# Energy Efficiency / Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010)

# Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES)

## Presented to

**Commonwealth Edison Company**

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## Section E. Executive Summary

This document is the Final Evaluation Report of the ComEd Residential Central Air Conditioning Efficiency Services (CACES) program for program year 2 (PY2). It updates the May 2010 Preliminary Evaluation Report that included participant data through the fall of 2009. This document describes the PY2 evaluation activities, findings, and recommendations for ComEd's CACES program.

The main goals of the CACES program are to increase the efficiency of existing air conditioning equipment and promote the quality installation of new and 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 participating contractors as vendors focusing on quality and using sophisticated diagnostic tools.

The residential CACES program consists of two distinct programs serving different markets through a common marketing and delivery infrastructure. The first is the Diagnostics and Tune-Up program, which targets improved efficiency for existing residential air conditioning equipment. The second is the Quality Installation program that targets 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, to recommend general improvements to the savings estimation process, and to quantify gross and net savings impacts from review of the program tracking and engineering calculations. The Process Evaluation addresses key process-related program strengths and weaknesses and identifies ways in which the program can be improved.

### *E.2 Evaluation Methods*

The CACES program is a combination of two residential air conditioning programs, each of which requires a different impact evaluation approach. For the Diagnostics and Tune-Up program, the evaluation used on-site data collection, long-term monitoring, and analysis of load research data to determine impact parameters. This approach was selected because of the diagnostic technology deployed for the program and the diverse group of technicians that deliver the program to consumers. The Quality Installation program was planned to have thousands of participants with replacement equipment for which a billing analysis approach is a robust estimator of impacts.

Process questions and interviews with key personnel are common to both programs in CACES. The process evaluation employed in-depth interviews with key program personnel and HVAC contractors to research relevant process questions.

### *E.3 Key Findings*

The impact results for the Diagnostic and Tune-Up program and the Quality Installation program are shown in Table E-0-1 and Table E-0-2, respectively. The combined CACES results are shown in Table E-0-3. ComEd expects participation in the two constituent programs to be complementary, appealing to different market segments depending on weather conditions and economic drivers.

Diagnostics and Tune-Up program more than doubled its participation goals, but evaluated gross energy savings were much lower than ex ante estimated because of two prime factors – lower hours of operation (both *monitored* runtimes and estimations of runtime using load research data which were subsequently weather normalized) and baseline equipment efficiency conditions that were better than anticipated. The evaluation team posits several reasons for low run-time hours and high baseline efficiency:

1. The monitored low run-times is due to the combination of mild weather during the cooling season and poor national economic conditions.
2. There was no prolonged heat wave during the cooling season to spur AC use.
3. Poor economic conditions might mean that mostly homes with annual service contracts were tested with this program. Annual service should serve to increase the initial baseline efficiency of central air conditioners.
4. Conversely, homes that might have less efficient equipment perhaps did not get tune-ups because of the economy.

None of these hypotheses can be tested with the data collected in PY2. However, in order to exclude the economic effects, the evaluation used an alternate data set, load research data, for estimating run time hours. Diagnostic and Tune-Up program results using the load research data are shown in Table E-0-1. *Ex Post* Program Savings - Diagnostics and Tune-Ups

. The load research data also indicated fewer annual hours of operation than program planning estimates.

**Table E-0-1. *Ex Post* Program Savings - Diagnostics and Tune-Ups**

| | PY2 Goal | PY2 *Ex Ante* | Evaluated PY2 Gross | Evaluated PY2 Net* | Realization Rate |
|---|---|---|---|---|---|
| Participants (#customers) | 6,500 | 16,293 | 16,293 | 16,293 | 100% |
| Energy Savings (MWh) | 1,802 | 5,495 | 1,632 | 1,632 | 29.7% |
| Demand Savings (MW) | 2.9 | 9.02 | 3.24 | 3.24 | 35.9% |

* Net-to-Gross ratio = 1.0 for PY2 evaluation

The Quality Installation program faced similar weather and economic influences during PY2. Economic conditions and a mild summer resulted in far fewer participants than planned; therefore, the program fell far short of the goals. Though the results are weather-normalized, the savings among participating consumers was less than the ex ante estimates. The effects of the weak economy cannot be factored out of this analysis using fixed effect billing analysis.

**Table E-0-2. *Ex Post* Program Savings - Quality Installation**

| | PY2 Goal | PY2 *Ex Ante* | Evaluated PY2 Gross | Evaluated PY2 Net* | Realization Rate |
|---|---|---|---|---|---|
| Participants (#customers) | 17,460 | 871 | 871 | 871 | 100% |
| Energy Savings (MWh) | 7,227 | 477 | 332 | 332 | 69.6% |
| Demand Savings (MW) | 9.3 | 0.72 | 0.58 | 0.58 | 81.4% |

* Net -to-Gross ratio = 1.0 for PY2 evaluation

**Table E-0-3. *Ex Post* Program Savings – CACES (combined)**

| | PY2 Goal | PY2 *Ex Ante* | Evaluated PY2 Gross | Evaluated PY2 Net* | Realization Rate |
|---|---|---|---|---|---|
| Participants (#customers) | 23,960 | 17,164 | 17,164 | 17,164 | 100% |
| Energy Savings (MWh) | 9,029 | 5,972 | 1,964 | 1,964 | 32.9% |
| Demand Savings (MW) | 12.2 | 9.74 | 3.82 | 3.82 | 39.3% |

* Net -to-Gross ratio = 1.0 for PY2 evaluation

It is important to realize that these results represent the first year of operation for this program. The program is innovative in its use of generally small vendors to market and deliver the program. Outreach to participating contractors and consumers continues with high-level goals to grow the program and change the way HVAC service is delivered in the ComEd service territory. Furthermore, the impacts of a poor economy are very difficult to determine.

The qualitative assessment of net-to-gross, based on in-depth interviews with contractors, is a ratio of 1.0. A quantitative assessment was not possible with the survey methods deployed in PY2.

Future evaluations should include the following items:

1. Better estimates for equipment runtime. Improvements might include earlier installation of runtime equipment, a larger run-time evaluation sample, and a more diverse sample across the service territory or further analysis of load research data that integrates field data results.
2. Determine persistence of tune-up parameters. Do machines maintain higher efficiency indices for several years? Can the program be used to determine cost-effective tune-up intervals or flag units that are annual problems?
3. Quantitative net-to-gross determination. Are the independent participating contractors really changing their methods due to program influence or are they simply getting paid an incentive for the same scope of work with the same results that they achieved without the program?
4. Participant customer interviews. Are customers aware of the ComEd program and that their air-conditioning contractor is participating in the program? Do they preferentially select participating contractors? Are they satisfied with the services incented by the program?
5. Billing analysis of non-participants for quality installation. The fixed effect model used in PY2 is good for controlling for customer behavior, weather and demographics, but it does not account for changes in behavior induced by outside influences, such as the recession. A carefully constructed non-participant control group could account for economic effects.

# Section 1. Introduction to Program

## 1.1 Program Description

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 first is the Diagnostics and Tune-Up program, which targets improved efficiency for existing residential air conditioning equipment. The second is the Quality Installation program that targets 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.

Together, these programs represent about 3.25% of the planned MWh savings estimated for the three year *Energy Efficiency and Demand Response Plan 2008-2010* (*EE & DR Plan*), and they are allocated about 12.2% of the overall budget for the three-year planning cycle. Roughly 80% of the combined CACES planned savings and costs are attributed to the Quality Installation program.

Program goals from the original program plan[1] are shown in Table 1-1 and

Table 1-2. ComEd expects that economic conditions will dictate the participation of one program over the other. For example, the current recession might cause consumers to delay the purchase of new equipment and shift participation towards the diagnostic program to keep existing equipment operating longer.

**Table 1-1. Diagnostic and Tune-Up Program Goals**

| | PY 1 | PY 2 |
|---|---|---|
| Participation Goals | 0 | 6,500 |
| Energy Savings Goals (MWh) | 0 | 1,802 |
| Demand Savings Goals (MW) | 0 | 2.9 |
| Program Costs (millions) | $0.1 | $1.3 |

[1] *Commonwealth Edison 2008-2010 Energy Efficiency and Demand Response Plan*, November 15, 2007.

**Table 1-2. Residential New HVAC with Quality Installation Program Goals**

| | PY 1 | PY 2 |
|---|---|---|
| Participation Goals | 0 | 17,460 |
| Energy Savings Goals (MWh) | 0 | 7,227 |
| Demand Savings Goals (MW) | 0 | 9.3 |
| Program Costs (millions) | $0.0 | $4.5 |

Both programs kicked off in June 2009 at the start of PY2 in the Plan, though independent contractor recruitment began in January 2009 and continues as the program is implemented.

### 1.1.1 Implementation Strategy

**Roles of the Implementation Contractor**

ComEd selected Honeywell Utility Solutions to implement the CACES program. They were selected based on prior work on similar programs for other utilities and other factors. 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[2] of the contractors and conducted Business and Technical training sessions. Beyond training Honeywell is 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.

**Program Timeline**

Because the CACES program requires a network of frequently small independent participating contractors, ComEd elected to start this program in the PY2 of the *EE & DR Plan*. Recruiting and training of independent participating contractors began in late 2008 and continues on an on-going basis. The initial estimates assumed much higher consumer participation in the new equipment and Quality Installation program, but it was clear by early 2009 that national

[2] 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 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.

economic conditions and the slow-down of the housing market would significantly reduce participation for the new equipment aspect of the program.

**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.

The 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. The technical training included both classroom work and practical field use of the diagnostic equipment, the Service Assistant (SA) made by FDSI. Business training was targeted to the office staff of the HVAC contractors to make them familiar with the program administrative requirements and to 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 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. Key elements of the marketing strategy include:

- Direct consumer marketing: To increase consumer awareness about the value of HVAC tune-up services, ComEd marketed the program through bill inserts and other direct mail approaches. Customers are directed to the ComEd website as a primary source of information and to the Call Center as a secondary source of information.
- Mass-market advertising: During special promotions, ComEd used mass-market advertising (radio/newspaper/television) to promote services provided through the program.
- Cooperative advertising: ComEd offered co-marketing advertising templates (e.g., brochures and customer postcards) for participating HVAC contractors to use in their marketing efforts.

**HVAC Contractor Participation**

In its inaugural year, the program has seen continued growth in HVAC contractor participation.

**Table 1-3. Contractor and Service Assistant Enrollments**

| | Participating Contractors | Service Assistants in Field |
|---|---|---|
| May 2009 | 58 | 117 |
| June 2009 | 66 | 138 |
| August 2010 | 130 | 272 |

Early expectations were that large service contractor companies would dominate in the program due to the initial cost of the SA tool, but smaller companies were also active in the program in its first year. One hundred and thirty-four different contractors have purchased SA tools for the program. Three companies with multiple locations have 15 or more SAs registered with the program, and five more have 5 or more SAs. ComEd feels that these data demonstrate the potential wide reach of the program.

**Program Incentives**

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. These 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 substantially over-subscribed.

**Table 1-4. 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 are 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. Furthermore, 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.[3]

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 fail 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*

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

*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.

### *1.2 Evaluation Questions*

The evaluation sought to answer the following key researchable questions. Some of the researchable questions can be addressed in Program Year 3.

Impact Questions:

1. Update gross savings estimates based on field verification of a sample of participants.
2. Estimate net-to-gross ratio based on HVAC contractor interviews.
3. Investigate persistence of optimized HVAC system parameters – refrigerant charge and airflow – over time.
4. Create improved deemed savings estimates and NTG estimates for use in future year DSM plans.

