEK DAY?

[IF RESPONDENT SAYS IT DEPENDS, PROBE FOR A TYPICAL WINTER WEEK DAY WHEN THE HEAT PUMP IS ON]
[FOR EACH RESPONSE, PROBE FOR AND RECORD FROM AND TO TIMES, AS WELL AS AM/PM AND TEMPERATURES]
[AFTER EACH SETTING PROBE: "IS YOUR THERMOSTAT SET TO ADJUST TEMPERATURE AT ANY OTHER TIMES DURING THE DAY OR NIGHT?"]

a.	Setting 1	From [OPEN END] AM/PM	To [OPEN END] AM/PM	Temp [OPEN END]
b.	Setting 2	From [OPEN END] AM/PM	To [OPEN END] AM/PM	Temp [OPEN END]
c.	Setting 3	From [OPEN END] AM/PM	To [OPEN END] AM/PM	Temp [OPEN END]
d.	Setting 4	From [OPEN END] AM/PM	To [OPEN END] AM/PM	Temp [OPEN END]

[ASK IF HP2B=1]
HP2e. What does the temperature have to be outside for you to start using your heat pump for heating?

[NUMERIC OPEN END; 998=DK; 999=REF]

[ASK IF HP2B=1 OR HP2B=2 AND HP2C<>1]

HP2f.When you use your heat pump, between what hours do you TYPICALLY have the heat pump running ON WEEK DAYS?

[IF RESPONDENT SAYS IT DEPENDS, PROBE FOR A TYPICAL WINTER WEEK DAY WHEN THE PUMP IS ON]

[FOR EACH RESPONSE, PROBE FOR AND RECORD FROM AND TO TIMES, AS WELL AS AM/PM]

[AFTER EACH RESPONSE PROBE: DO YOU TURN THE HEAT PUMP BACK ON AT ANY OTHER TIME OF DAY OR NIGHT?]

a.	Period 1	From [OPEN END] AM/PM	To [OPEN END] AM/PM
b.	Period 2	From [OPEN END] AM/PM	To [OPEN END] AM/PM
c.	Period 3	From [OPEN END] AM/PM	To [OPEN END] AM/PM
d.	Period 4	From [OPEN END] AM/PM	To [OPEN END] AM/PM

[ASK IF HP2B=1 OR HP2B=2 AND HP2C<>1]

HP2g. At what temperature do you set your thermostat during each of the periods that you just mentioned? Let's start with... [READ TIME PERIODS FROM BELOW]?

[IF RESPONDENT SAYS IT DEPENDS, PROBE FOR A TYPICAL WINTER WEEK DAY]

a.	Period	From READ IN	To READ IN	Temp [OPEN END]
b.	Period	From READ IN	To READ IN	Temp [OPEN END]
c.	Period	From READ IN	To READ IN	Temp [OPEN END]
d.	Period	From READ IN	To READ IN	Temp [OPEN END]

DEMOGRAPHICS

I have a few more questions and then we are done.

D1. Do you own or rent your home?
- 01. Own
- 02. Rent
- 00. (Other, specify)
- 98. (Don't know)
- 99. (Refused)

D2. Which of the following best describes your home?
- 01. Detached single family
- 02. Townhouse
- 03. Duplex or two-family
- 04. Apartment, condominium or multifamily home with three or more units
- 00. (Other, specify)
- 98. (Don't know)
- 99. (Refused)

[ASK IF D2=4]
D2a. What floor do you live on? [NUMERIC OPEN END]

[SKIP IF D2=4]
D3. To the best of your knowledge, what type of fuel or energy does your water heater use?
- 01. Electricity
- 02. Natural gas
- 03. Propane or bottled gas
- 04. Solar
- 00. Or other fuel type (Specify)
- 98. (Don't know)
- 99. (Refused)

SITE VISIT RECRUITER

[READ IF EV1B=1 OR EV1C=1 OR 2]
To better evaluate this program's performance, Con Edison is conducting a metering study to measure how much energy is saved by using high-efficiency air conditioners like the one you installed through the <PROGRAM>. Technicians will be collecting information from the air conditioners of selected customers. Participants in the study will receive two $50 gift cards. The study includes two visits to your home. The first visit will take about 1 hour and would take place during the month of June. The air conditioner needs to already be installed. During this visit, we would need your permission to gather building characteristics and temporarily unplug your room air conditioner. The technician will install a metering device on your air conditioner that will stay in place until September when the technician returns to retrieve the device. That visit will take about 30 minutes. For your participation, you will receive a $50 gift card during the first visit and another $50 gift card during the second visit. The data will be used strictly for the study of the <PROGRAM> and will not affect your electric service or any past or future incentives at all.

