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Energy Efficiency / Demand Response Plan: Plan Year 4 (6/1/2011-5/31/2012)

Final Evaluation Report:

Central Air Conditioning Efficiency Services (CACES) Program
Final

Presented to

Commonwealth Edison Company

February 25, 2013

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E. Executive Summary

This document is the Evaluation Report of the ComEd Residential Central Air Conditioning Efficiency Services (CACES) program for program year 4 (PY4). This evaluation describes the PY4 evaluation activities, findings, and recommendations for ComEd's CACES program. Due to results which did not meet ComEd's efficiency savings expectations for the first two years of the program (PY2 and PY3), ComEd elected to sunset CACES during the middle of PY4 - thus this report is the final evaluation report for the program.

As conceived, the main goals of the CACES program are to increase the efficiency of existing air conditioning equipment and promote the quality installation of high-efficiency equipment in replacement situations and in new construction. The program also seeks to improve the overall quality of residential HVAC services by increasing the visibility of participating independent contractors as vendors focusing on quality and using state-of-the-art diagnostic tools.

The residential CACES program consists of two distinct programs serving different markets through a common marketing and delivery infrastructure. The Diagnostics and Tune-Up program targets improved efficiency for existing residential air conditioning equipment. The Quality Installation program addresses high-efficiency equipment installations for new and replacement air conditioning equipment. Both of these programs are co-marketed and branded as CACES and they have the same administrative staff at ComEd, Implementation Contractor (IC) and network of independent participating contractors that deliver the programs to consumers. Because of the close links between these programs, the Evaluator is submitting a single unified report for CACES.

E.1 Evaluation Objectives

The primary objectives of the Impact Evaluation are to review and verify or adjust reported savings for both the Quality Installation and Diagnostics and Tune-up programs. Due to the sunset status of the program there is no Process Evaluation for PY4.

E.2 Evaluation Methods

Since this program will not be offered in future program years, Navigant and ComEd chose to reduce the evaluation activities in PY4. For the Diagnostics and Tune-Up program, the evaluation used PY4 tracking system data and prior analysis of load research data for hours of operation to re-estimate savings on a site-by-site basis. No verification or measurement data were collected on-site in PY4. The Quality Installation program impact evaluation will use PY3 per participant, weather-normalized results applied to PY4 participation records in the tracking system. No new billing analysis was conducted for PY4.

There were no process evaluation interviews conducted for the CACES Program in PY4.

E.3 Key Impact Findings and Recommendations

Participation in the CACES programs reflects the sunset status that became effective during September 2011. ComEd ceased promoting the programs at that time and paid its last incentive in November 2011. Progress towards PY4 goals is not relevant to a sunset program.

The impact results for the Diagnostic and Tune-Up program and the Quality Installation program are shown in Table E-1 and Table E-2, respectively. The combined CACES results are shown in Table E-3.

Diagnostics and Tune-Up program savings *per participant* exceeded *ex ante* values in PY4. This result is due to measured baseline performance of serviced equipment in PY4 which was worse as compared to PY3. Planned savings per participant had been sharply reduced to reflect the evaluation results from prior program evaluations[1]. Despite the better PY4 results per participant, the factors contributing to low savings in PY2 and PY3 appear to persist. These include:

1. Poor economic conditions might mean that fewer home owners elected to perform preventative maintenance service on AC equipment[2], unless they have annual service contracts where equipment is serviced unless refused. Among PY4 participants, 37.5% also participated in PY2 or PY3. Annual service should serve to increase the initial baseline efficiency of central air conditioners.
2. Conversely, homes that might have less efficient equipment perhaps did not get tune-ups because of the economy.
3. Hours of operation have been over-estimated in *ex ante* simulations. Residential behavior is extremely difficult to capture in simulations.

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[1] PY2 results were lower than the original *Commonwealth Edison 2008-2010 Energy Efficiency and Demand Response Plan*, November 15, 2007 due to lower estimates of hours of operation and baseline equipment efficiency that was better than anticipated during PY2. PY3 evaluation results confirmed hours of operation and baseline unit efficiency prior to tune-ups, thus savings per unit was relatively unchanged.

[2] http://www.prweb.com/releases/2012/7/prweb9686858.htm "Maintaining, monitoring and repairing existing equipment also accounts for a significant share of revenue, lending the Heating and Air Conditioning industry some stability amid the volatile construction markets of recent years, but also making it susceptible to changes in the levels of disposable income," says IBISWorld industry analyst Andrea Alegria."

Table E-1. *Ex Post* Program Savings - Diagnostics and Tune-Ups

	PY4 *Ex Ante*[1]	Evaluated PY4 Gross	Evaluated PY4 Net*	Realization Rate
Participants (#customers)	9,969	9,973	9,973	100%
Energy Savings (MWh)	2,084	2,133	2,133	102.4%
Demand Savings (MW)[2]	NA	2.89	2.89	NA

1 Based on ComEd's reported Ex Ante estimates
2 ComEd does not have demand savings goals for this program
** Net-to-Gross ratio = 1.0 for PY4 evaluation*

Persistence of tune-up savings was not part of the impact evaluation in PY4 due to the program sunset. By comparing PY3 post-installation performance to PY4 pre-installation performance we see some decrease in the efficiency index. A drop of 5% in performance from one year to the next is typical.

Program participation in the Quality Installation program also reflects the program sunset decision. The last installation for the Quality Installation Program occurred at the end of September 2011. Evaluated savings is based on the per unit savings determined with the PY3 billing analysis.

Table E-2. *Ex Post* Program Savings - Quality Installation

	PY4 *Ex Ante*	Evaluated PY4 Gross	Evaluated PY4 Net*	Realization Rate
Participants (#customers)	1,000	1,007	1,007	100.7%
Energy Savings (MWh)	400	438	438	109.5%
Demand Savings (MW)[2]	NA	0.66	0.66	NA

1 Based on ComEd's reported Ex Ante estimates
2 ComEd does not have demand savings goals for this program
** Net-to-Gross ratio = 1.0 for PY4 evaluation*

Table E-3. *Ex Post* Program Savings – CACES (combined)

	PY4 *Ex Ante*	Evaluated PY4 Gross	Evaluated PY4 Net*	Realization Rate
Participants (#customers)	10,969	10,980	10,980	100.1%
Energy Savings (MWh)	2,484	2,571	2,571	103.5%
Demand Savings (MW)	NA	3.54	3.54	NA

Source: Program Database and Navigant Analysis

Navigant notes that these results represent the third year of operation for this program. The program is innovative in its use of smaller vendors to market and deliver the program. Outreach to participating contractors and consumers had ambitious goals to grow the program and change the way HVAC service is delivered in the ComEd service territory. The impacts of a poor economy may have disproportionately contributed to the sunset of the program.