Process questions:

1. What are key barriers to participation for eligible ComEd customers? What are key barriers to participation for eligible independent participating contractors? How can they be addressed by the program?
2. How did customers become aware of the program? How did eligible independent participating contractors become aware of the program? What marketing strategies could be used to boost program awareness and participation, if needed?
3. How efficiently is the program being administered? What methods could be implemented to improve the efficiency of program delivery?

# Section 2. Evaluation Methods

For the Diagnostic and Tune-Up program participants, the Navigant Consulting team conducted extensive field research to gather data about equipment size, rated efficiency and operating efficiency and equipment run-times. For all but run-times, our research was primarily focused on confirming data collected and reported by the independent participating contractors.

## 2.1 *Analytical Methods*

### 2.1.1 Impact Evaluation Methods

**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

In this evaluation, each of these parameters in the equations above was examined and verified. The independent participating contractor 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 team confirmed these data with our own Service Assistant and we measured run-time on equipment with long-term dataloggers and analyzed load research data to determine annual energy use.

**Quality Installation**

The anticipated savings from the Quality Installation program reflect the effects of two separate features of the program: (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 (SEER 13.0). Given the size of the anticipated participant population, the evaluation plan for this program proposed a fixed-effect billing analysis for the participants. Billing analysis is an effective and relatively inexpensive method for estimating savings when the savings are expected to be greater than 5% of the bill. This is the case for the predicted savings from proper sizing, refrigerant charge and higher SEER levels if only summer bills are analyzed. The results of the billing analysis will be a reliable estimate of savings for equipment replacement customers and a good comparison number for the estimate of savings for new equipment customers that come from the building simulation method used in the *Energy Efficiency and Demand Response Plan*.

Fixed effect billing analysis, where participants are compared to their own prior usage, has internal controls for consumer behavior and can be normalized to typical weather, the two leading factors when looking at residential air-conditioning energy usage. Of the 871 Quality Installation participants in PY2, 256 installed equipment during the cooling season of 2009 which provides the usage data for the billing analysis. The evaluation team was provided with data billing data for 236 of these sites.

**Billing Analysis: Model**

We estimated a linear fixed effects model. 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 2-1**

$$Kwhd_{kt} = \alpha_0 + \alpha_1 CDDd_t + \alpha_2 Post_{kt} \cdot CDDd_t + \alpha_2 Post_{kt} \cdot CDDd_t \cdot D_k + \boldsymbol{\beta}_1 \mathbf{X}_k + \varepsilon_k + \phi_{kt}$$

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; $\varepsilon_k$ is a term accounting for household-level unobservable variables; and $\phi_{kt}$ 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 $\alpha_0$. This deviation is treated as a parameter to be estimated, in which case we can rewrite Equation 2-1 as the fixed effects model:

**Equation 2-2**

$$Kwhd_{kt} = \alpha_0 + \gamma_k + \alpha_1 CDDd_t + \alpha_2 Post_{kt} \cdot CDDd_t + \alpha_3 Post_{kt} \cdot CDDd_t \cdot D_k + \varepsilon_{kt} \ .$$

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:

$$Kwhd_{kt} = \alpha_0 + \gamma_k + \alpha_1 CDDd_t + \alpha_2 CDDd_t ,,$$

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

$$Kwhd_{kt} = \alpha_0 + \alpha_1 CDDd_t + \alpha_2 CDDd_t + \alpha_3 CDDd_t .$$

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 2-1 and Table 2-2. For the multi-family model, we did not distinguish SEER 13 from SEER 14+ installations because there were so few SEER 14+ records (28 total records, seven post-installation records), and so the term $Post_{kt} \cdot CDDd_t \cdot D_k$ is omitted from the model. In both models, the null hypothesis of no fixed effects (no savings) is strongly rejected. The R-squared is much higher for the single family model than for the multi-family model.

**Table 2-1. Results for the Fixed Effects Regression Model: Single Family Dwelling**

| Variable | Parameter Estimate | Standard Error | T-statistic |
|---|---|---|---|
| Intercept | 32.46 | 3.75 | 8.66 |
| $CDDd_t$ | 2.17 | 0.25 | 8.63 |
| $Post_{kt} \cdot CDDd_t$ | -0.49 | 0.19 | -2.61 |
| $Post_{kt} \cdot CDDd_t \cdot D_k$ | -0.69 | 0.35 | -1.94 |

R-squared: 0.93; F-statistic on fixed effects: 55.62 (65, 260)

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

| Variable | Parameter Estimate | Standard Error | T-statistic |
|---|---|---|---|
| Intercept | 47.29 | 6.19 | 7.64 |
| $CDDd_t$ | 1.19 | 0.70 | 1.69 |
| $Post_{kt} \cdot CDDd_t$ | 0.45 | 0.42 | 1.06 |

R-squared=0.73; F-statistic on fixed effects = 8.61 (20, 66)

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 2.17.
- For single family residences, the coefficient estimate for $CDD_t \cdot Post_{kt}$ indicates that installing a new SEER 13.0 unit reduces the effect of a cooling degree day on energy consumption by 0.49 kWh, from 2.17 to 1.68. The standard error on $\alpha_2$ is 0.19, and the 90% confidence interval is [0.18, 0.80].
- For single family residences, the coefficient estimate for $CDD_t \cdot Post_{kt} \cdot D_{kt}$, in conjunction with the coefficient on $CDD_t \cdot Post_{kt}$, indicates that installing a new SEER 14+ unit reduces the effect of a cooling degree day by .49+.69=1.18 kWh, from 2.17 kWh to .99, a decrease of 54.4%.
- Keeping in mind that the energy savings for SEER 14+ units is $-(\alpha_2 + \alpha_3)$, the 90% confidence interval for the energy savings from a SEER-14+ unit, as calculated using the delta method, is [0.685, 1.675] kWh per CDD.
- It is not possible to conclude at a statistically significant level that the program generated energy savings for multi-family dwellings. This is most likely due to the small sample size.
- 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.

Absent a robust regression model for multi-family installations, the evaluation will apply the single family realization rate to multi-family installations.

#### 2.1.2 Process Evaluation Methods

The Process evaluation was based on in-depth interviews with key personnel at ComEd and Honeywell Energy Services. Phone interviews with air conditioning contractors participating in the program were also used to assess program process matters.

## 2.2 *Data Sources*

For both the Diagnostics and Tune-Up and Quality Installation programs, participation records were provided as part of the Program Tracking Database administered by ComEd. The criteria 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.

**Diagnostics and Tune-Up**

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.

In some cases program tracking data were confirmed independently for the evaluation. Unit operating data were derived from nameplate model numbers and lookups against the Preston's Guide.[4] We also referred to manufacturer literature if model year was not clear from the nameplate information. The efficiency adjustments were estimated with the Service Assistant tool. Run time data were initially measured with dataloggers and correlated with actual regional[5] temperature data to determine the operating hours for each temperature. Subsequent research into the runtime hour question required use of hourly load research data for almost 2000 customers.

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[4] Preston's Guide 2005 edition. Comprehensive database of air conditioner manufacturer specifications for most equipment sold in North America in the past 40 years. Given the model number and serial numbers Preston's guide provides unit efficiency (SEER) and capacity.

[5] To be consistent with the *Energy Efficiency and Demand Response Plan*, Navigant Consulting collected hourly temperature data from O'Hare, Rockford and the Quad Cities (Moline, IL) airports for use in the analysis.

**Quality Installation**

Electricity billing data for a census of summer 2009 Quality Installation participants (256 consumers) was requested from ComEd. Roughly 92% of the participants, 236 customers,, had at least one record pre- and post-installation electric use record required for same-site pre and post-installation analysis. The billing analysis was performed with weather from the 2009 calendar year as a regression variable. Weather data were acquired from the National Climatic Data Center (NCDC) which is a part of NOAA, the National Oceanic and Atmospheric Administration. The regression results were then normalized to a typical year using Typical Meteorological Year data, TMY2.

Data for the Process Evaluation was acquired by conducting in-depth interviews with contractors and key program administrators among ComEd and Honeywell staff.

**Billing Analysis: Data**

The billing analysis drew on an original dataset that included 236 residences for which billing data was available before installation of the AC unit, with 3,941 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 cooling degree day data are presented in Figure 2-1 and Figure 2-2.

» 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.

Due to these criteria for inclusion, the data used in analysis was pared down to a total of 87 residences and 418 billing records.

Because *ex ante* savings are based on dwelling type, Navigant Consulting conducted separate regression analyses for single and multi-family dwellings. As indicated in Table 2-3, the analysis for multi-family dwellings was especially thin, with only 90 records, of which only seven were for SEER 14+ installations. For this reason, we did not distinguish SEER 13 and SEER 14+ installations in the billing analysis fixed effects regression for multi-family dwellings.

**Table 2-3. Summary of the Data**

| Data Category | Number of sample *residences* | Number of sample *residences* with SEER 14+ installations | Number of *records* | Number of *records* with SEER 14+ installations | Number of post-installation *records* | Number of post-installation *records* with SEER 14+ installations |
|---|---|---|---|---|---|---|
| **Single-Family** | 66 | 19 | 328 | 95 | 93 | 25 |
| **Multi-Family** | 21 | 5 | 90 | 28 | 28 | 7 |
| **Total** | 87 | 24 | 418 | 123 | 121 | 32 |

Cooling degree day (CDD) data were based on temperatures at Chicago-O'Hare airport, though participating residences included in the analysis are also located closer to Rockford and Moline, Illinois weather stations. This simplification causes less precision in the estimates than would be possible with more localized CDD data, but in our judgment, this error is likely very small. Furthermore, an available dataset that included residence cities for many participants was not preferred because it omitted too many observations. Figure 2-2 presents cooling degree days over the study period 2007-2009. Of particular significance is that the summer of 2009, which contains *all* of the post-installation billing records, was unusually cool. In the typical meteorological year, the number of cooling degree days at O'Hare is 773; in the summer of 2009 it was 585.

Figure 3 presents the total number and number of post-installation billing records for all households included in the analysis. The average number of post-installation records is very low, 1.39.