(IF NEEDED: If you agree to participate, a team of two field technicians, on behalf of Con Edison, will come to your residence to install power and temperature logger devices on your air conditioner and thermostat as well as take measurements of your home. These loggers will record when your air conditioner is in use and how well it is performing. Technicians will need to get access to the area where the room air conditioner is located within your home. The loggers would be installed in an unobtrusive place and will be removed by us at the end of the research project in September.)

[READ IF CENTRALAC_QTY_VERIFIED>0]
To better evaluate this program's performance, Con Edison is conducting a metering study to measure how much energy is saved by using high-efficiency air conditioners like the one you purchased through the <PROGRAM>. Technicians will be collecting information from the air conditioners of selected customers. Participants in the study will receive two $50 gift cards. The study includes two visits to your home. The first will take about 3 hours and would take place during the month of June. During this visit, we would need your permission to walk around the entire house to gather building characteristics, turn the AC down 10 degrees, and to potentially turn off the power to the entire house for up to 30 minutes. The technician will install a metering device on your air conditioner that will stay in place until September when the technician returns to retrieve the device. That visit will take between 1 and 2 hours. For your participation, you will receive a $50 gift card during the first visit and another $50 gift card during the second visit. The data will be used strictly for the study of the <PROGRAM> and will not affect your electric service or any past or future incentives at all.

(IF NEEDED: If you agree to participate, a team of two field technicians, on behalf of Con Edison, will come to your residence to install power and temperature logger devices on your air conditioner and thermostat as well as take measurements of your home. These loggers will record when your air conditioner is in use and how well it is performing. Technicians will need to get access to the area where the furnace, air handler, or air conditioner is located within your home. The loggers would be installed in an unobtrusive place and will be removed by us at the end of the research project in September.)

[READ IF HEAT_PUMP_QTY_VERIFIED>0]
To better evaluate this program's performance, Con Edison is conducting a metering study to measure how much energy is saved by using high-efficiency heat pumps like the one you purchased through the <PROGRAM>. Technicians will be collecting information from selected customers during both cooling and heating seasons. Participants will receive three $50 gift cards for their participation. The study includes three visits to your home. The first visit will take about 3 hours and would need to take place during the month of June. During this visit, we would need your permission to walk around the entire house to gather building characteristics, turn the heat pump down 10 degrees, and to potentially turn off the power to the entire house for up to 30 minutes. The technician will install a metering device on your heat pump that will stay in place until the following April. The second visit will occur in October and will take about one hour for the technician to check the meters and then reset the equipment for the heating season. The third visit will be in April 2013 when the technician returns to collect the metering device. This visit will take about one hour. For your participation, you will receive a $50 gift card at each visit. The data will be used strictly for the study of the <PROGRAM> and will not affect your electric service or any past or future incentives at all.

(IF NEEDED: If you agree to participate, a team of two field technicians, on behalf of Con Edison, will come to your residence to install power and temperature logger devices on your heat pump and thermostat as well as take measurements of your home. These loggers will record when your heat pump is in use and how well it is performing. Technicians will need to get access to the areas where the outdoor unit and all indoor units are located within your home. The loggers would be installed in an unobtrusive place and will be reset by us in October and then removed by us at the end of the research project in April.)

[ASK R1 IF EV1B=1 OR EV1C=1 OR 2 OR CENTRALAC_QTY_VERIFIED>0]
R1. Are you interested in participating in this study and receiving two $50 gift cards?
- 01. Yes
- 02. No
- 98. (Don't know)
- 99. (Refused)

[ASK IF HEATPUMP_QTY_VERIFIED>0]
R2. Are you interested in participating in this study and receiving three $50 gift cards?
- 01. Yes
- 02. No
- 98. (Don't know)
- 99. (Refused)

[READ IF R1=1 OR R2=1]
Great! Thank you. A representative will be in contact with you to schedule your site visits. Those are all the questions I have for today. Thank you for your time and help in this important study.