In PY3, an assessment of the net-to-gross ratio, NTG, was made through interviews with independent participating and non-participating air conditioning contractors. Since the incentive is paid to the contractors, changes in contractor behavior were used to determine the net-to-gross ratio. Interview responses supported NTG near 1.0: contractors have improved their tune-up techniques using more sensors and data to optimize equipment. It was found that when sizing and installing equipment they are more likely to use more rigorous and accurate techniques than they were without the program. Navigant did not conduct additional NTG research in PY4. As a result our NTG estimate remains 1.0.

E.4 Key Process Findings and Recommendations

Due to the program sunset, there is no Process Evaluation to report in PY4.

E.5 Conclusions

This final evaluation of the CACES programs has mixed results in PY4. The Diagnostics and Tune-up realization rate is high due to servicing equipment with lower baseline efficiency indices (e.g., equipment had degraded performance prior to tune-up) as compared to prior program years. The Quality Installation realization rate is near 100%, but the *ex ante* savings per participant for both programs were revised downward from the initial program plans, thus overall program savings is somewhat disappointing for this program which has been described as innovative.

The Net-to-Gross estimate for both programs remains at 1.0. Contractor interviews conducted in PY3 confirm that they have, in general, implemented more rigorous and improved methods for equipment service, sizing and installation. Improved practices have also carried over into service territories outside of ComEd's territory which suggests some market transformation is occurring, possibly due program activity.

Persistence of savings also appears to be good. Many PY4 participants also participated in PY2 and/or PY3. Navigant saw small (about 5%) year-to-year decreases in the performance of equipment as measured by the efficiency index on the service equipment. While savings persistence is encouraging, it does also depress program savings when participants get annual tune-ups through the program.

1. Introduction to the Program

The residential Central Air Conditioning Efficiency Services (CACES) program consists of two distinct programs serving different markets though a common marketing and delivery infrastructure. The Diagnostics and Tune-Up program targets improved efficiency for *existing* residential air conditioning equipment. The Quality Installation program targets residential *new and replacement* air conditioning equipment. Both of these programs are co-marketed and branded as CACES and they have the same administrative staff at ComEd, Implementation Contractor (IC), and independent participating contractors who deliver the programs to consumers.

Due to poor savings performance in PY2 and PY3, ComEd sunset the program mid-way through PY4 and the program will not continue past PY4.

1.1 *Evaluation Questions*

The PY4 evaluation sought to answer the following key researchable questions.

<u>Impact Questions:</u>

1. Estimate verified gross program impacts for electric energy and demand.

<u>Process questions:</u>

No process evaluation was conducted, thus no process questions were researched.

1.2 *Implementation Strategy*

1.2.1 Roles of the Implementation Contractor

Honeywell Utility Solutions is the Implementation Contractor for the CACES program. Together, ComEd and Honeywell recruited independent participating contractors to deliver the program through their normal business activities. Honeywell and their partner, Field Diagnostic Services, Inc. (FDSI), sold the equipment required[3] of the contractors and conducted

[3] Both programs required contractors to use the Service Assistant (SA) diagnostic tool to measure and report field data. This tool is designed and sold by FDSI. It incorporates electronic sensors to measure system temperatures and pressures which are linked back to a PDA device that compares field data with expected values given the nameplate information of the unit. Programmed diagnostic logic suggests corrective courses of action to optimize sensor outputs and thus unit efficiency and capacity. The principle is that this device is superior to traditional gauges used by contractors, because it has expert logic built in and sensor readings are compared simultaneously to get a more

Business and Technical training sessions for the program and the diagnostic equipment, respectively. Honeywell is also responsible for day-to-day program administration, including conducting quality control activities, maintaining consumer and participating contractor relations and administering data flow during the program cycle using the FDSI databases and field data collection protocols.

1.2.2 Program Timeline

The seasonality of cooling in Illinois forces the program delivery timeline to be out-of-synch with the program year reporting structure, which is June 1 – May 31. Recruiting and training of independent participating contractors occurred year-round, but was concentrated in the spring of the prior program year. Likewise, much tune-up activity occurs in the spring. Roughly 50% of equipment installations and tune-up activities incented through the program are performed from late April to the end of May at the end of the one program year and the rest occur June through September at the beginning of the next program year.

1.2.3 Program Delivery Mechanisms and Marketing Strategy

The CACES program is delivered through a network of independent participating HVAC contractors operating in ComEd's service territory that have been trained in program protocols and participation processes. ComEd and the IC conducted multiple recruitment and training events to inform contractors of opportunities and incentives available through the HVAC Diagnostics & Tune-Up program and the New HVAC with Quality Installation program.

Contractor training had two parts. Technical training addressed the use of diagnostic tools to check refrigerant charge and airflow over AC system coils and was targeted toward the field technicians. Business training was targeted to the office staff of the HVAC contractors to make them familiar with the program administrative requirements and assist with the marketing aspect of the program.

The diagnostic process is based on an automated analysis of the manual and automated sensor inputs to the SA provided by the technician. The SA tool suggests changes to refrigerant charge, general service and/or airflow based on operating data, and the technician then makes the necessary modifications. Use of the diagnostic tool and the extra time adhering to the protocols are additional costs to the HVAC contractors, but the resulting diagnosis and repairs should provide better service for consumers. ComEd seeks to encourage improved service and offset the additional costs with incentives that are paid to the HVAC contractor on a per job basis. The

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accurate snapshot of system performance. The Service Assistant also uplinks field data to the FDSI data server where data are compiled for reporting to Honeywell and ComEd.

contractors have the option of passing the incentive through to the consumer in the form of a lower fee for the service, or retaining the incentive, depending on their own marketing strategy.

The HVAC Diagnostics & Tune-Up program is aimed at the mass market and, as such, requires a higher level of marketing activity to capture consumers' attention and generate sufficient project flow.