**Figure 2-1. Daily Cooling Degree Days – Chicago O'Hare Airport 2007 - 2009**

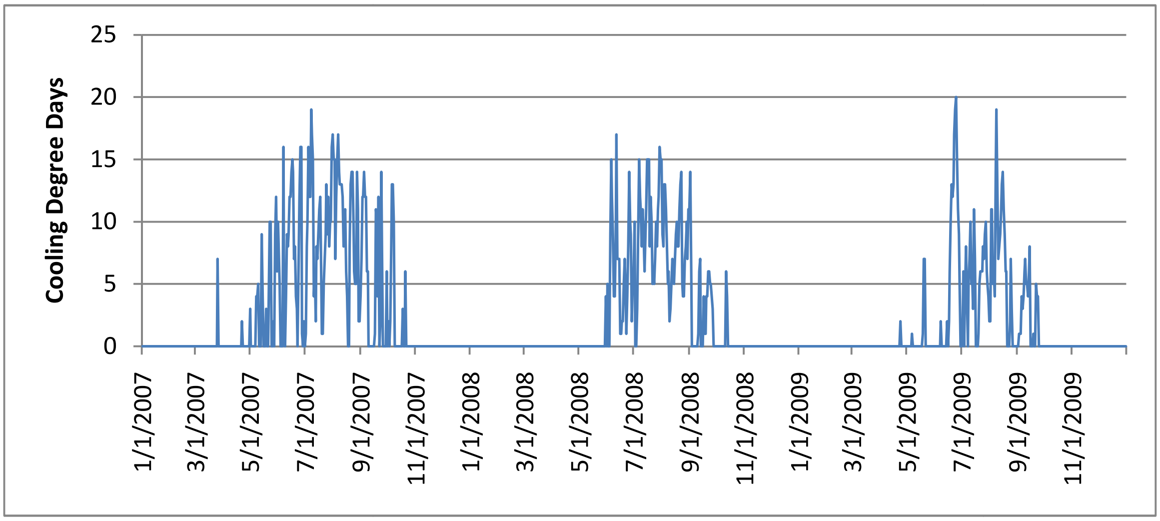



**Figure 2-2. Monthly Cooling Degree Days per Day, Chicago**

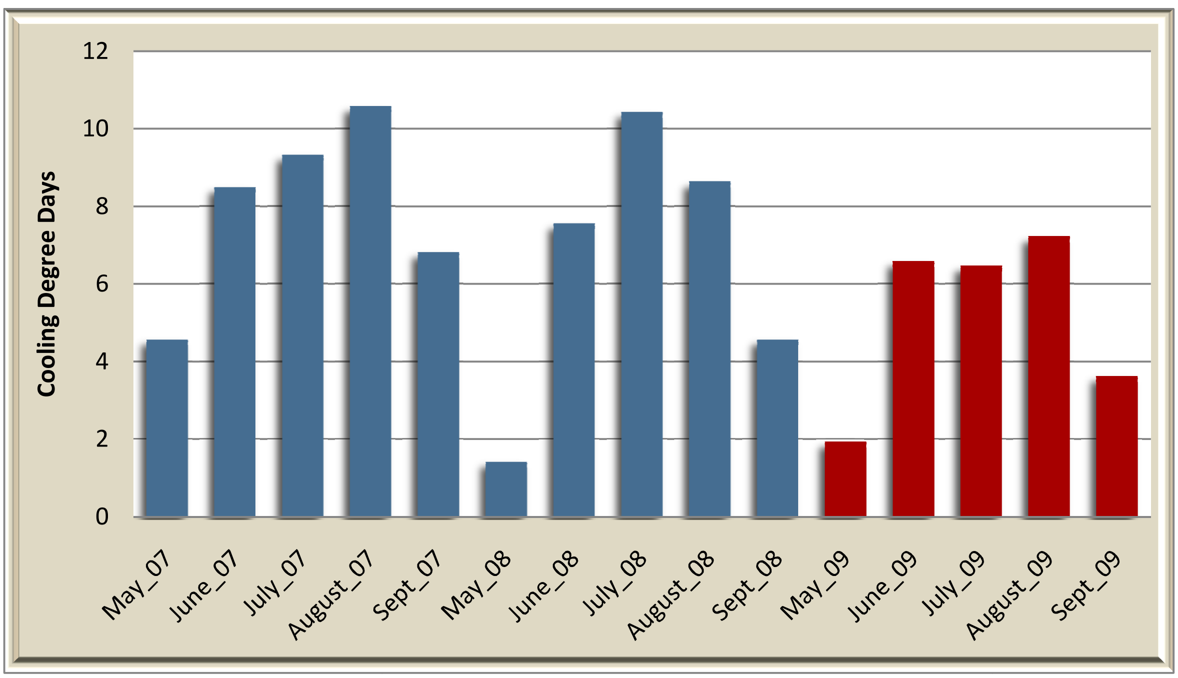
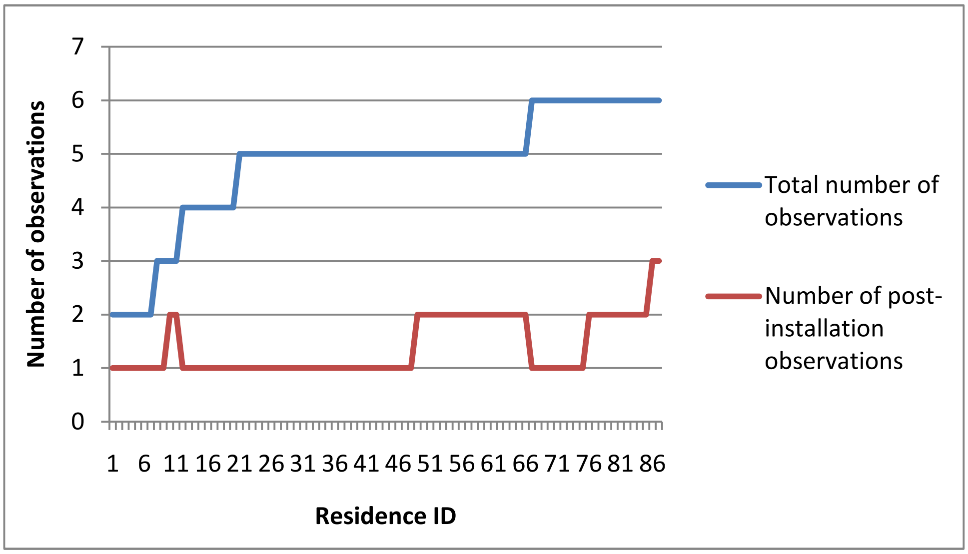


**Figure 2-3. Available Billing Records across Sample Residences**




## 2.3 *Sampling Plan*

### 2.3.1 Diagnostic and Tune-Up

Evaluation of the program began with its kick-off. As a result, the number of participants was not clear when work began and the Evaluation Team assumed that the goal of 6,500 participants would be met. Given the assumed population size, the key parameter in determining the sample size is variation in the field data. Our field data collection was two-fold – runtime and efficiency adjustment estimates.

Estimating residential air conditioning runtime without end-use data is difficult, because variation among consumers can be very high. Factors that affect equipment runtime include, but are not limited to: outdoor temperature and humidity; the home's thermal envelope (insulation, fenestration type, and orientation and air sealing); external shading; use of internal shades; normal number of daytime occupants; personal preference of occupants; vacation hours of occupants; use of windows and window fans for space comfort and ventilation; and space temperature setpoints. Given these factors, a fairly wide variation of operating hours is anticipated. To achieve 90/10 confidence/precision for this parameter, a sample of 68 customers is required.

The sample size to reliably estimate the efficiency adjustments can be smaller. This is because completed tune-ups tend to minimize low-end outliers and raise them toward the implicit goal of 100 efficiency index (100% of *rated* efficiency). Reducing the number of outliers and clustering the post tune-up efficiency index closer to 100 will tend to reduce the variation in this parameter and thus a smaller sample can be used to characterize the population with equivalent confidence and precision. By verifying the efficiency index at all of the sites where we installed run-time monitoring, the Navigant team ensured adequate sampling for the efficiency impact parameter.

In order to gather data for PY2 during PY2, the evaluation team needed to focus field data collection on the earliest program participants. Starting field collection in August or September would not have generated sufficient data for estimating annual runtime. Therefore, we drew our sample from a list of June 2009 participants provided by ComEd in mid July 2009. We used the following criteria for sampling.

- Roughly split the sample 50/50 between the Chicago metro area and out-state regions.
- No more than ten sites serviced by the same contractor.
- Proximity among sites to facilitate multiple tests in a given day of travel.
- At least three attempts to contact and schedule a site visit.
- No overlap with program Implementation Contractor quality control visits (Honeywell was to perform QC on about 10% of all installations).

The final run-time estimate analysis also utilized a set of roughly 2100 load research customers. This data set contains hourly consumption data for the 2007 and 2008 calendar years for this select group of customers. Navigant Consulting chose to analyze the 2008 data, since the number of Cooling Degree Days was closest to the long-term averages for all three weather stations.

All field measurements were completed by the first week of August 2009 and field data collection of run-time continued though the end of peak cooling season in mid-September.

#### 2.3.2 Quality Installation

For the Quality Installation program impact analysis, Navigant Consulting attempted a census of summer 2009 participants. For reasons listed above in the data section, the final analysis was based on a sample of 87 participants. Table 2-4 shows the attrition of Quality Installation participants as used in the evaluation.

**Table 2-4. Billing Analysis Sample**

| | Dropped from Sample | Net Sample Size |
|---|---|---|
| Gross Number of Quality Installation Participants | NA | 256 |
| Billing Data provided by ComEd | 20 | 236 |
| Insufficient data for analysis | 149 | 87 |

# Section 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 set points. Key assumptions include pre-service effective equipment efficiency of SEER 8.0 and post service effective efficiency of SEER 10.16.

### 3.1.1 Verification and Due Diligence

As part of this evaluation, the Navigant Consulting team explored the quality assurance and verification activities currently carried out by program and implementation staff. We compared these activities to industry best practices[6] for similar residential programs to determine:

1. If any key QA and verification activities that should take place are currently not being implemented.
2. If any of the current QA and verification activities are biased (i.e., incorrect sampling that may inadvertently skew results, purposeful sampling that is not defendable, etc.).
3. If any of the current QA and verification activities are overly time-consuming and might be simplified or dropped.

This assessment primarily relied on in-depth interviews with program and implementation staff and documentation of current program processes, where available.

The remainder of this section includes a summary of key quality assurance and verification activities currently conducted by ComEd's residential programs and recommendations for improvement; an overview of data collection activities carried out for this task; and detailed findings on current QA and verification activities by program. We will provide a similar assessment in Program Year 3.

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[6] See the Best Practices Self Benchmarking Tool developed for the Energy Efficiency Best Practices Project: http://www.eebestpractices.com/benchmarking.asp.

Data for this task were gathered through in-depth interviews with the following program and implementation staff, Table 3-1. An observation of the program's business training[7] and review of related training materials was also used for this task.

**Table 3-1. In-Depth Interviews**

| Program | Person | Date Interviewed |
|---|---|---|
| Residential HVAC program | ComEd Program Manager | 06/05/09 |
| Residential HVAC program | Honeywell Manager | 06/05/09 |

The Due Diligence and Quality assurance review examined four factors: contractor eligibility, customer and equipment eligibility, data verification, and record retention.

###### 1.1.1.1.1 Contractor Eligibility

To participate in the program, contractors must attend trainings to become familiar with the program processes. Trainings consist of two parts:

- » Technical training – The technical training teaches HVAC contractors the proper installation and tune-up of central air conditioning systems. This includes hands-on training with the Service Assistant diagnostic and verification tool from Field Diagnostics.
- » Business training – The contractors' business staff must attend a training to learn about the program and its administrative requirements. The program's incentives are outlined, including their thresholds and tiers. Administrative tasks such as preloading information into the Service Assistant tool, obtaining ARI numbers and uploading customer data onto Honeywell's contractor portal are covered in detail. After attending this training, contractors are sent their log-in information to access the contractor portal which allows them to apply for and receive incentives.

Participating contractors can be located outside of ComEd's service territory as long as they serve ComEd territories. Contractors provide ComEd with the ZIP codes of their served markets, which are used for lead generation.

[7] The evaluation team attended the program's Business and Sales Training at Honeywell's offices in Arlington Heights, IL on May 27, 2009.

**Assessment:** ComEd's procedures for the verification of contractor eligibility ensure that participating contractors are trained in both the technical and administrative aspects of the program and serve relevant geographic markets. No changes are needed in this area.

###### 1.1.1.1.2 Customer and Equipment Eligibility

For the contractor to receive an incentive for the installation or tune-up of a system, the customer must be a ComEd residential customer. The web-based Honeywell contractor portal has a "verify" button to verify the customer's meter number when entered. If an address comes up in the verification window that does not match the account, the contractor should contact Honeywell for support.

The program defines a residential central air conditioning system as one that is ducted and cools more than one space or room.

**Assessment:** The definitions of eligible customers and equipment are very simple and do not need additional criteria. Allowing the contractor to verify the customer information when inputting their data online should reduce input mistakes and limit non-eligible customers.

###### 1.1.1.1.3 Verification of Data by Service Assistant Tool

The program's quality control protocols center on the Service Assistant tool[8] with the assumption that each tool is assigned to one technician. If that technician leaves the company, the replacement employee will attend the program's technical training and be assigned the unassigned Service Assistant tool.