[READ IF R1=2,98,99 OR R2=2,98,99]
Those are all the questions I have for today. Thank you for your time and help in this important study.

Appendix F – Residential HVAC Trade Ally Discussion Guide

Hi, my name is _________ and I'm calling from Opinion Dynamics on behalf of Con Edison about their Residential HVAC program. We are doing a brief survey with contractors or other trade allies who have been involved in projects that received incentives through Con Edison's Residential HVAC program. We are trying to understand the influence of Con Edison's Residential HVAC program on the residential central cooling and heating market in Downstate New York.

I would like to speak with the person most knowledgeable about your company's interactions with Con Edison's Residential HVAC program. Are you the best person to speak with about that? [IF NO, OBTAIN CORRECT CONTACT; IF YES ASK IF IT IS A GOOD TIME TO TALK; IF NO, SCHEDULE A TIME TO TALK IN THE NEXT WEEK].

The questions that I have will take about fifteen minutes and your responses will be kept strictly confidential.

[IF NEEDED: ALERT INTERVIEWEE THAT THE CALL WILL BE RECORDED. NOTE THAT RESPONSES WILL REMAIN CONFIDENTIAL AND ONLY BE REPORTED IN AGGREGATE WITH OTHER RESPONSES.]

V1. Our records indicate that your company installed high efficiency HVAC equipment that allowed customers to receive incentives through Con Edison's Residential HVAC program between 2009 and 2011. Is that correct? [IF NO, THANK AND TERMINATE]

Background Questions

I wanted to start with a couple of questions about you and your company.

B1. Do you know the areas where Con Edison provides electric services?

[IF FAMILIAR, ASK ABOUT CON EDISON'S SERVICE TERRITORY. IF NOT, ASK ABOUT DOWNSTATE NEW YORK, AND MENTION MANHATTAN, QUEENS, STATEN ISLAND, BROOKLYN, THE BRONX, AND WESTCHESTER]

B2. What percent of your company's business is in <Con Edison's service territory/downstate New York>?

B3. What percent of your business in <Con Edison's service territory/downstate New York> is residential?

Customer Recommendations

I would like to learn more about how you recommend HVAC systems to potential customers. When answering, please think about <Con Edison's service territory/downstate New York>.

Throughout the rest of the interview, I will be asking you about various efficiency levels of <CACs/Heat Pumps>. When I say high efficiency, I mean any equipment SEER 15 and above, and when I say less efficient equipment I mean any equipment with SEER of less than 15.

M1. When recommending equipment to customers and developing project specifications, what factors go into the decision making process? What is the single biggest factor that impacts what you recommend? [PROBE FOR: COST, ENERGY SAVINGS, PERFORMANCE, AVAILABILITY, NON-ENERGY BENEFITS, SUCH AS DECREASED NEED FOR MAINTENANCE, COMFORT, ETC.]

M2. In what percent of sales situations do you recommend high efficiency <CACs/Heat Pumps> to your customers? [IF NEEDED DEFINE THAT THE PRODUCTS ARE CACS OR HEAT PUMPS WITH SEER 15 AND HIGHER]

a. [IF NOT 100%] When you don't recommend high efficiency <CACs/Heat Pumps>, what are the reasons?

b. How does that compare to 2011? [PROBE FOR PERCENT INCREASE OR DECREASE IF CHANGE NOTED]

M3. In what percent of sales situations do you present your customers with more than one equipment option, where at least one of which is less efficient and at least one is high efficiency? [IF NEEDED DEFINE THAT THE PRODUCTS ARE CACS OR HEAT PUMPS WITH SEER 15 AND HIGHER]

a. [IF MORE THAN 0%] Why are you presenting more than one equipment option to your customers? [PROBE FOR CUSTOMERS REQUIRING TO PRICE MORE THAN ONE OPTION, DESIRE TO STAY COMPETITIVE TO WIN THE BUSINESS, ETC.]

b. When presenting more than one option to your customers, with at least one of them being high efficiency, how frequently do you emphasize the high efficiency option over the less efficient option?

c. How does that compare to 2011? [PROBE FOR PERCENT CHANGE IF CHANGE NOTED]