1.2.4 HVAC Contractor Participation and Incentives

In its third year, the program has seen continued strength in HVAC contractor participation. More than one hundred and thirty different contractors have purchased more than 270 Service Assistant tools for the program. ComEd feels that this data demonstrates the potential wide reach of the program.

Contractors gain several benefits through program participation. They can represent that they perform a premium service, they gain marketing visibility with listing among program independent participating contractors, and there is a cash incentive paid to contractors. Payments are based on the number of service calls that pass ComEd-established criteria. ComEd payments decreases with the volume of service calls completed, but volume eligibility is determined for each Service Assistant tool. This incentive design serves several purposes: successful contractors will have multiple tools in the field; incentives are front loaded to speed the payback of the investment the contractor made with the Service Assistant and limits ComEd financial exposure if the program is over-subscribed.

Table 1-1. Incentive Structure

		Incentive Revenue Earnings Per Individual Service Assistant Tool		
		$0 - $10,000	>$10,000	Over Subscription
Incentive Level	Tune-Up	$100	$50	$10
	Quality Installation & Right-sizing	$150	$100	$10
	SEER 14 or better	$150	$100	NA

Source: CACES Participating Contractor Agreement – Attachment A 4/10/2009

Diagnostic and Tune-Up incentives were only paid if the service call "passes" certain performance criteria. The contractor must use the Service Assistant (SA) tool to assess the equipment performance; perform basic service to the unit as needed, including coil cleaning and filter changes; check thermostat operation; document a post service efficiency index (EI) greater than 90% as determined by the SA; review results with the consumer; and transmit data to program tracking database. If after completing all of the applicable corrective actions listed above, a system fails to meet the 90% EI threshold, but does have an efficiency index of at least 85% or achieves an efficiency gain of at least 10% points, it will be eligible for a tune-up incentive, providing the contractor performs the following:

a. Determines and documents the cause(s) for the system's reduced efficiency index.

b. Provides customer with a written explanation of the deficiency and an estimate to correct it.[4]

The Quality Installation and Right-Sizing criteria for passing and earning an incentive include: using the SA to document a final efficiency index of greater than 90%; documented use of Manual J procedures and calculations to select the capacity of the equipment. An alternate path to incentives is also provided for equipment installed on deficient existing ductwork:

> *Installations that utilize a home's existing ductwork and fails to achieve an EI of at least 90%, but do achieve an EI of at least 85% after the contractor has performed the air flow corrections/adjustments listed below, will be eligible for a QIV incentive, if the reduced efficiency is related to a deficiency in the system's ducting, provided the contractor provides the customer with a written explanation of the deficiency and an estimate to correct it.*
>
> *Air-flow corrections/adjustments:*
>
> » *Adjust trunk and branch dampers as required*
> » *Check and adjust supply registers*
> » *Verify proper fan speed (correct if required)*
> » *Ensure that no return vents are blocked or covered*

Additional Quality Installation incentives are earned if the unit installed is SEER 14.0 or better.

[4] CACES Participating Contractor Agreement – Attachment B Tune-up process 4/10/2009.

2. Evaluation Methods

For the CACES Program in PY4, the Navigant Consulting team focused on estimating savings with data collected through the program and prior year billing analysis.

2.1 *Analytical Methods*

2.1.1 **Impact Evaluation Methods**

The Diagnostic and Tune-up and Quality Installation programs benefit from two different evaluation approaches with complementary data – engineering assessment and billing analysis.

2.1.1.1 Diagnostics and Tune Up

Residential air conditioning energy use is typically that of an on/off device. There is some minor unit performance variation, relative to outdoor ambient temperature, and some new and high-efficiency machines have variable airflow and compression controls, but most air conditioners installed in the residential market turn on, use a constant power draw to serve the cooling needs of the home, and then turn off. As such, electric demand can be characterized by:

Rated Unit Efficiency (kW/ capacity) x *in situ* efficiency adjustments x Capacity = Unit kW

Total air conditioning energy use is determined by multiplying Unit kW by the hours of operation for a given unit. Hotter and more humid outdoor conditions typically result in longer hours of operation.

Unit kW x hours of operation = annual kWh

The independent participating contractors recorded rated unit efficiency and capacity based on nameplate data and used the Service Assistant diagnostic tool (required for the program) to determine adjustments to efficiency. The Navigant Consulting analyzed whole-house load research data to estimate air conditioning hours of operation.

2.1.1.2 Quality Installation

The Quality Installation program includes two separate features: (1) improved installation techniques that achieve operating efficiency closer to manufacturer specifications, and (2) installation of equipment with rated efficiency greater than federally mandated minimum standards (currently SEER 13.0). Given the size of the participant population, the evaluation for this program uses a fixed-effects billing analysis for the participants. The PY3 evaluation report includes details on the billing analysis methods, model and results.

2.1.1.3 *Gross Program Savings*

For the Diagnostic and Tune Up Program Navigant estimates the gross program savings based on unit-by-unit estimates of demand saving for a census of participants. The estimates are based on unit nameplate information collected by participating contractors and the efficiency index from the Service Assistant determined during pre- and post-service tests. Energy savings are the product of demand savings and estimated hours of operation by climate zone.

For the Quality Installation Program the PY3 billing analysis resulted in estimates for energy savings per home per Cooling Degree Day. Gross program savings is the product of participation, savings per CDD and normalized annual CDD. Due to the program sunset, PY3 per participant results are applied to PY4 participation.

2.1.1.4 *Net Program Savings*

In PY3 the Navigant Team interviewed independent participating contractors for indications of free-ridership and spillover (net-to-gross- NTG - in combination). Net savings is the product of gross savings and the NTG factor. Navigant found little indication of free-ridership or spillover within ComEd's service territory. Navigant did not conduct any additional NTG research in PY4 and PY3 estimates for NTG are used in PY4.

2.1.2 **Process Evaluation Methods**

Navigant did not conduct a process evaluation for the CACES program in PY4.

2.2 *Data Sources*

For both the Diagnostics and Tune-Up and Quality Installation programs, ComEd provided participation records as part of the Program Tracking Database administered by ComEd and the implementation contractor. The criterion used to determine participation was whether an incentive check was authorized for a particular consumer. This criterion excluded consumers with data in the database that might have been excluded from the program because the service address was not in the ComEd service territory, or they did not meet the program criteria of sufficient performance improvement.