To ensure that each tool (and the assigned contractor) is performing and gathering the data correctly, Honeywell performs a follow-up quality control test. At least one quality control test must be performed per tool before any incentive payments are made to the contractor. Following that, two quality control tests per tool must take place in the first 90 days. After these initial three tests, 10% of jobs are selected and tested.

"Notice of Inspection" forms are left with each customer following a tune-up or installation. This form does not need to be signed by the customer and only informs them that their contractor is participating in a ComEd program and they may be contacted for quality control purposes. Jobs chosen for quality control tests are selected within two weeks of the tune-up or installation. The customer is not required to agree to the quality control test and Honeywell maintains that they will try to accommodate customers' schedules by offering evening and Saturday morning hours. The program staff believes that one out of five customers contacted

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[8] The Service Assistant tool is a device manufactured by Field Diagnostics (FDSI) that combines a Palm PDA with sensors to measure the temperature and pressure of an HVAC system.

for the quality control test will agree. The Honeywell quality control staff will continue to contact customers until the required testing numbers are met. When a job is selected, the associated contractor is notified.

Once agreed to by the customer, the quality control test will check the pressure and temperature measurements reported by the contractor. To account for variability in operating conditions, the readings may be within 5% of the reported number. According to the contractor participation agreement, "if actual field conditions do not corroborate conditions indicated on the participating contractor's incentive application, then the participating contractor will have 14 days to correct for any deficiencies, or he/she may become ineligible for the applied for incentive applied for." During the training, Honeywell states that if the readings are different, they will assume the difference is due to a reporting or clerical error and will work with the contractor to identify the problem. If a tool (and associated technician) is consistently off compared to others in the program, Honeywell will share this information with the contractor.

**Assessment:** The process to verify data by the service assistant tool is adequate for quality control. Contractors cannot receive incentive payments until their first job is reviewed and there is a requirement for multiple reviews during the first three months of participation. Continued random testing helps to ensure that contractors maintain a desired level of quality. The program may consider requiring a higher number of inspections during the first 90 days up to the 10% on-going inspection rate (three inspections per tool in this time period are currently required). This would ensure that technicians new to the use of the tool receive the same ratio of inspections during their learning curve as on-going use. The 10% inspection rate following the initial 90 day period is adequate.

###### 1.1.1.1.4 Record Retention Audit

In addition to the field audit, the program also performs a record retention audit to ensure that the correct documentation is maintained and that contractors provide customers with a description of the work required. Auditors review the documentation of the same customers who are audited in the field. Honeywell currently plans to spend one day a week in the contractor offices reviewing paperwork and four days in the field. In both cases, the auditors will work from a defined sample of jobs to be reviewed.

For repairs that would typically be actionable by the service technician, the program requires that contractors provide a price (or, at a minimum, a price range) to the customer. For other services requiring the expertise of an estimator (such as a system replacement), the program accepts written documentation of the identified issues and the recommended course of action, but does not require a cost estimate.

Contractors must retain these documents for a minimum of six months from the date of completion of the service. Failure to produce any of the listed documents will result in a "failed audit." Contractors will have 30 days to correct any problems identified in the audit or may lose the eligibility for incentives. If the office audit reveals deficiencies with the list of documentation, additional work orders will be reviewed. Multiple failures may result in the contractor's removal from the program.

The documentation required for each incentive is:

- Tune-Up Incentive
  - Standard service work order showing (at a minimum) homeowner name, address, phone number, homeowner signature, date work performed, condenser manufacturer, model and serial number, and a detail of the work performed
  - A signed copy of the Notice of Inspection Policy
- QIV (Quality Installation Verification) and Right Sizing Incentive
  - Standard service work order showing (at a minimum) homeowner name, address, phone number, homeowner signature, date work performed, condenser and evaporator manufacturer, model and serial number, and a detail of the work performed
  - A signed copy of the Notice of Inspection Policy
  - A copy of the method and calculations used to determine the proper size air conditioning system for the home
- High SEER accelerator incentive
  - Standard service work order showing (at a minimum) homeowner name, address, phone number, homeowner signature, date work performed, condenser and evaporator manufacturer, model and serial number, and a detail of the work performed, plus the ARI reference number of the condenser, evaporator coil and air handling equipment combination as installed
  - A signed copy of the Notice of Inspection Policy

**Assessment:** The program's record retention audit is comprehensive and ensures that contractors are providing their customers with detailed descriptions of the problems and possible solutions, including price. This also helps the program check discrepancies with their field audits.

There was confusion among the attendees of the business training about what is required for the record retention audit and how it relates to the field audit. In order to enhance the compliance of this quality assurance process, the program should work to provide a clearer description in the participation agreement and training material.

Overall, ComEd and its implementer, Honeywell, provide acceptable levels of quality assurance and verification for its residential HVAC programs. The programs seek to ensure that both the contractor and customers are eligible, that the contractor properly uses the Service Assistant Tool and its related protocols, and that the contractor maintains relevant records of its activities related to the program.

Table 3-2 summarizes the quality assurance and verification activities currently carried out by the residential HVAC programs. It also presents recommended changes to current procedures, as well as suggestions regarding additional activities that ComEd and Honeywell could implement to enhance current quality assurance and verification.

**Table 3-2. Summary of QA Activities in Place and Recommendations**

| QA Activities in Place | Recommended Change |
|---|---|
| » Eligibility checks | » None |
| » Verification of data by Service Assistant Tool | » Increase number of required inspections |
| » Record retention audit | » Clarify audit requirements |

#### 3.1.2 Tracking System Review

The tracking system consists of three tables in a relational database. These tables were mostly organized around customer contact and tracking data (table: RAC_IncentiveFile), unit nameplate data (table: RAC_UnitDataFile), and diagnostic parameters data (table: RAC_CycleDataFile). The database is capable of tracking participation by location (premise ID), by customer (Site ID, ComEd account number and HVAC Unit ID) and by participating contractor (Workorder ID and service assistant number). The Premise ID, Site ID, Unit ID and Workorder ID are the primary key fields for linking tables together.

Several important milestone dates are tracked in the database:

- New Date – the date a work order is generated through the ComEd system to perform qualifying tune-ups or installations
- Scheduled Date – the date service is scheduled to be performed. The field is not always updated with field changes
- Service Date Completed – the date service is actually performed as updated from field tools.
- Check Date – the date ComEd cuts the incentive check to the service contractor.
- Log time – the date and time the Service Assistant is used to take field measurements
- RecordInsertTime – the date and time that Service Assistant data are uploaded to the FDSI database. This date is often many days after the field service occurs.

On the advice of ComEd, the evaluation determined participation based on the date that incentive checks were written to contractors for each participant. Due to un-avoidable administrative lag, this date is later than the program year conclusion. For PY2, participants were included in the program population if incentive checks were written prior to June 30, 2010.

The data provided by ComEd and Honeywell were adequate for the evaluation task, though some quality control issues are apparent. A small number (less than 100) of participants had incomplete data with respect to Unit nameplate information and/or matched pairs of pre-service and post-service measurements. These problems did not appear to be systematic, and do not affect the analysis. For PY2 we assume that participants with incomplete data are similar to those with complete data and we apply average per-unit savings estimates to those participants.

Recommendations:

In general, Navigant Consulting found the database adequate to the evaluation task. We have a few recommendations to facilitate more effective evaluation in the future.

1. Ensure that key fields used to link tables are the same data type. For example, the site ID in the Incentives Table is a text string, but in the other tables it is a long integer. Relational databases require matching data types as well as values when building relationships. Site ID should be a long integer-type throughout the database.
2. Include geographic identifiers in the base data. Our impact analysis determined saving by geographic (weather) zone. In order to do this we had to request supplemental data from ComEd to allocate participants among weather zones. If a region field were included in the base database (most appropriately the UnitDataFile table), these allocations would be faster.
3. Implement more quality control for acquiring complete data for each installation. Equipment nameplate data must be complete and each site must have both pre-service and post service SA field data.
4. In the Energy Efficiency and Demand Response program portfolio, program savings is defined on measures implemented during the June 1 – May 31 program year. Participation in the CACES program should be linked more closely to measure implementation dates rather than administrative dates such as when checks are written. The LogTime date/time stamp from the SA seems to be a logical choice, though quality control must ensure that the SAs are registering accurate dates when they are set up.

### 3.1.3 Gross Program Impact Parameter Estimates

**Diagnostic and Tune-Up**

The key parameters for estimating gross impacts for each consumer are rated efficiency and capacity, *in situ* efficiency adjustments, and runtime hours. Navigant Consulting examined program data and performed on-site verification of program data for a sample of 68 participants to verify each of these parameters. For these same 68 participants, Navigant Consulting installed dataloggers to record equipment runtime. Table 3-3 presents a summary of the evaluation field data compared to the participating contractor data for the same customers. The table also compares the average of the performance parameters in the sample (68 records) to the average performance parameters of all participant data in the database. The parameter sample size from the database is somewhat smaller than the participant sample due to incomplete records in the database discussed earlier.

Unit Efficiency and Capacity

In the *Commonwealth Edison Company's 2008-2010 Energy Efficiency and Demand Response Plan*, the planners assumed that the efficiency of the equipment that qualified for incentive was SEER 8.0 as operating and the efficiency of the tuned-up units would be SEER 10.16. These values are a combination of the rated efficiency and degradation from the rated efficiency or Efficiency Index (EI) in terminology of the Service Assistant, SA.

Independent participating contractor contractors recorded equipment data for rated efficiency, capacity and other physical unit parameters in their SA for all customers. Performance data including EI and CI are saved on the SA following successful tests and all participant data are uploaded to a database managed by FDSI. For a sample of participants, the evaluation team performed site inspections, confirmed nameplate information and independently measured EI and other operating parameters with our own SA. We also verified rated capacity and efficiency against the Preston's Guide. Table 3-3 compares the parameters from the evaluation sample to the program participant population as a whole.

**Table 3-3. Diagnostic and Tune-Up Efficiency and Capacity Parameters**

| Average Rated Efficiency | Evaluation On-Site Sample | | | Program Population | |
|---|---|---|---|---|---|
| | Contractor Pre-Test | Contractor Post-Test | Evaluator Verification | Population Pre-Test | Population Post-Test |
| Average Rated Efficiency (SEER) | 10.4 | | 10.5 | 10.6 | |
| Average Efficiency Index (EI) | 94.3 | 98.7 | 103.5[9] | 94.12 | 97.85 |
| Average In situ Efficiency (SEER est.) | 9.8 | 10.3 | 10.8 | 10.0 | 10.4 |
| Average Rated Capacity (tons) | 2.8 | | 2.9 | 2.8 | |
| N | 68 | 68 | 68 | 16,268 | 16,272 |

The Evaluation Team concludes that the contractor field estimates are adequate for all of these parameters. Differences are not endemic and can simply reflect minor differences in operating conditions at the time of measurements and/or calibration differences among different tools used. Figure 3-1 is a histogram of installed rated unit efficiencies recorded among all participants during this evaluation. 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 that will grow as older machines are retired. Figure 3-2 shows the distribution of equipment size among program participants. The average machine is 2.84 tons capacity.

[9] The manufacturer of the Service Assistant, FDSI, confirmed that efficiency indices or capacity indices greater than 100 are possible, given inherent measurement accuracy among the many sensors.