Program Influence on Customer Recommendations

M4. Thinking about the time frame between 2009 and 2011, has any of the following changed? [IF NEEDED CLARIFY: BECOMING ACTIVE WITH THE PROGRAM MEANS STARTING TO INTERACT WITH PROGRAM STAFF AND/OR WORK ON PROJECTS THAT APPLIED FOR CON EDISON'S INCENTIVES]

[IF TRADE ALLY UNABLE TO COMMENT ON THE 2009-2011 TIME FRAME, ASK TO COMMENT ON THE CHANGES IN THE PAST FEW YEARS]

aa. Your knowledge of high efficiency options. [IF YES:] What factors contributed to this change? How did each of the factors you just mentioned influence your knowledge of high efficiency options?

bb. Your comfort level with discussing the benefits of high efficiency to your customers. [IF YES:] What factors contributed to this change? How did each of the factors you just mentioned influence your comfort level?

cc. Your confidence level in recommending/selling high efficiency options. [IF YES:] What factors contributed to this change? How did each of the factors you just mentioned influence your confidence level?

dd. The frequency with which you emphasize high efficiency options over less efficient options when offering multiple equipment options. [IF YES:] What factors contributed to this change? How did each of the factors you just mentioned influence the frequency with which you emphasize high efficiency options over less efficient options?

I would now like to ask you to rate the influence of the program as opposed to other factors in influencing each of the areas we just discussed. Using the scale of 1 to 7, where 1 means not at all influential and 7 means very influential, how influential was the Con Edison program, including incentives, marketing and support on..?

a. [ASK IF M4AA=YES] Your knowledge of high efficiency options. Why do you say that? How influential were other factors not related to the program? [ASK TO PROVIDE A RATING OF INFLUENCE ON A 1-7 POINT SCALE]

b. [ASK IF M4BB=YES] Your comfort level with discussing the benefits of high efficiency to your customers. Why do you say that? How influential were other factors not related to the program? [ASK TO PROVIDE A RATING OF INFLUENCE ON A 1-7 POINT SCALE]

c. [ASK IF M4CC=YES] Your confidence level in recommending/selling high efficiency options. Why do you say that? How influential were other factors not related to the program? [ASK TO PROVIDE A RATING OF INFLUENCE ON A 1-7 POINT SCALE]

d. [ASK IF M4DD=YES] The frequency with which you emphasize high efficiency options over less efficient options when offering multiple equipment options. Why do you say that? How influential were other factors not related to the program? [ASK TO PROVIDE A RATING OF INFLUENCE ON A 1-7 POINT SCALE]

M5. Again, thinking about the time frame between 2009 and 2011, how, if at all, has the frequency with which you recommend high efficiency <CACs/Heat Pumps> changed? [IF NEEDED CLARIFY: BECOMING ACTIVE WITH THE PROGRAM MEANS STARTING TO INTERACT WITH PROGRAM STAFF AND/OR WORK ON PROJECTS THAT APPLIED FOR CON EDISON'S INCENTIVES] [PROBE FOR CHANGE IN PERCENTAGE CHANGE]

[IF TRADE ALLY UNABLE TO COMMENT ON THE 2009-2011 TIME FRAME, ASK TO COMMENT ON THE CHANGES IN THE PAST FEW YEARS]

If change noted:

a. What are you doing more of – presenting only high efficiency options to customers instead of presenting both high and less efficient, or adding a high efficiency option to less efficient option in more sales situations?

b. How influential was Con Edison's Residential HVAC program in this change on a scale of 1 to 7, where 1 means not at all influential and 7 means very influential? [PROBE FOR SPECIFIC PROGRAM COMPONENTS: INCENTIVES, TRAINING, ETC.]

c. How influential are other factors not related to the program? [ASK TO PROVIDE A RATING OF INFLUENCE ON A 1-7 POINT SCALE] What are these other factors? [PROBE FOR TAX CREDITS/GOVERNMENT REBATES, GENERAL EE AWARENESS, CHANGE IN CODES OR STANDARDS.]

Program Influence on Equipment Stocking

I would now like to explore your company's stocking practices over the past few years.

S1. Do you stock <CACs/Heat Pumps> equipment in advance of customers ordering it or do you order it on as needed basis?