2.2.1 **Diagnostics and Tune-Up Data**

In addition to tracking program participation metrics, the program tracking database contains key equipment performance data collected by independent participating contractors in the field and uploaded to the FDSI data server. These data include: equipment make and model information, rated capacity and efficiency, plus other equipment and site-related fields. Furthermore, the database includes all pre-implementation and post-implementation performance data generated by the Service Assistant from each of the units serviced that earned program incentives. Thus, the program tracking database is the primary source of program data used in the evaluation.

As in PY2, in PY3 Navigant estimated equipment runtime by analyzing load research data for almost 2,000 customers covering the 2008 – 2010 calendar years. This source of data was chosen because Navigant and ComEd had reservations about using a smaller sample of end-use metered data during a recessionary period.

2.2.2 Quality Installation Data

The Quality Installation Program participants had similar data in the program tracking database, except that only post-installation data are captured with the Service Assistant. In PY4 Navigant used these data only to establish the number of quality installation participants by dwelling type and climate region. The PY3 billing analysis established per unit savings. See the PY3 report for billing analysis details.

2.2.3 Process Evaluation Data

Due to the program sunset, Navigant did not conduct process research for PY4.

3. Program Level Results

3.1 *Impact Results*

In the *Energy Efficiency and Demand Response Plan*, ComEd estimated savings from the Diagnostics and Tune-Up program and the Quality Installation program with eQuest energy simulations of three residential types: multifamily, single-family attached, and single-family detached. The models were run with three weather data sets: Chicago, Rockford and Moline. Hours of operation will depend on the weather region and interior comfort set points.

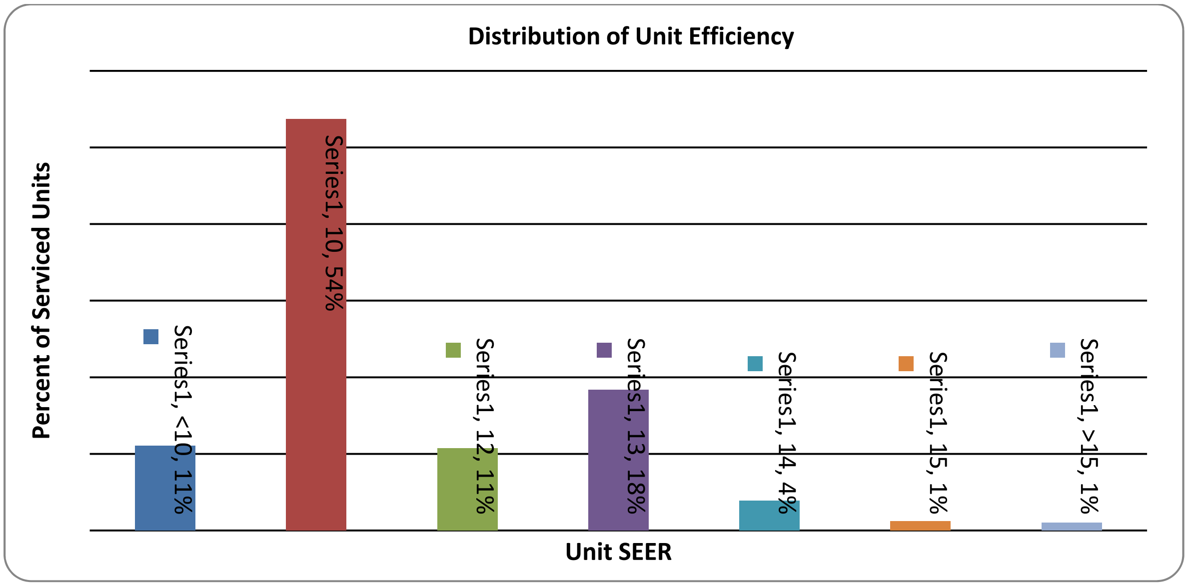
3.1.1 **Verification and Due Diligence**

In PY4 Navigant did not conduct activities to specifically verify data and examine program quality control. Prior evaluations indicated quality data are tracked in the database, and due to the program sunset additional resources were not applied to verification and due diligence questions. Navigant re-affirms prior conclusions that tracking data accurately describe affected equipment and measured performance.

Figure 3-1 is a histogram of installed rated unit efficiencies recorded among all PY4 participants. The figure shows that SEER 10 machines that met recently-superseded minimum efficiency dominate the population. Newer machines that meet the current federal minimum efficiency of SEER 13 have significant market penetration. Comparing PY4 data to PY3 and PY2 we see fewer SEER 10 or lower machines in the population as those units are retired and more SEER 13.0 and higher machines[5] are installed. Figure 3-2 shows the distribution of equipment size among program participants. The average machine is 2.85 tons capacity – roughly unchanged among prior program years.

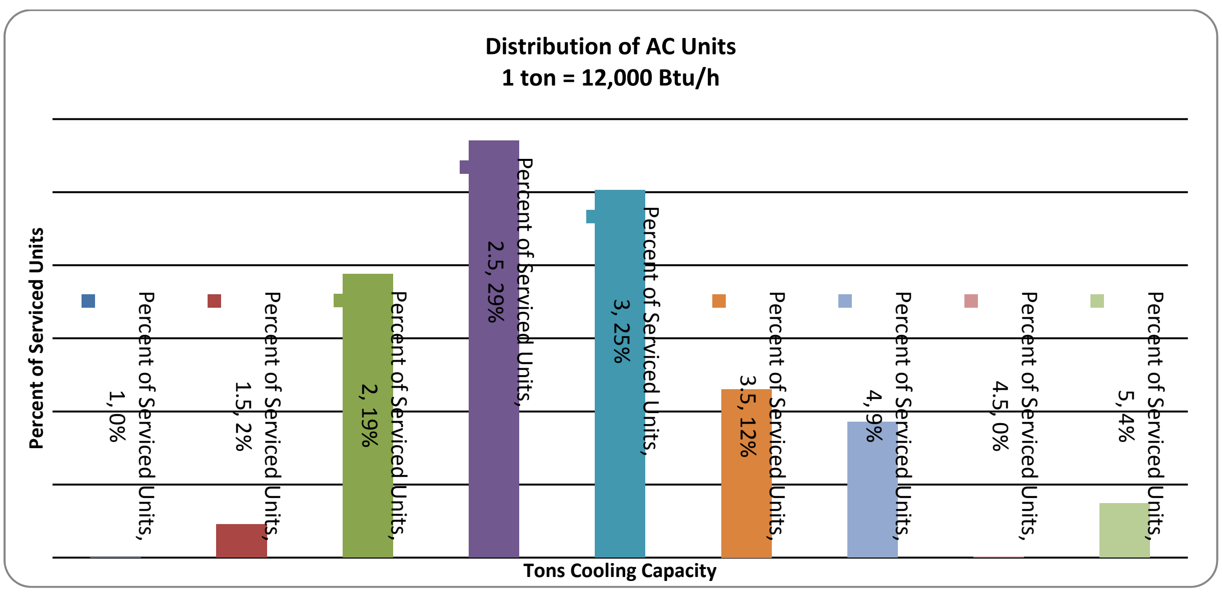
[5] Units SEER 10 and less than SEER 10 comprised 56% and 17% of PY2 participants or 73% combined. The same efficiency units comprise 70% of the PY3 participants and 65% of PY4 participants.