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

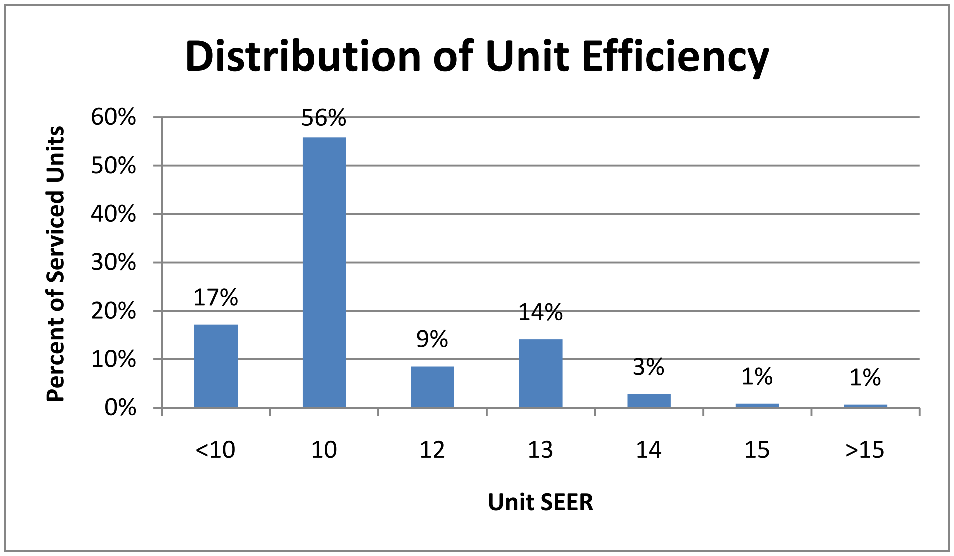
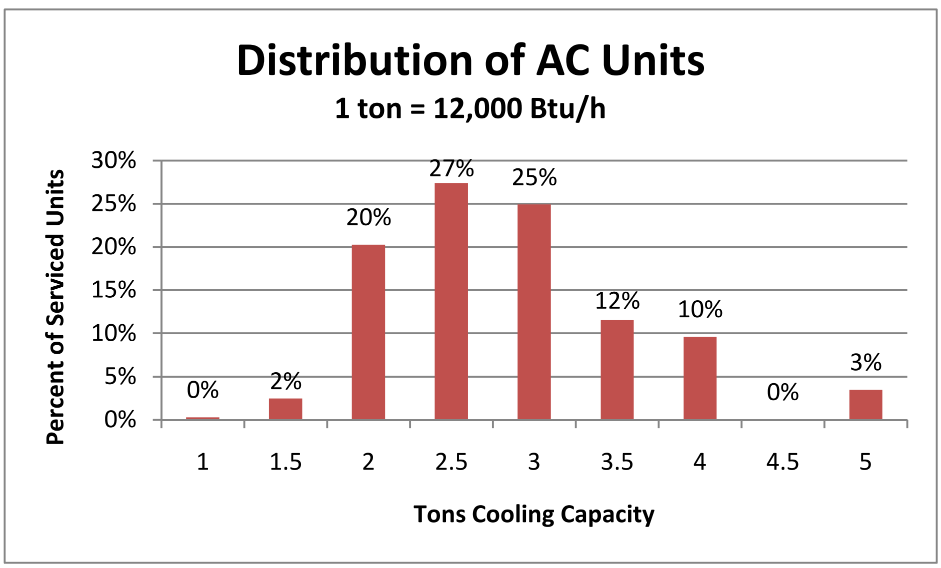
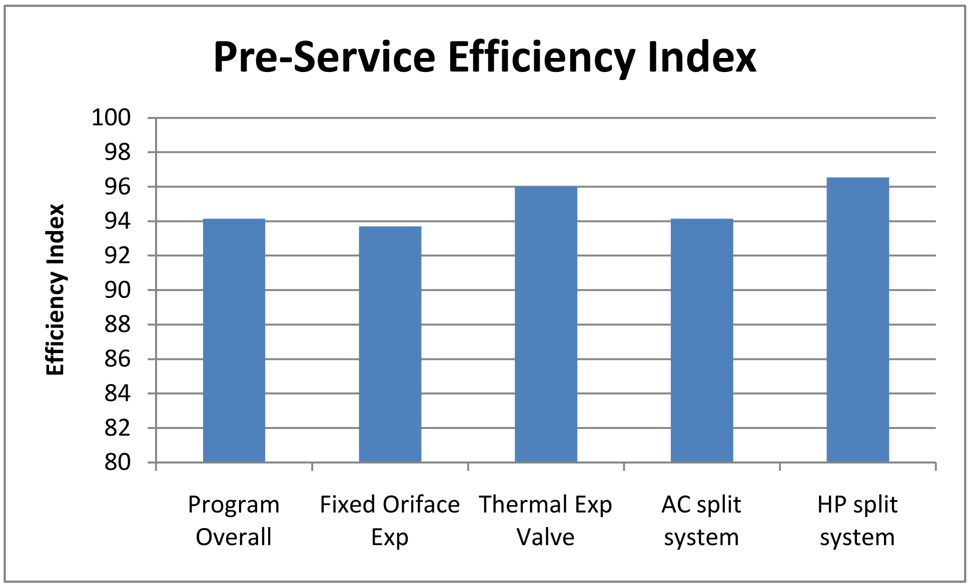



**Figure 3-2. Distribution of AC Unit Capacity among All Participant Consumers**




The efficiency index, EI, is the target parameter of the diagnostic program. A quality tune-up will increase the EI form 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. Incentives are generally earned for increasing the EI to above 90[10]. Field data on *pre-service* units show an average EI of 94.1. After service the average EI was almost 98. The increase in the EI is significant at the 90/10 confidence and precision level; however, it is not the magnitude expected. Figure 3-3 shows pre-service EIs for different groupings of participants. 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**




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.[11] The Evaluation Plan called for run-time monitoring at 68 sites to develop more accurate estimates of run-time. Our end-use metering during the 2009 cooling season showed significantly lower runtime hours – only 292 hours of runtime on average. The low utilization in 2009 was a result of an extraordinarily mild summer and other factors such as national economic conditions. Weather normalization to TMY2 data increased the estimated annual run-time substantially to 436 hours,

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[10] See Table 1-4 and program incentives discussion.
[11] 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.

but the effects of the poor economy cannot be normalized in the same fashion. Navigant considered causes for low runtimes, and we submit a few ideas of explanation.

1. The economic conditions in 2009 may have made consumers more conservative about AC use in order to save money.
2. Reported behavior for residential AC load control programs suggests lower utilization during isolated hot days as compared to prolonged heat waves. Residential load control studies show decreased compliance when load control occurs on consecutive days. That is, customers tolerate reduced comfort for one or two days, but after several days of heat and load control, they will frequently disable or override controls to regain comfort. For the summer of 2009, there were few, if any, prolonged heat spells; therefore, if customers were able to forego AC for a day of heat, they often did not need to suffer succeeding days of heat and resort to AC use.
3. The measured runtime hours are based on post tune-up data. A benefit of the tune-up is increased capacity and thus reduced runtime hours; therefore, we will have a bias toward lower runtimes in the evaluation sample; however, we do calculate pre- tune-up hours based on capacity indices.

As an alternative to the field-collected data, ComEd supplied Navigant with a data set of about 2100 residential load research customers. We analyzed 2008 hourly data for customers without electric space heat to estimate air conditioning run-time hours. 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[12] 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.

[12] Typically in April and May when neither heating nor cooling was expected.

**Table 3-4. Weather Normalized Run-Time Hours Estimated with Load Research Data**

| Weather Station | Single Family[a] | Multi-Family |
|---|---|---|
| Chicago | 570 hours | 506 hours |
| Rockford | 512 hours | 467 hours |
| Moline | 676 hours | 623 hours |

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

For the PY3, the Evaluation will further research runtime.

**Quality Installation**

Table 3-5 provides billing analysis estimates of seasonal savings under the QI program for single family dwellings. As explained in Section 2.1.1, a model of savings for multi-family residences was statistically weak, and so we do not calculate an estimate of seasonal savings. To illustrate the range of savings as influenced by ambient temperature we include 2007 (atypically warm year) and 2009 (atypically cool year) for comparison. For SEER 13 units the estimated average savings for a single family residence in a typical meteorological year (TMY) is 312 kWh (5.8% of seasonal total). For SEER 14+ units predicted average savings are higher: 754 kWh (13.9% of seasonal total) for a TMY. For both SEER 13 and SEER 14+ units, 90% confidence intervals indicate one can conclude with high confidence that true savings are positive.

**Table 3-5. Predicted Cooling Season[a] Energy Savings per Residence**

| | Year | | |
|---|---|---|---|
| | 2007 | 2009 | TMY |
| **Predicted baseline (KWh)** | 6199 | 5038 | 5420 |
| **SEER 13 Savings (KWh)** | 487 | 227 | 312 |
| **Percent savings** | 7.8% | 4.5% | 5.8% |
| **90% Confidence Interval Low (KWh)** | 179 | 83 | 115 |
| **90% Confidence Interval High (KWh)** | 795 | 371 | 510 |
| **SEER 14+ Savings (KWh)** | 1176 | 548 | 754 |
| **Percent savings** | 19.0% | 10.9% | 13.9% |
| **90% Confidence Interval Low (KWh)** | 678 | 316 | 435 |
| **90% Confidence Interval High (KWh)** | 1673 | 780 | 1073 |

[a]Season is defined as May 15-Sept. 15. Confidence intervals calculated using the delta method.

Results are attended by three important caveats with implications for the billing analysis in the next evaluation cycle.

First, the analysis involved relatively few post-installation records because most of the installations were done in the summer of 2009. As previously noted, Figure 2-3 in Section 2.2 graphs each residence's total number of billing records and number of post-installation records. Overall, the total number of records is 418, and the number of post-installation records is 121, which is an average of only 1.39 post-installation records per residence. This issue will be resolved in the billing analysis of the next evaluation cycle due to the addition of data from the 2010 summer season.

Second, the 2009 summer was quite cool in the Midwest, providing less than ideal data for measuring the effect of high efficiency AC units on energy bills. Figure 2-1 presents daily cooling degree days at Chicago-Midway for the period 2007-2009, and Figure 2-2 groups this data into monthly totals. Most likely this issue too will be resolved by the additional data collected in the summer of 2010.

Finally, there exists the possibility that estimates are confounded by exogenous temporally-correlated factors, in particular, the economic recession that began in the third quarter of 2008. 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.

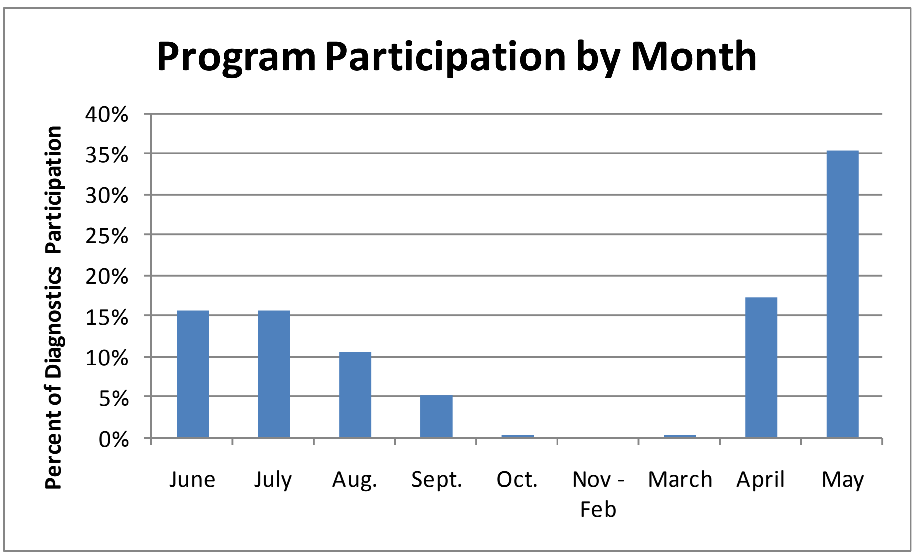
### 3.1.4 Gross Program Impact Results

**Diagnostic and Tune-Up**

Navigant Consulting reviewed the participation data from the tracking system, and we determined that there were 16,293 documented participants in the database. The criteria for participation were a check date prior to June 30, 2010 and an incentive paid greater than $10. The late June cut-off date extends beyond the program year which ended on May 31, 2010. The extra time permitted ComEd to fully process payments for units serviced prior to May 31, 2010. The incentive threshold eliminated a few test records that had carried through the database. In the future Navigant recommends using a cut-off date more closely related to field activities rather than administrative functions.