[ASK IF TRADE ALLIES STOCK EQUIPMENT IN ADVANCE, ELSE SKIP TO THE NEXT SECTION]

S2. How do you decide: [PROBE FOR CURRENT DEMAND, PRICE, PAST DEMAND, PRESENCE OF REBATES FROM MANUFACTURERS, TAX CREDITS, CON EDISON INCENTIVES]

a. How many of <CACs/Heat Pumps> systems to stock in advance?

b. What <CACs/Heat Pumps> system types to stock?

c. What efficiency levels of <CACs/Heat Pumps> systems to stock?

S3. Let's talk about your inventory of <CACs/Heat Pumps> systems in 2009. What percent of your inventory then was comprised of <CACs/Heat Pumps> systems:

b. SEER 15 and less than SEER 16

c. SEER 16 and higher

S4. Has there been a change in your stocking practices of <CACs/Heat Pumps> systems between 2009 and 2011?

a. [IF YES] Has the size of the <CACs/Heat Pumps> inventory increased or decreased over that period of time? Why do you say that? What factors influenced the change?

[ASK IF INCREASED]

aa. How much did it increase by in percentage terms?

ab. How influential was Con Edison's Residential HVAC program in this change? [PROBE FOR SPECIFIC PROGRAM COMPONENTS: INCENTIVES, TRAINING, ETC.] How influential are other factors not related to the program? What are these other factors? [PROBE FOR TAX CREDITS/GOVERNMENT REBATES, GENERAL EE AWARENESS, CHANGE IN CODES OR STANDARDS.]

b. [IF YES] Has the share of <CACs/Heat Pumps> systems SEER 15+ increased, decreased or stayed the same?

[ASK IF INCREASED]

ba. How much did it increase by in percentage terms?

bb. How influential was Con Edison's Residential HVAC program in this change? [PROBE FOR SPECIFIC PROGRAM COMPONENTS: INCENTIVES, TRAINING, ETC.] How influential are other factors not related to the program? What are these other factors? [PROBE FOR TAX CREDITS/GOVERNMENT REBATES, GENERAL EE AWARENESS, CHANGE IN CODES OR STANDARDS.]

Program Influence on DHPs Installations/Sales

[ASK IF TRADE ALLY INSTALLED DHPS THROUGH THE PROGRAM]

DHP1. According to Con Edison's records, your company is shown as the installation contractor for [READ NUMBER] DHPs that were rebated by the program between 2009 and 2011. About what percentage of those DHP installations were for:

a. New installations where heating or cooling equipment had never been used before?

b. Room air conditioner replacements

c. Heat pump replacements (ductless or standard)

d. Other system replacements [PROBE ON SYSTEM TYPE]

DHP2. We are trying to figure out what would have been installed in these cases if Con Edison had not offered its Residential HVAC rebate program. In particular, if the Con Edison program had not existed, can you tell us roughly what percentage of these installations would have ended up being…

a. DHPs

b. standard heat pumps, or

c. no heat pump installation at all?

[ASK IF ANY % WOULD HAVE BEEN DHPS]

DHP3. And for those installations that still would have been DHPs, what percentage would have been the exact same SEER?

[ASK IF NOT ALL 100% SAME EXACT SEER] Would that lower efficiency have been the SEER 13 or something higher? [PROBE TO GET AN ESTIMATE OF EFFICIENCY LEVEL]

[ASK IF ANY % STANDARD HEAT PUMPS]

DHP4. For those installations that would have been standard heat pumps, what SEER level do you think they would have been, on average?

DHP5. Since 2009 have you installed any DHPs that were not rebated under Con Edison's program?

[ASK IF DHP5=YES]

a. About how many of these did you install?

[ASK IF DHP5=YES]

b. What were the most common efficiency levels for those DHPs? [PROBE FOR PERCENTAGE BREAKDOWN ACROSS EFFICIENCIES IF NEEDED]

Program Influence on Sales/Installations

My next few questions are about your company's sales and installations of <CACs/Heat Pumps>. When answering, please think about <Con Edison's service territory/downstate New York>.

PI1. What is the approximate number of <CACs/Heat Pumps> installations that that your company performed in <Con Edison's service territory/downstate New York> between 2009 and 2011?