Figure 3-1. Distribution of AC Unit Efficiency among All Participant Consumers



Source: Program Database

Figure 3-2. Distribution of AC Unit Capacity among All Participant Consumers

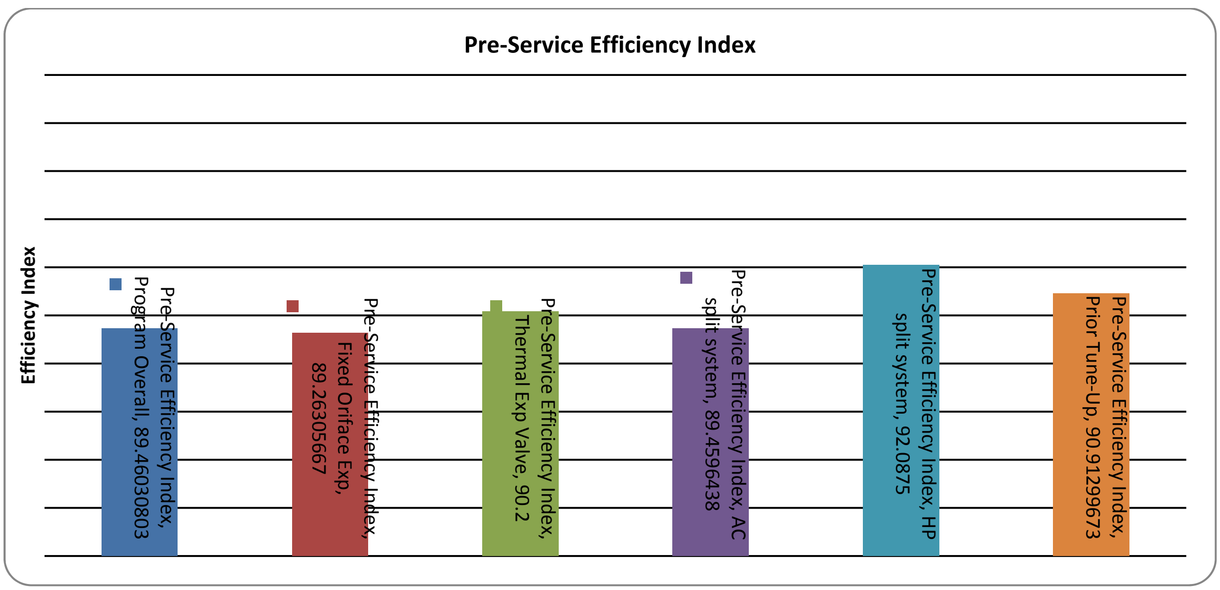


Source: Program Database

The efficiency index, EI, is the target parameter of the diagnostic program. A quality tune-up will increase the EI from a low value toward a target of 100. In the program planning stages, the assumed efficiency index on units before service was about 80 based on an operating SEER of 8.0 for machines rated at SEER 10.0. The program plan assumed the effective SEER would rise from 8.0 to SEER 10.16 post service. Incentives are generally earned for increasing the EI to above 90[6]. Field data on *pre-service* units show an average EI of 89.5. After service the average EI was 98.6. The increase in the EI is significant at the 90% confidence level; however, it is not the magnitude expected for a cost-effective program.

PY4 participants who also participated in prior years had an average pre-service EI of 90.9. The higher pre-service EI for this group, though not statistically different at 90% confidence, may be an indication of persistence and it may point out the effect on the overall program performance. Figure 3-3 shows pre-service EIs for different groupings of participants. The average PY4 pre-service EI is significantly lower than PY2 and PY3 (approximately 93.0 to 94.0). Post-service EIs were not different among groups of customers at statistical significance, indicating relatively uniform post tune-up performance among these groups.

Figure 3-3. Pre-Service Efficiency Index – Select participant groupings



Source: Program Database

[6] See Table 1-1 and program incentives discussion.

Run Hours of Operation

The *Energy Efficiency and Demand Response Plan* based savings estimates on simulations of typical single-family attached and detached homes and multifamily residential units using weather data from the Typical Meteorological Year 2 (TMY2) dataset. The simulations do not explicitly list the run hours of air conditioning equipment, but during training sessions for the Service Assistant, Honeywell and ComEd staff recommended using 742 hours.[7] .

Ideally, measured run-time would be the basis of program runtime estimates. A runtime study for the PY2 CACES Program evaluation yielded uncertain results due to extra-ordinarily cool weather and economic conditions. Similar concerns preceded the PY3 evaluation cycle, thus further end-use monitoring was not implemented. Instead in PY3 Navigant analyzed a data set of about 2100 residential load research customers for 2008-2010. The analysis had several steps.

1. Each customer's data was examined to determine whether summer daily average consumption was at least 6% higher than individually determined baseline periods[8] as an indication of AC operation.
2. Customers with an indication of AC were further filtered to eliminate those with outlier data, such as total consumption less than 100 kWh per month or anomalously high individual hourly consumption data.
3. Customers were assigned to one of three representative weather stations based on location.
4. Consumption of load research data was pooled by weather station and we performed a linear regression with daily Cooling Degree Days CDDd.
5. Energy use above the baseline was assumed to be cooling related, and cooling energy was converted to hours of use per customer using average unit efficiency and size from the prior analysis.
6. Runtime estimates were normalized to TMY2 data for an entire cooling season.