Figure 3-4 shows program participation by month. Note again that the program year is June 2009 through May 2010. More than 50% of program participation is attributed to April and May, the busiest season for tune-up work. Furthermore, the number of Service Assistants in the field grows with contractor participation. April and May 2010 are, therefore, also the months with the *greatest capacity* to perform tune-ups.

**Figure 3-4. Diagnostics Program Participation by Month**




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[13], pre-service and post-service efficiency adjustments to estimate unit power savings. Energy savings is the product of average unit power savings[14] and runtime. Normalized run hours were determined with the most appropriate of the three weather stations for each participant.

Table 3-6 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 lower than the plan estimates because that equipment was in better shape than anticipated in the plan.

**Table 3-6. Average Diagnostic and Tune-up Savings for Different Customer Types**

| | *Ex Ante* kWh/Participant | *Ex Post* kWh/participant |
|---|---|---|
| Multi-Family | 85 | 68 |
| Single Family Attached | 233 | 99 |
| Single-Family Detached | 395 | 106 |

**Table 3-7. Customer Participation by Building Type**

| | Participation |
|---|---|
| Multi-Family | 2,235 |
| Single Family Attached | 1,535 |
| Single-Family Detached | 12,523 |

[13] 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.

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

**Table 3-8. *Ex Post* Program Savings – Diagnostic & Tune-Up**

| | PY2 Goal | PY2 *Ex Ante* | Evaluated PY2 Gross | Realization Rate |
|---|---|---|---|---|
| Participants (#customers) | 6,500 | 16,293 | 16,293 | 100% |
| Energy Savings (MWh) | 1,802 | 5,495 | 1,632 | 29.7% |
| Demand Savings (MW) | 2.9 | 9.02 | 3.24 | 35.9% |

Low realization rate for demand and energy savings are a result of better baseline performance of customer AC units (average SEER 10.0 performing in the field ) than anticipated in the program plan (SEER 8.0). Lower power savings is the main factor in lower energy savings, but lower hours of operation also drive down energy savings realization rates.

**Quality Installation**

Navigant Consulting reviewed the participation data from the tracking system, and we determined that there were 871 documented complete participants in the database. Among those participants, 87 had sufficient data to perform a billing analysis to determine energy savings. Accurate analysis requires at least one full month of post-installation data to compare to pre-installation consumption. Participation and installation after mid-summer frequently required removing these participants from the analysis sample.

Table 3-9 presents planned savings for each segment compared to the evaluated savings estimates for the three residential segments and the two types of Quality Installation criteria. As noted previously, billing records for multi-family installations did not support a significantly robust estimate of savings. Furthermore, the single family program population and analysis sample segment is dominated by detached construction, so Navigant Consulting applies the estimated savings only to the single-family detached segment. In order to estimate savings for the other two housing segments, we use the same realization rates from the detached segment for the multi-family and attached segments.

**Table 3-9. Average Quality Installation kWh Savings for Different Customer Types**

| | Plan kWh | Evaluated kWh | Realization Rate |
|---|---|---|---|
| SEER 13 | | | |
| Multi-Family | 114 | 63 [a] | 54.8% [a] |
| Single Family Attached | 328 | 180 [a] | 54.8% [a] |
| Single-Family Detached | 569 | 312 | 54.8% |
| SEER 14 and Higher | | | |
| Multi-Family | 178 | 154 [a] | 86.8% a |
| Single Family Attached | 493 | 428 [a] | 86.8% a |
| Single-Family Detached | 869 | 754 | 86.8% |

[a] Multi-family and single-family attached evaluated savings and realization rate are based on the single-family detached analysis

**Table 3-10. Quality Installation Customer Participation**

| | SEER 13 Participants | SEER 14+ Participants | Total Participants |
|---|---|---|---|
| Multi-Family | 155 | 14 | 169 |
| Single Family Attached | 46 | 27 | 73 |
| Single-Family Detached | 393 | 236 | 629 |
| Total | 594 | 277 | 871 |

**Table 3-11. *Ex Post* Program Savings – Quality Installation**

| | PY2 Goal | PY2 *Ex Ante* | Evaluated PY2 Gross | Realization Rate |
|---|---|---|---|---|
| Participants (#customers) | 17,460 | 871 | 871 | 100% |
| Energy Savings (MWh) | 7,227 | 477 | 332 | 69.9% |
| Demand Savings (MW) | 9.3 | 0.72 | 0.58 | 81.4% |

#### 3.1.5 Net Program Impact Results

The original three-year evaluation plan[15] called for determination of a net-to-gross (NTG) ratio through a battery of related questions administered to a large number of contractors. Through the course of early evaluation tasks, the Evaluation Team recommended a PY2 approach for fewer, but more in-depth, interviews to probe the administration of the program and the challenges with the program that the evaluators anticipated. This in-depth interview approach precluded the NTG battery of questions.

Feedback from the contractors during the in-depth interviews does qualitatively address the NTG issues:

- The contractors noted that the CACES protocol was notably more time consuming than their typical annual equipment service, thus the program-required detailed diagnosis was not always done in the field absent the program.
- Likewise, the Manual J sizing calculations required for the Quality Installation were more involved and time-consuming than previously delivered.
- None of the contractors interviewed were using similar diagnostic tools in the field prior to the program.
- Comments made during training sessions attended by the evaluators also tend to support the opinion that the contractors gained diagnostic knowledge and ability through the program that could be applied in the field.

Feedback such as these comments from contractors leads the Evaluation Team to conclude that a NTG ratio of 1.0 is appropriate at this time. The PY3 evaluation will include questions for quantification of the NTG ratio.

### 3.2 *Process Evaluation Results*

The process evaluation of the CACES program focuses on the following researchable questions:

1. What are key barriers to participation for eligible ComEd customers? What are key barriers to participation for eligible independent participating contractors? How can they be addressed by the program?
2. How did customers become aware of the program? How did eligible independent participating contractors become aware of the program? What marketing strategies could be used to boost program awareness and participation, if needed?
3. How efficiently is the program being administered? What methods could be implemented to improve the efficiency of program delivery?

[15] March 26, 2009.

Data sources include a review of program materials and program data base, in-depth interviews with program staff and implementers (n=2), and in-depth interviews with participating contractors (n=14).

### 3.2.1 Process Themes

There are many themes to explore during a process evaluation. The Navigant Consulting team engaged the contractor participants in in-depth interviews to explore the issues that were foremost in their minds. Several common themes emerged:

*Program Administration*

In general, contractors seemed to be generally satisfied with overall program administration. The participation requirements were not overly burdensome. Even though each SA tool costs several thousand dollars, contractors did not consider the purchase of the tool a significant barrier.

They felt that both the technical and the administrative training sessions were useful and well-run. There were sufficient training opportunities such that scheduling training was not a burden. The technical training covered a lot of complicated material involving the tool. Technicians find that practice in the field is ultimately required. Some contractors have Honeywell provide follow up training with their techs. Satisfaction with the administrative training was also high, though contractors were not prepared for the additional administrative burden.

Contractors were less satisfied with the payment of incentives, though most attributed delays to the program start-up and noted that more recent payments had been more prompt. Several contractors noted that it was odd to receive dozens of $100 (for example) checks instead of one large check. Some contractors also noted that it was hard to keep track of open and closed rebates and that a tracking report would help greatly.

Most contractors are very satisfied with Honeywell and say that the firm is very responsive and tries to help contractors solve their problems. However, some contractors noted that Honeywell could be hard to get a hold of and that it may take a week for a response. Common recommended changes to the program included increased marketing, more customer referrals, and a reporting function in the contractor portal.

*Contractor Internal Administration*

Some contractors noted that the program's impact on the administrative side is greater than they expected. The administrative demands include getting specific work-order numbers from ComEd, researching equipment specifications while technicians are in the field, and processing and tracking incentive payments.

One early concern with the program was the requirement for nameplate data to enter rated efficiency and capacity into the Service Assistant (SA) tool. Most contractors reported they did not come across many units with missing nameplate information. Several contractors utilized office staff to research unit ratings while technicians were on-site. Two interviewed contractors simply did not perform the test on units with unreadable nameplates because they felt the tool would not be accurate without these data.

The SA tool and the database of records generated from data uploads provides contractors with opportunities to generate automatic reports based on their service. Most contractors do not make use of this option and instead write it on a service ticket that they leave with their customers. Most contractors do not have a portable printer to generate reports while on-site. One contractor stated that they do not generate reports because they are not comfortable with the results coming back from the Service Assistant Tool.

The Service Assistant tool is a key part of the program's process. Much of both the technical and business trainings focus on incorporating the tool into standard practice. Although the use of the tool in the field is integral to the program, the administrative changes required to support the tool are substantial. Honeywell and Field Diagnostic Services (FDSI) recommend pre-loading customer information onto the tool through FDSI's website. Contractors must also enter customer information into the Honeywell Utility Solutions Contractor Portal. This generates a work order, which is later matched with a job and submitted for rebate. Many contractors found the multiple data entry steps cumbersome. Additionally, most contractors maintain their own accounting system, creating confusion and extra work matching accounts. Some contractors found that not creating a work order in the Honeywell system before the job saved time; these contractors used their own invoice numbers as a placeholder and later generated a work order and matched it to the job.

Many contractors reported issues with the data entry process when first joining the program. Most of these contractors claim that their issues were resolved after using the tool and portal for a period of time. Larger contractors with dedicated administrative staff and multiple tools appear to have the most ease with the data entry process. This type of contractor was more likely to have made the data entry process part of the firm's daily routine. Smaller firms without dedicated administrative staff were more likely to struggle with the process.

*Program Marketing*

Program marketing has two different aspects – first, how contractors hear about the program, and second, how consumers hear about the program and whether they request services from the database of ComEd trained contractors.

With respect to marketing to contractors, most learned about the CACES program from a vendor or distributor, not ComEd. This is understandable, since a few vendors will have extensive direct contact with contractors.

From the contractor perspective, marketing to consumers could be stronger. Contractors reported very few (two or three for some contractors) if any customers referred to them from the program. This was a disappointment for contractors, who were expecting more cold calls as a result of participating in the program. One contractor noted that it took most of the summer to appear on ComEd's website.

*Impacts on Business Practices and Tune-Up Business Volume*

Assessing the business impact of this program in 2009 is challenging because of the severe economic downturn and extremely mild weather that allowed consumers to ride out the summer with older equipment or they did not worry about less efficient operation because of low operating hours. Participating contractors report that the program has had little impact on their sales and installations of high efficiency equipment. Most interviewed contractors reported no impact. One noted that there is some impact on sales because they can show customers the result of the test, but the impact is less than they expected.

Contractors also did not experience an impact in the number of tune-ups performed. Instead, they use the tool on existing customers that would have a tune-up anyway. One contractor even reported that they do fewer tune-ups per day because the new protocol takes longer.