PI2. Now, if you were to divide all of your company's installations of the <Reference quantity from PI1> <CACs/Heat Pump> systems between 2009 and 2011 across the following SEER levels, what percent of the installations were..?
[PROBE IF NEEDED: YOUR BEST ESTIMATE IS FINE]
[NOTE TO INTERVIEWER: PLEASE DO NOT INCLUDE DUCTLESS MINI SPLIT SYSTEMS. I WILL ASK YOU ABOUT THOSE SHORTLY.]
[MAKE SURE THAT RESULTS SUM UP TO 100%]

a. Lower than SEER 15
b. SEER 15 and less than SEER 16
c. SEER 16 and higher

PI3. What percent of the <CACs/Heat Pumps> systems with SEER 15 and higher received incentives through the program?

[ASK IF PI3<100%]

PI4. It looks like not all of the <CACs/Heat Pump> systems that qualified for program incentives received incentives. Why is that? [IF NEEDED, PROBE FOR CUSTOMERS NOT WANTING TO BOTHER WITH SUBMITTING FORMS, INCENTIVE MONEY NOT BEING WORTH THE TIME SPENT, ETC.]

PI4a. Has Con Edison's program helped with <CACs/Heat Pump> system installations that your company performed between 2009 and 2011? [IF YES], How?

PI5. If Con Edison's Residential HVAC program incentives, marketing, and support had not existed, would your company have made fewer, more, or the same number of SEER 15 or greater <CACs/Heat Pump> system installations between 2009 and 2011?

a. [IF FEWER] In percentage terms, how many fewer SEER 15 or greater <CACs/Heat Pump> systems do you think your company would have installed within the same time period if it hadn't been for the program? Why do you say that? [PROBE IF NEEDED: YOUR BEST ESTIMATE IS FINE]

PI6. If Con Edison's Residential HVAC program incentives, marketing, and support had not existed, what percent of the PROGRAM REBATED <CACs/Heat Pump> systems do you think you would still have installed? Why do you say that? [PROBE FOR THE INFLUENCE OF PROGRAM RELATED FACTORS, SUCH AS INCENTIVES, AND NON-PROGRAM RELATED FACTORS, SUCH AS TAX CREDITS, DISTRIBUTOR STOCKING PRACTICES, CUSTOMER DEMAND, ETC.]

[ASK IF PI3<100%]

PI7. Now thinking about the SEER 15 or greater <CACs/Heat Pump> systems that DID NOT receive incentives through the program, if the Con Edison's Residential HVAC program incentives, marketing, and support had not existed, what percent of those <CACs/Heat Pump> systems do you think you would still have installed? Why do you say that? [IF UNSURE, PROBE FOR BEST ESTIMATE]

PI8. Do you think Con Edison Residential HVAC program (and available rebates) influences decisions made by HVAC manufacturers about what equipment to carry? Why do you say that?

PI9. What about distributors, do you think that Con Edison Residential HVAC program influences their stocking and distribution practices? Why do you say that?

Customer Decision Making Process

I would now like to learn how your customers make decisions about HVAC equipment upgrades. Again, when answering the questions, please think about <Con Edison's service territory/downstate New York>.

C1. What factors do your customers consider when deciding on the equipment for an upgrade project? [PROBE FOR: COST, ENERGY SAVINGS, PERFORMANCE, NON-ENERGY BENEFITS, SUCH AS DECREASED NEED FOR MAINTENANCE, AESTHETICS, ETC.]

C2. Thinking about all of your residential customers that participated in Con Edison's Residential HVAC program between 2009 and 2011, which of the following scenarios was most typical for them?

a. The customers installed what you recommended.

b. The customers wanted to work with you to make a decision about what to install.

c. The customer had already selected the equipment and just wanted you to install it.

[PROBE FOR PERCENTAGES.]

C3. What percent of residential customers that participated in Con Edison's Residential HVAC program between 2009 and 2011 already knew about program incentives? [IF UNSURE, PROBE FOR BEST ESTIMATE]

C4. Do customers generally rely on you to fill out and submit rebate application forms or do they do it themselves? [PROBE FOR PERCENTAGES.]

Program Knowledge and Interactions

I would now like to ask you a few questions about your knowledge and interactions with Con Edison's Residential HVAC program, and then we will be done.