Navigant did not repeat this analysis in PY4, and we used the hours of operation values derived in PY3.

[7] 742 hours is the average of Rockford, Moline and Chicago as provided by an Energy Star Savings Calculator: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls.
[8] Baseline periods are typically in April and May when neither heating nor cooling are expected.

Table 3-1. Weather Normalized Run-Time Hours Estimated with Load Research Data

Weather Station	Single Family[a]	Multi-Family
Chicago	561 hours	500 hours
Rockford	519 hours	474 hours
Moline	620 hours	610 hours

[a] load research data did not distinguish between single-family attached and detached dwelling types.
Source: Navigant Analysis

Table 3-2. Diagnostics and Tune-up *ex Post* Savings by Residence Type

	Ex Post kWh/participant	*Ex Post* kW/participant
Multi-Family	172	0.381
Single Family Attached	203	0.408
Single-Family Detached	221	0.446

Source: Navigant Analysis

3.1.1.1 *Quality Installation*

The results billing analysis performed in PY3 are shown in Table 3-3. Results are weather-normalized to NOAA 1981-2010 Climate Normals data (Typical Meteorological Year). The analysis included a census of PY2 and PY3 participants using a fixed-effects model where participants are compared to their own history.

Table 3-3. Predicted Cooling Season[15] Energy Savings per Residence – Quality Installation

	Single Family Detached[a]	Single Family Attached[a]	Multi-Family[b]
SEER 13	387 kWh	279 kWh	339 kWh
SEER 14+	600 kWh	513 kWh	604 kWh

[a] load research data did not distinguish between single-family attached and detached dwellings.
[b] Confidence intervals are expressed at the 90% two-tailed. A smaller multi-family population results in a wider confidence interval.

Results are attended by important caveats also noted in the PY3 evaluation:

Overall, the total number of billing analysis records was 11,467, and the number of post-installation records was 6,297, which is an average of more than 2.6 post-installation cooling season records per residence.

Finally, there exists the possibility that estimates are confounded by exogenous temporally-correlated factors, in particular, the economic recession that began in December 2007 and the weak recovery that persists. This creates possibly serious estimation issues and could be resolved in subsequent analyses by including in the data billing records for residential customers who *did not* install a new AC unit.

3.1.2 **Gross Program Impact Results**

3.1.2.2 Diagnostic and Tune-Up

Navigant Consulting reviewed the participation data from the tracking system, and we determined that there were 9,973 documented participants in the database. The criteria for PY4 participation were an incentive check date on or after June 30, 2011 and an incentive paid greater than $10. The late June cut-off date extends beyond the prior program year which ended on May 31, 2011. The extra time permitted ComEd to fully process payments for units serviced in PY3. The incentive threshold eliminated a few test records that had carried through the database.

Savings from the tune-up program are the result of improved effective efficiency of the equipment and equipment run-hours. For each participant, we used inputs for equipment capacity, unit EER[9], pre-service and post-service efficiency adjustments to estimate unit power savings. Energy savings is the product of average unit power savings[10] and runtime. Normalized run hours were determined with the most appropriate of the three weather stations for each participant.

Table 3-4 presents planned savings for each segment compared to the evaluated savings estimates for the three residential segments, averaged among all three weather stations. Savings among all market segments is higher than the plan estimates because pre-service equipment was in worse shape than anticipated based on prior participation.

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[9] Residential air-conditioners are generally rated in SEER (Seasonal Energy Efficiency Ratio) which accounts for operating conditions both during the most oppressive outdoor heat and during more typical non-peak demands. Unit demand savings is a function of EER which is the efficiency at peak only. Navigant applied correlations (California Energy Commission 2005) of unit SEER and EER to determine EER values given rated SEER.

[10] SEER values are used to calculate seasonal average power savings.

Table 3-4. Average Diagnostic and Tune-up Savings for Different Customer Types

	Planned *(Ex Ante)* kWh/participant	Evaluated *(Ex Post)* kWh/participant
Multi-Family	148	172
Single Family Attached	163	203
Single-Family Detached	221	221

Source: Navigant Analysis

Table 3-5. Customer Participation by Building Type

	Participation
Multi-Family	1,040
Single Family Attached	1,253
Single-Family Detached	7,680

Source: Program Database

Table 3-6. *Ex Post* Program Savings – Diagnostic & Tune-Up

	PY4 *Ex Ante* Saving	PY4 Evaluated *ex post* Gross	Realization Rate
Participants (#customers)	9,969	9,973	100%
Energy Savings (MWh)	2,084	2,133	102.4%
Demand Savings (MW)	NA	2.89	NA

Source: Navigant Analysis

Per participant *ex ante* energy savings had been adjusted downward based on the PY2 and confirmed by the PY3 evaluation. PY4 per participant *ex post* savings increased substantially as a result of poorer baseline performance of customer AC units (average SEER 9.7 performing in the field) as compared to the program plan (SEER 8.0) and prior year average (10.1 SEER).

3.1.2.3 Quality Installation

Navigant Consulting reviewed the participation data from the tracking system, and we determined that there were 1,007 documented complete PY4 participants.

Table 3-7 presents planned savings for each segment compared to the billing analysis unit savings estimates for three residential segments and the two types of Quality Installation criteria. All segments but High SEER single-family detached participants have a realization rate greater than 100%, but that one segment comprises 26% of all participants.

Table 3-8 shows that single family detached homes account for 80% of Quality Installation participants and high SEER machines account for 30% of installations. Overall Quality Installation program results are shown in Table 3-9. *Ex ante* demand savings are not tracked by ComEd.