Most contractors claim that there is not much difference between using the tool and their previous standard operating procedure. The largest difference is that tune-ups take about 30 minutes to one hour longer with the pre-test and post-test. Most say that it does not change anything they would normally do, but the SA helps ensure they are doing the tune-ups properly. Both using wireless sensors and practicing have cut down the test time somewhat.

Contractors report that the program has made no discernable impact on their overall business, including revenues and hiring practices, though economic conditions might make any real increases less perceptible.

*Impacts on High-Efficiency (HE) Equipment Sales*

Contractors' views of the program's impact on the demand for HE installations are mixed. Some have found that the economic downturn and mild summer have created a large drop in demand for new units. Others (most) have seen an increase in demand for HE units, but primarily as a result of the federal tax incentives. Demand is also affected by the ComEd program and deals from manufacturers, like Trane's 15-month 0% financing. All have seen an increase in the general awareness of HE systems.

Contractors promote the program beyond simple efficiency increases. They also sell customers on two-stage cooling, comfort benefits and better warranty. Further reasons for customers to install high efficiency HVAC systems include lower operating costs, better equipment, better warranty, two-stage cooling and the shift from R22 to 410, as well as the tax credit and rebates available.

Cost is the primary reasons not to install HE systems. Customers have trouble coming up with the high initial cost and feel that the incremental cost is not going to be made up by the savings. Contractors note that AC is not used enough in the region to be worth the difference in cost. Higher efficiency furnaces are more of a priority.

Contractors find that the rebate (and similar incentives like the tax credit) is very important to most customers, as it helps them afford replacements or upgrades in a time of a struggling economy and job losses.

Overall, according to contractors, the share of HE installations (SEER 14 or higher) ranged from 5% to 65%. The average is about 30%. Several contractors did not know the share of sales attributable to HE equipment.

Overall, most contractors are satisfied with the program. The overarching theme to their comments is that the program is new and has kinks, but they are improving and that next summer will be much better in terms of participation and payback. The most common recommended changes include more marketing/customer referrals and a reporting function in the contractor portal.

### 3.2.2 Program Theory

This section contains the program theory, logic model, and performance indicators of the CACES program. We created this model based on discussions with program management and implementers as well as program documentation. The program theory and logic model is to be used:

- As a communication tool by
  - allowing the implementer to show reasoning to other stakeholders
  - bringing common understanding between implementer and evaluator
- As an evaluation tool to
  - Focus evaluation resources
  - Clearly show what evaluation will do and expected answers from evaluation
  - Provide a way to plan for future work effort

The logic model (LM) is a graphic presentation of the intervention – what occurs and clear steps as to what change the activities undertaken by the intervention are expected to bring about in the targeted population. Logic models can be impact or implementation oriented. An impact model is sparse in terms of how the programs works, but clearly shows the outputs of the program and what they are aimed at affecting. Outcomes are changes that could occur regardless of the program and should be written as such. The implementation model is how the program works and typically resembles a process flow chart. The attached model is an impact model.

We use numbered links with arrows between each box in the logic model. These numbers allow us to:

» Clearly discuss different areas of the model
» Describe why moving from one box to the other brings about the description in the later box
» Set up hypotheses for testing of specific numbered links
» Explicate what we will and will not be testing within the evaluation

The program theory (PT) is a description of why the intervention is expected to bring about change. It may reference theories of behavioral change (e.g., theory of planned behavior, normative theory) or be based on interviews with the program managers as they describe their program.

**Creation of the Logic Model**

There are several different "looks" to logic models. For this evaluation, we are using a multi-level model that has a generic statement about resources in the header, activities in the first row, outputs of those activities in the second row, and outcomes in the third (proximal) and fourth (distal) rows. External factors are shown on the bottom of the diagram.

When we created the boxes in the logic model, we used the following "road-map."

**Activities**

These are discrete activities that roll up to a single "box" that is shown in the model. It separates out activities that may be performed by different groups. Each activity typically has an output. We used program documentation (implementation plans) and/or discussion with program managers to determine activities.

**Outputs**

These are items that can be counted or seen. It may be the marketing collateral of a marketing campaign, the audits performed by a program, or the number of completed applications. All outputs do not need to lead to an outcome. We used the same sources as for activities to determine outputs.

**Proximal Outcomes**

These are changes that occur in the targeted population that the program directly "touches." Multiple proximal outcomes may lead to one or more distal outcomes.

**Distal Outcomes**

These are changes that are implicitly occurring when the proximal outcome occurs. For example, an energy efficiency program may use marketing to bring about changes in Awareness, Knowledge, or Attitudes as a proximal outcome, which leads to the distal outcomes of: intent to take actions, which leads to actual installation of EE equipment, which leads to energy impacts.

**External Factors**

These are known areas that can affect the outcomes shown, but are outside of the programs influence. Typically, these are big areas, such as the economy, environmental regulations, codes/standards for energy efficiency, weather, etc. Sometimes these can arise from our discussions with the program managers, but often they were thought about and included based on our knowledge.

**Expanding the Impact Logic Model**

Once the impact logic model was drafted, a table was created that describes the links, the potential performance indicators that could be used to test the link, the potential success criteria that would indicate the link was successful, and potential data sources of the link.

When thinking about how to write each of the performance indicators, we asked ourselves "What would we look at to judge whether the link description actions are occurring" and wrote the answer as the performance indicator.

Success criteria were created by us and are thought to be reasonable.

**Figure 3-5. Logic Model**

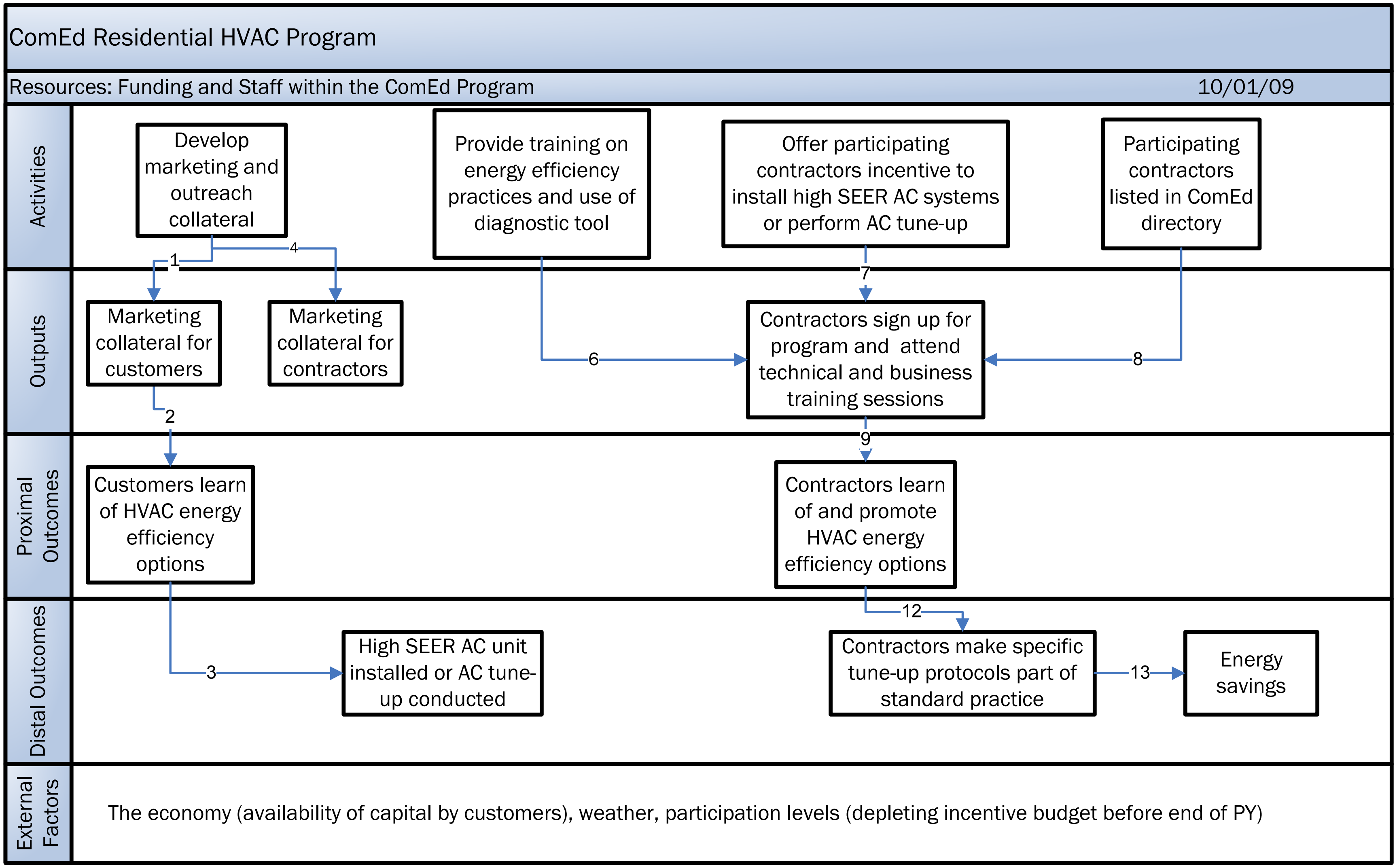

ComEd Residential HVAC Program
Resources: Funding and Staff within the ComEd Program
10/01/09
Activities
Outputs
Proximal Outcomes
Distal Outcomes
External Factors
Develop marketing and outreach collateral
Provide training on energy efficiency practices and use of diagnostic tool
Offer participating contractors incentive to install high SEER AC systems or perform AC tune-up
Participating contractors listed in ComEd directory
Marketing collateral for customers
Marketing collateral for contractors
Contractors sign up for program and attend technical and business training sessions
Customers learn of HVAC energy efficiency options
Contractors learn of and promote HVAC energy efficiency options
High SEER AC unit installed or AC tune-up conducted
Contractors make specific tune-up protocols part of standard practice
Energy savings
1
2
3
4
6
7
8
9
12
13
The economy (availability of capital by customers), weather, participation levels (depleting incentive budget before end of PY)