K1. How long has your company been performing HVAC installations that received rebates through the program? How long have you personally known about Con Edison's Residential HVAC program? [IF NEEDED: WHEN DID YOU COMPLETE YOUR FIRST PROJECT THAT RECEIVED INCENTIVES THROUGH CON EDISON]

K2. How knowledgeable do you consider yourself about Con Edison's Residential HVAC program requirements and offerings? Would you say very knowledgeable, somewhat knowledgeable, not very knowledgeable, or not at all knowledgeable? [PROBE FOR KNOWLEDGE OF PROGRAM ELIGIBILITY REQUIREMENTS, INCENTED EQUIPMENT OPTIONS, INCENTIVE LEVELS, PARTICIPATION PROCESS, ETC.]

K3. Since you started performing installations through the program, how frequently did you have interactions with Con Edison's staff? What types of interactions did you have with Con Edison's program staff/implementation partner staff? [PROBE TO QUANTIFY FREQUENCY – ONCE OR TWICE A MONTH, ONCE OR TWICE EVERY COUPLE OF MONTHS, ETC.] [PROBE TO UNDERSTAND IF THEY ARE PROJECT RELATED OR NON-PROJECT RELATED INTERACTIONS] [PROBE FOR TYPES, FREQUENCY AND CONTENTS OF INTERACTIONS – TRAINING SESSIONS, IN-PERSON MEETINGS, PHONE CONVERSATIONS, ETC.]

K4. Do you remember receiving any marketing or promotional materials or any ongoing communications from Con Edison between 2009 and 2011? [PROBE FOR TYPES OF MATERIALS – BROCHURES, CASE STUDIES, NEWSLETTERS, CO-BRANDED MARKETING, ETC. – AS WELL AS THEIR FREQUENCY]

K5. Did you attend any training sessions, meetings, or events, both formal and informal, facilitated by Con Edison between 2009 and 2011? What kind of training did you receive? [PROBE FOR TRAINING AND GUIDANCE ON HOW TO PREPARE CUSTOMER APPLICATIONS, SPECIFICS ON QUALIFIED MEASURE TYPES]

K6. Did you receive ANY OTHER information or support from the program between 2009 and 2011 that either improved your ability to sell and promote energy efficiency to customers or improved your overall knowledge of energy efficient equipment options? If so, what support did you receive?

K7. Before we adjourn, is there anything else that you would like to mention about how Con Edison's Residential HVAC program influence your recommendations and sales of high efficiency equipment?

These are all the questions that I have for you. Thank you very much for your time and input!

APPENDIX G – GLOSSARY OF TERMS

CECONY or CE (in some tables) – Consolidated Edison Company of New York.

census stratum – In a stratified sample design, the stratum with those participants with the largest savings may have a calculated sample size that exceeds the population of the stratum. A stratum that meets this condition is referred to as a census stratum.

coefficient of variance (CV) – A normalized measure of dispersion of a probability distribution and defined as the ratio of the standard deviation, σ,to the mean, μ:

$$c_v = \frac{\sigma}{\mu}$$

common area (CA) – The areas of a multifamily building that are not leased to tenants, such as corridors and lobbies.

DPS – New York Department of Public Service.

Energy Efficiency Portfolio Standard (EEPS) – The state-mandated utility-administered programs.

EER (Energy Efficiency Ratio) - The air conditioner EER is its British thermal units (Btu) rating over its wattage.

energy management system (EMS) – A system used by building operators to monitor, measure, control, and schedule their building loads.

error ratio – In energy efficiency evaluation, the error ratio is a measure of the degree of variance between the reported savings estimates and the evaluated estimates. For a sample, the error ratio is:

$$er = \frac{\sqrt{\sum_{i=1}^{n} w_i \frac{e_i^2}{x_i^{\gamma}} \sum_{i=1}^{n} w_i x_i^{\gamma}}}{\sum_{i=1}^{n} w_i x_i}$$

where n is the sample size, w_i is the population expansion weight associated with each sample point i, x_i is the program-reported savings for each sample point i, y_i is the evaluated gross savings for each sample point i, error for each sample point $e_i = y_i - bx_i$, and γ= 0.8.

ex ante savings estimate – Forecasted savings used for program and portfolio planning purposes.

ex post savings estimate – Savings estimate reported by an evaluator after the energy impact evaluation has been completed.

free rider, free ridership (FR) – A program participant who would have implemented the program measure or practice in the absence of the program.