Table 3-7. Average Quality Installation kWh Savings for Different Customer Types

	Plan kWh	Evaluated kWh	Realization Rate
Quality Installation SEER 13			
Multi-Family	63	339	538%
Single attached	180	279	155%
Single detached	312	387	124%
Quality Installation SEER 14+			
Multi-Family	1419	604	43%
Single attached	647	513	79%
Single detached	986	600	61%

Source: Plan Cycle 2 filing 10/1/2010 and Navigant Analysis

Table 3-8. PY4 Quality Installation Customer Participation

	SEER 13 Participants	SEER 14+ Participants	Total Participants
Multi-Family	49	11	60
Single-Family Attached	106	28	134
Single-Family Detached	549	264	813
Total	704	303	1007

Source: Program Database

Table 3-9. *Ex Post* Program Savings – Quality Installation

	PY4 *Ex Ante*	Evaluated PY4 Gross	Realization Rate
Participants (#customers)	1,000	1,007	100.7%
Energy Savings (MWh)	400	438	109.5%
Demand Savings (MW)	NA	0.66	NA

Source: Navigant Analysis

3.1.3 Net Program Impact Results

Due to the program sunset, no interviews were conducted for the program and no new net-to-gross research was conducted. Navigant applies the PY3 NTG ratio of 1.0 for energy and demand savings

3.2 *Process Evaluation Results*

Due to the program sunset, no process evaluation research was conducted for the program in PY4

4. Conclusions and Recommendations

The CACES Program was sunset by ComEd prior to October 2011which was approximately half way through its third year of implementation. While it fostered some good results as far as the delivery of quality HVAC services, there have been challenges to achieve the anticipated savings that would justify continuing the program.

4.1 *Program Impacts Conclusions and Recommendations*

The Diagnostic and Tune Up program has been sunset. The following conclusions and recommendations should be considered should the program be resurrected in future years.

For all years of operation, the program consistently enrolls consumers with equipment that is operating relatively well with average efficiency indices, EI, above 91 (100 = rated performance). Though a lower average EI was observed in PY4 (EI_{PY4} = 89.5) as compared to PY2 and PY3 ($EI_{PY2/3}$ = 92.0), efficiency indices, above 90 do not leave much room for improvement. Part of the cause of high initial EI is attributed to serviced equipment that receives annual or biennial service. More than 37% of PY4 participants also participated in PY2 or PY3. Analysis of their test data shows that a one year service interval tends to maintain fairly high performance year-to-year. It may also be that economic conditions causes owners of more distressed machines to postpone service, thus the program has not had a chance to benefit the most needy equipment.

> ***Recommendation.*** Consider targeting the program to equipment that does not receive annual service. Possibly pay a premium incentive for participants with poor initial EI or basing the incentive on EI improvement. Conversely, consider limiting incentives for annually serviced equipment.

The challenge for improving program impacts is finding the customers that will benefit the most from the program. This may entail more outreach directly to customers rather than contractors, but there must also be a value proposition for the customers. Some program dissatisfaction among customers is that they do not get an incentive directly.

> ***Recommendation.*** Consider marketing the program to consumers with tips to determining if their equipment operates poorly – Examples include: ice on suction lines, dirty condensers, poor air flow or inadequately cool supply air.

Runtime hours are also affecting realization rates for both programs. Our PY3 analysis of load research data leads Navigant to conclude that initial runtime estimates were over-estimated. Residential air-conditioning use is not as predictable as commercial space cooling. Homes are often vacant and un-conditioned during hours of peak cooling loads. Individuals have control over thermostats and on/off switches to control cooling.

Recommendation. Consider conducting more research into the hours of operation question. Use a broader and larger sample or sample from among load research customers to more accurately mine load research data for AC operation.

4.2 *Program Processes Conclusions and Recommendations*

No process research was conducted.

5. Appendices

5.1 *Data Collection Instruments*

None employed in PY4.

5.2 *Billing Analysis Details*

Billing Analysis: Model (Repeated from the PY3 report for reference only.)

We estimated a linear fixed effects model for air conditioning energy use. Such a model essentially creates a separate dummy variable for each residence in the analysis that captures all household-level effects. In particular, we begin with the linear model:

Equation 5-1

$$Kwhd_{kt} = \alpha_{k0} + \alpha_1 CDDd_t + \alpha_2 Post_{kt} \cdot CDDd_t + \alpha_3 Post_{kt} \cdot CDDd_t \cdot D_k + \boldsymbol{\beta}_1 \mathbf{X}_k + \varepsilon_k + \phi_{kt}$$

where $Kwhd_{kt}$ is the kWh per day consumed by household *k* in billing period *t*; $CDDd_t$ is the average cooling degree days (CDD per day) during the billing period; $Post_{kt}$ is a dummy variable denoting whether the billing period is before ($Post_{kt} = 0$) or after ($Post_{kt} = 1$) the installation of the new AC unit; D_k is a dummy variable taking a value of one if the new unit's SEER rating is 14+ and zero if the unit is SEER 13; $\mathbf{X}_k$ is a vector of other household/residence characteristics that may affect kWh usage, such as the size of the residence and the number of household members; ε_k is a term accounting for household-level unobservable variables; and ϕ_{kt} is a term accounting for other unobservable effects.

The fixed effects model defines the household-specific constant $\gamma_k = \boldsymbol{\beta}_1 \mathbf{X}_k + \varepsilon_k$ as a deviation from the mean constant α_{k0}. This deviation is treated as a parameter to be estimated, in which case we can rewrite Equation 1 as the fixed effects model:

Equation 5-2

$$Kwhd_{kt} = \alpha_{k0} + \gamma_k + \alpha_1 CDDd_t + \alpha_2 Post_{kt} \cdot CDDd_t + \alpha_3 Post_{kt} \cdot CDDd_t \cdot D_k + \varphi_{kt}$$

In the absence of a new installation, predicted kWh consumption per day for the average household is $Kwhd_{kt} = \alpha_0 + \gamma_k + \alpha_1 CDDd_t$. For a household with a new installation with an efficiency rating of SEER 13, the predicted consumption per day is:

$$Kwhd_{kt} = \alpha_{k0} + \gamma_k + \alpha_1 CDDd_t + \alpha_2 CDDd_t$$

and for a household with a new installation with an efficiency rating equal to or greater than SEER 14 it is:

$$Kwhd_{kt} = \alpha_{k0} + \gamma_k + \alpha_1 CDDd_t + \alpha_2 CDDd_t + \alpha_3 CDDd_t \cdot D_k .$$

The result of this specification is that the kWh savings from a cooling degree day is $-\alpha_2$ for the installation of a SEER 13 unit, and $-(\alpha_2 + \alpha_3)$ for the installation of a SEER 14+ unit.

Separate models were estimated for single family and multi-family residences. Estimation results are presented in Table 5-1 and Table 5-2. In both models, the null hypothesis of no fixed effects (no savings) is strongly rejected.

Table 5-1. Results for the Fixed Effects Regression Model: Single Family Dwelling

Variable	Parameter Estimate	Standard Error	T-statistic
$CDDd_t$	2.642	0.099	26.71
$Post_{kt} \cdot CDDd_t$	-0.478	0.058	-8.24
$Post_{kt} \cdot CDDd_t \cdot D_k$	-0.273	0.062	-4.42
Intercept	19.312	0.79	24.47

R-sq = 0.149; 9753 observations, 2007 households

Table 5-2. Results for the Fixed Effects Regression Model: Multi- Family Dwelling

Variable	Parameter Estimate	Standard Error	T-statistic
$CDDd_t$	1.782	0.181	9.84
$Post_{kt} \cdot CDDd_t$	-0.432	0.089	-4.9
$Post_{kt} \cdot CDDd_t \cdot D_k$	-0.34	0.176	-1.93
Intercept	4.759	1.397	3.41

R-sq: within = 0.146, between = 0.081, overall = 0.066; 1713 observations , 385 households

Key results are the following:

» For single family residences, the coefficient estimate for $CDDd_t$ estimate indicates that under baseline conditions, an additional $CDDd_t$ increases kWh usage by 2.64.

» For multi-family residences, the coefficient estimate for $CDDd_t$ estimate indicates that under baseline conditions, an additional $CDDd_t$ increases kWh usage by 1.78.

» The billing analysis cannot estimate demand (kW) savings directly, since billing data are monthly rather than hourly. Demand savings for the program are estimated using energy estimates from the billing analysis and runtime hours estimates from the Diagnostics and Tune-Up program.

Billing Analysis Inputs

The billing data included 2399 residences with 34,500 summer season billing records Several criteria for inclusion in the analysis reduced these counts:

» The analysis omitted the billing period in which the AC unit was installed.

» The analysis included only those billing periods for which the cooling degree days per day (CDDd) was at least 5.0. This was done to better isolate the effect of AC efficiency gains.

» The analysis excluded all installations for which there was not at least one feasible billing period before installation (i.e., a billing period with CDDd>5.0), and one feasible period after installation.

Because *ex ante* savings are based on dwelling type, Navigant Consulting conducted separate regression analyses for single-family and multi-family dwellings. After applying the inclusion criteria to the billing data, the PY3 pre-installation data set of single family residences consists of 2007 residences and 9753 billing record observations, the multi-family data consists of 385 residences and 1713 billing observations. The combined 11,467 observations and 2392 households provide on average 4,8billing record observations per household.

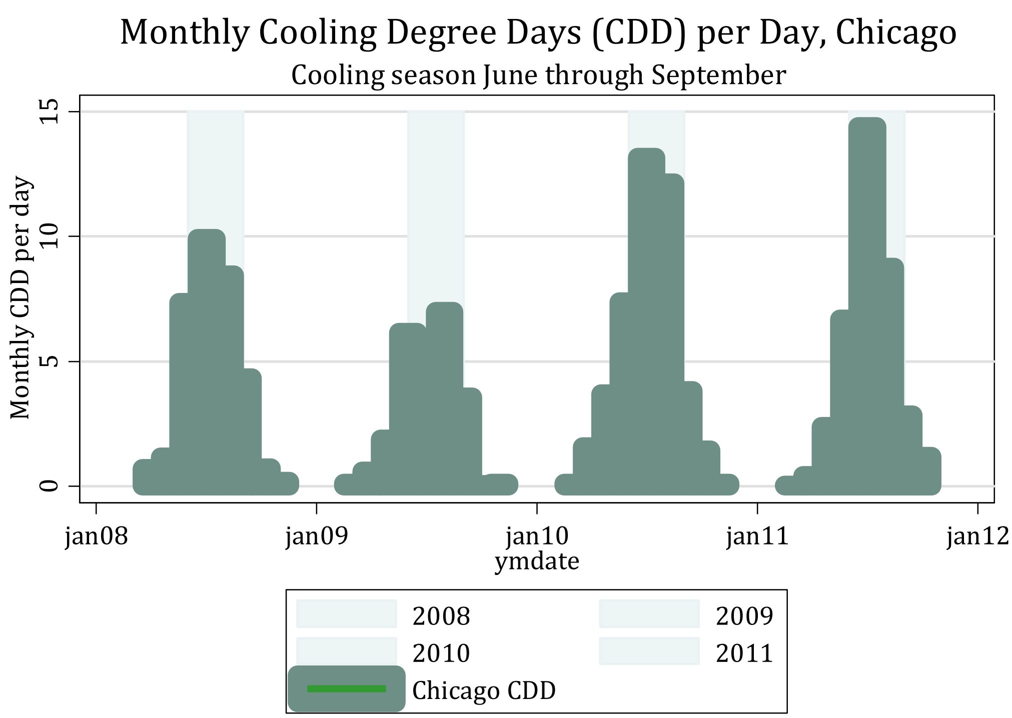
There were 6297 post installation observations for 2392 households, an average of 2.62 post installation billing records per household. Of these, there were 5128 post installation observations for 2007single households, an average of 2.56 post installation billing records per household. There were 1169 post installation observations for 385 of multi-family households, an average of 3.04 post installation billing records per household.

Table 5-3. Summary of the Data PY3 cooling season

Data Category	Number of sample *residences*	Number of sample *residences* w/ SEER 14+ installations	Number of *records*	Number of *records* w/ SEER 14+ installations	Number of post-installation *records*	Number of post-installation *records* with SEER 14+ installations	Post-installation *records* per Participant
Single-Family	2007	761	9754	3770	5128	1870	2.56
Single-Family Detached	1754	681	8520	3381	4471	1655	2.55
Single-Family Attached	253	80	1233	389	657	215	2.60
Multi-Family	385	35	1713	166	1169	97	3.04
Total	2,392	796	11,467	3,936	6,297	1,967	2.63

Figure 5-1 presents cooling degree days over the study period 2008-2010 at the Chicago O'Hare weather station. While the summer of 2009 was unusually cool, the 2010 cooling season was slightly warmer than long-term averages. In the typical meteorological year, the number of cooling degree days at O'Hare is 773; in the summer of 2009 it was 587. In 2010 the total was 1064

Figure 5-1. Daily Cooling Degree Days – Chicago O'Hare Airport 2007 - 2010



Source: http://www.degreeday.net