HSPF (Heating Seasonal Performance Factor) - HSPF is the measurement used to gauge the heating efficiency of heat pumps. (A heat pump's cooling efficiency is measured by its SEER). HSPF is calculated by taking the total annual heating requirements, including all energy inputs (defrost and back-up heating energy included) divided by the total electric power used.

HVAC – Heating, ventilation, and air conditioning.

interval meter – An electric utility meter that measures and stores energy use and demand in 15-minute intervals. Interval meters are required for New York customers to participate in Independent System Operator demand response programs.

in-unit (IU) – The areas of a multifamily building that are leased to tenants, i.e., the individual apartments.

measurement and verification (M&V) – A subset of program impact evaluation that is associated with the documentation of energy savings at individual sites or projects using one or more methods that can involve measurements, engineering calculations, statistical analyses, and/or computer simulation modeling.

National Action Plan for Energy Efficiency – Model energy efficiency program impact evaluation guide abbreviated as NAPEE. This is the DPS-recommended reference guide for impact evaluations.

New York Technical Manual (NYTM) – The DPS-mandated reference document for calculating EEPS program savings.

net to gross, net-to-gross ratio (NTG, NTGR) – The relationship between net energy or net demand savings, where net is measured as what would have occurred without the program, what would have occurred naturally, and gross savings (often evaluated savings). The NTGR is the ratio of net savings to gross savings.

O&R – Orange & Rockland Utilities.

relative precision – Measures the expected error bound of an estimate on a normalized basis. It must be expressed for a specified confidence level. The relative precision (*RP*) of an estimate at 90% confidence is:

$$RP = 1.645 \frac{CV}{\sqrt{n}} \sqrt{1 - \frac{n}{N}}$$

where *n* is the sample size, *N* is the population size, and the coefficient of variance is *CV* = standard deviation / estimate mean value. The square root expression at the end of the equation is the finite population correction factor, which becomes inconsequential and unnecessary for large populations.

realization rate – The term is used in several contexts in the development of reported program savings. The primary applications include the ratio of project tracking system savings data (e.g., initial estimates of project savings) to savings that (1) are adjusted for data errors and (2) incorporate evaluated or verified results of the tracked savings. In the Updated Guidelines, the realization rate does not include program attribution.

savings realization rate (RR) – The ratio of the field of evaluation energy savings to the program's claimed savings. The RR represents the percentage of program-estimated savings that the impact evaluation team estimates as being actually achieved based on the results of the evaluation M&V analysis.

SEER (Seasonal Energy Efficiency Ratio) - SEER is defined as the total cooling output (in British thermal units or Btu) provided by the unit during its normal annual usage period divided by its total energy input (in watt-hours) during the same period.

self-reported approach (SRO) – A method for gathering program attribution data through direct interviews with participants.

smart strip – A power strip that uses a master/slave configuration to allow the operational status of one plugged-in appliance to dictate whether or not power is supplied to the other outlets (appliances).

snapback – Snapback occurs when customers actually increase their energy consumption due to reductions in the cost of energy.

spillover (SO) – Includes **participant spillover (PSO)** and **nonparticipant spillover (NPSO)** – Reductions in energy consumption and/or demand caused by the presence of the energy efficiency program, beyond program-related gross savings of participants.

PSO occurs when additional actions are taken to reduce energy use at the same site, but these actions are not included as program savings.

NPSO is the reduction in energy consumption and/or demand from measures installed and actions taken or encouraged by nonparticipating vendors or trade allies because of the influence of the program.

stratified ratio estimator (SRE) – An efficient sampling design combining stratified sample design with a ratio estimator. It's most advantageous when the population has a large coefficient of variation (CV). (A large CV occurs, for example, when a substantial portion of the projects have small savings and a small number of projects have very large savings.) The ratio estimator uses supporting information for each unit of the population when this information is highly correlated with the desired estimate to be derived from the evaluation, such as the tracking savings and the evaluated savings.

The RR calculation for electric energy is shown below:

$$RR = \frac{kWh_{Evaluation}}{kWh_{Program}}$$

Where, RR is the savings realization rate, $kWh_{Evaluation}$ is the evaluation M&V kWh savings (by evaluation M&V contractor), and $kWh_{Program}$ is the kWh savings claimed by program.

TMY3 – Typical meteorological year weather data.

thermostatic radiator valves (TRV) – TRVs regulate the flow of water through the radiator based on achieving a desired air temperature.