**Table 3-12. Performance Indicators Table**

| Link | Description of Link | Potential Performance Indicator | Potential Success Criteria for Performance Indicator | Evaluator Data Collection Activities Associated with Link |
|---|---|---|---|---|
| 1 | ComEd and Honeywell develop and distribute marketing and outreach materials to teach residential customers about the details and benefits of the program | Marketing collateral is effective | Sufficient opportunities for customers to be made aware of the program.<br>Marketing materials are written clearly and in such a way that information is easy to understand. | Program documentation and review of marketing materials |
| 2 | Through the marketing collateral, the customers learn of energy efficient HVAC equipment and installation/maintenance methods | Awareness of marketing | 1) High level of awareness of marketing materials (50% of customers aware of program)<br>2) High referral rate of material (75% of inquiries are related to marketing materials) | Customer survey results |
| 3 | After learning about energy efficient HVAC options from program marketing, customers decide to implement these options | Implementation of EE options | 1) EE measures installed (50% of customers install EE measures)<br>2) EE behaviors changed (75% report changed behavior) | Customer survey results |
| 4 | ComEd and Honeywell develop and distribute marketing and outreach collateral to inform contractors about the program and to convince them to join | Marketing collateral is effective | Sufficient opportunities for contractors to be made aware of the program.<br>Marketing materials are written clearly and in such a way that information is easy to understand. | Program documentation and review of marketing materials |

| Link | Description of Link | Potential Performance Indicator | Potential Success Criteria for Performance Indicator | Evaluator Data Collection Activities Associated with Link |
|---|---|---|---|---|
| 5 | Through marketing collateral, HVAC contractors learn of the program and sign up to attend training sessions | 1. Number of contractors participating in the program | 1. Contractors sign up to be part of the program<br>2. 100% of contractors are aware of marketing material | Contractor data base and contractor survey results |
| 6 | The technical training on energy efficiency practices and the use of the FDSI diagnostic tool encourage contractors to participate in the program. | 1. Number of contractors participating in the program | 1. Contractors sign up to be part of the program | Contractor data base and contractor survey results |
| 7 | The incentive offered to contractors who perform qualified tune-ups and install high SEER ACs encourages contractors to participate in the program | 1. Number of contractors participating in the program | 1. Contractors sign up to be part of the program | Contractor data base and contractor survey results |
| 8 | ComEd creates a referral service for participating contractors that encourages contractors to participate in the program. | 1. Number of contractors participating in the program | 1. Contractors sign up to be part of the program | Contractor data base and contractor survey results |
| 9 | As a result of the technical and business training, contractors become more aware of energy efficient business practices. | 1. Awareness of energy efficiency tune-up practices<br>2. Awareness of the energy saving benefits of high SEER ACs. | 1. 100% of contractors report learning about EE that they can apply in their work<br>2. 100% of contractors report that they are better able to explain EE benefits of a high SEER AC to customers | Contractor survey results |

| Link | Description of Link | Potential Performance Indicator | Potential Success Criteria for Performance Indicator | Evaluator Data Collection Activities Associated with Link |
|---|---|---|---|---|
| 10 | After learning about energy efficient HVAC options from a participating contractor, customers decide to implement these options | Implementation of EE options | 1) EE measures installed (50% of customers install EE measures)<br>2) EE behaviors changed (75% report changed behavior) | Customer survey results |
| 11 | The installation of high SEER ACs and AC tune-ups results in energy savings in ComEd territory | 1. kWh savings | 1. Program meets its kWh goals | Impact analysis |
| 12 | Continued participation in the program will lead to market transformation and result in the tune-up protocol becoming standard practice for contractors | Tune-up protocol becomes standard practice | Tune-up protocol becomes standard practice (100% of contractors use tune-up protocol for all tune-ups) | Contractor survey results |
| 13 | The standard practice of the program's tune-up procedures will lead to higher efficiency of existing systems in the market and energy savings | 1. kWh savings | Market transformation | Impact analysis |

### 3.3 Cost Effectiveness Review

This section addresses the cost effectiveness of the Central Air Conditioning Efficiency Services (CACES) program. Cost effectiveness is assessed through the use of the Total Resource Cost (TRC) test. The TRC test is defined in the Illinois Power Agency Act SB1592 as follows:

> *" 'Total resource cost test' or 'TRC test' means a standard that is met if, for an investment in energy efficiency or demand-response measures, the benefit-cost ratio is greater than one. The benefit-cost ratio is the ratio of the net present value of the total benefits of the program to the net present value of the total costs as calculated over the lifetime of the measures. A total resource cost test compares the sum of avoided electric utility costs, representing the benefits that accrue to the system and the participant in the delivery of those efficiency measures, to the sum of all incremental costs of end-use measures that are implemented due to the program (including both utility and participant contributions), plus costs to administer, deliver, and evaluate each demand-side program, to quantify the net savings obtained by substituting the demand-side program for supply resources. In calculating avoided costs of power and energy that an electric utility would otherwise have had to acquire, reasonable estimates shall be included of financial costs likely to be imposed by future regulations and legislation on emissions of greenhouse gases."*[16]

ComEd uses DSMore™ software for the calculation of the TRC test.[17] The DSMore model accepts information on program parameters, such as number of participants, gross savings, free ridership and program costs, and calculates a TRC which fits the requirements of the Illinois legislation. Environmental benefits have been quantified for $CO_2$ reductions, using a value of $0.013875 per kWh.

One important feature of the DSMore model is that it performs a probabilistic estimation of future avoided energy costs. It looks at the historical relationship between weather, electric use and prices in the PJM Northern Illinois region and forecasts a range of potential future electric energy prices. The range of future prices is correlated to the range of weather conditions that could occur, and the range of weather is based on weather patterns seen over the historical record. This method captures the impact on electric prices that comes from extreme weather conditions. Extreme weather creates extreme peaks which create extreme prices. These extreme prices generally occur as price spikes and they create a skewed price distribution. High prices are going to be much higher than the average price while low prices are going to be only moderately lower than the average. DSMore is able to quantify the weighted benefits of avoiding energy use across years which have this skewed price distribution.

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[16] Illinois Power Agency Act SB1592, pages 7-8.

[17] Demand Side Management Option Risk Evaluator (DSMore) software is developed by Integral Analytics.

Table 3-13 summarizes the unique inputs used in the DSMore model to assess the TRC ratio for the Central Air Conditioning Efficiency Services program in PY2. Most of the unique inputs come directly from the evaluation results presented previously in this report. Measure life estimates and program costs come directly from ComEd. All other inputs to the model, such as avoided costs, come from ComEd and are the same for this program and all programs in the ComEd portfolio.

**Table 3-13. Inputs to DSMore Model for Central Air Conditioning Efficiency Services Program**

| Item | Value Used |
|---|---|
| Measure Life | 10 years |
| Participants | 16,293 |
| Annual Gross Energy Savings | 1,964 MWh |
| Gross Coincident Peak Savings | 3.82 MW |
| Net-to-Gross Ratio | 100% |
| Utility Administration and Implementation Costs | $ 275,503 |
| Utility Incentive Costs | $1,652,515 |
| Participant Contribution to Incremental Measure Costs | $0 |

Based on these inputs, the Illinois societal TRC for this program is 0.33 and the program does not pass the TRC test. The standard TRC calculation produced by DSMore is also 0.29. The program's low realization rate is the leading reason for the program not passing the TRC test. Low realization rates for demand and energy savings are a result of better baseline performance of customer AC units (average SEER 10.0 performing in the field) than anticipated in the program plan (SEER 8.0). Lower power savings is the main factor in lower energy savings, but lower hours of operation also drive down energy savings realization rates.

# Section 4. Conclusions and Recommendations

The CACES program launched its first year in the midst of difficult economic times. Furthermore, it is an innovative program that is enlisting diverse independent participating contractors to reach out to customers and deliver the program. This mode of marketing is difficult especially when the economy is poor. Potential independent participating contractors may be looking to lay-off staff and/or focus operations. These challenges have affected important aspects of the program. Combined participation in the two parts of the CACES program has been low – about 72% of planning goals. While the Diagnostic and Tune-Up participation was 250% of goals, the Quality Installation program achieved only 5% of goals, in terms of participation.

Savings per participant in the Diagnostics and Tune-up program were much lower than expected. The primary factors driving the low realization rates are two-fold – lower operating hours and participants' existing equipment operated better than anticipated by the program plan. Without firm data to explain the low hours we note that the economy might be a factor as people saved money by running air conditioning less. Furthermore, despite occasional hot days there was no prolonged heat wave that often accompanies high use of air conditioning. The fact that participant equipment was operating more efficiently than expected can also be interpreted through an economic lens. It could be that consumers with the poorest performing equipment were among those least able to afford a tune-up in PY2.

Though participation and savings were low, we can conclude that the independent participating contractors were effectively delivering the program. Our verification tests showed close agreement with contractor data, both for performance and recording accurate model, efficiency and capacity data.

Recommendations for the program are mostly process-related.

1. The Quality Assurance assessment identified two areas for improvements:
   - Increase the number of verification audits, and
   - Clarify the data retention procedures for contractors.
2. In depth interviews with contractors identified several areas for future improvement:
   - Better centralized marketing of the program to consumers. Contractors did not experience the expected boost in sales or referrals through the program, and
   - Better centralized tracking of open and closed rebates would add transparency to the process and ease administrative burdens. Such a report might also be used to convey news about pending payments so that the delay for payment does not seem as long.
3. Include customer city information in the tracking data system to facilitate evaluation with regional weather data.

We have a few recommendations to facilitate more effective impact evaluation in the future.

1. Ensure that key fields used to link tables in the database are the same data type. For example, the site ID in the Incentives Table is a text string, but in the other tables it is a long integer. Relational databases require matching data types as well as values when building relationships. Site ID should be a long integer-type throughout the database.
2. Include geographic identifiers in the base data. Our impact analysis determined saving by geographic (weather) zone. In order to do this we had to request supplemental data from ComEd to allocate participants among weather zones. If a region field were included in the base database (most appropriately the UnitDataFile table), these allocations would be faster.
3. Implement more quality control for acquiring complete data for each installation. Equipment nameplate data must be complete and each site must have both pre-service and post service SA field data.
4. In the Energy Efficiency and Demand Response program portfolio, program savings is defined on measures implemented during the June 1 – May 31 program year. Participation in the CACES program should be linked more closely to measure implementation dates rather than administrative dates such as when checks are written. The LogTime date/time stamp from the SA seems to be a logical choice, though quality control must ensure that the SAs are registering accurate dates when they are set up.

Future evaluation work should include the following topics:

1. Better estimates for equipment runtime. Improvements might include earlier installation of runtime equipment, a larger run-time evaluation sample, and a more diverse sample across the service territory or further analysis of load research data that integrates field data results.
2. Determine persistence of tune-up parameters. Do machines maintain higher efficiency indices for several years? Can the program be used to determine cost-effective tune-up intervals or flag units that are annual problems?
3. Quantitative net-to-gross determination. Are the independent participating contractors really changing their methods due to program influence or are they simply getting paid an incentive for the same scope of work with the same results that they achieved without the program?
4. Participant customer interviews. Are customers aware of the ComEd program and that their air-conditioning contractor is participating in the program? Do they preferentially select participating contractors? Are they satisfied with the services incented by the program?
5. Billing analysis of non-participants for quality installation. The fixed effect model used in PY2 is good for controlling for customer behavior, weather and demographics, but it does not account for changes in behavior induced by outside influences, such as the recession. A carefully constructed non-participant control group could account for economic effects.

# Section 5. Appendices

## 5.1 Data Collection Instruments

**ComEd**
**Interview Guide**
**Participating Contractors: Residential HVAC**

**Introduction**

Hi, may I please speak with [name from list]?

My name is ___ and I'm calling from Opinion Dynamics, a market research company, on behalf of ComEd. We're talking to HVAC contractors who have participated in ComEd's Central Air Conditioning Efficiency Services (CACES) program to learn about their experiences with the program and to gain a better understanding of where the program could be improved.

I would like to ask you some questions about your experience so far with the CACES program. The questions will only take about 20 minutes, and your responses will be kept strictly confidential. Is this a good time to talk? [IF NO, SCHEDULE A CALL BACK.]

**I. Participation**

1. How did you first learn about ComEd's Residential HVAC (CACES) program? When did you first join? What convinced you to join?

2. Did you have any difficulties meeting the program requirements, such as purchasing the service assistant tool, administrative requirements or attending the training?

3. What impact has the CACES program had on your sales/installations of high-efficiency AC systems? Would you sell/install fewer or the same number of high-efficiency units without the program?

4. What impact has the CACES program had on your sales of AC tune-ups? Would you perform the same number of tune-ups without the program?

5. Has the CACES program had an effect on your business (such as revenues, customers, etc. - not installation practices)? Please explain.

6. Since the program started in June, have you noticed a change (increase or decrease) in demand for high efficiency HVAC in your market? [Note increase or decrease]

i. [If demand has increased] Has the program had any influence on this increase in demand?
ii. What other factors help to sell these higher units? [Probe for awareness / impact of the change in the federal standard to 13 SEER.]

7. Since the program started in June, have you noticed a change in demand for AC tune-ups in your market? [Note increase or decrease].
   i. [If demand has increased] Has the program had any influence on this increase in demand?
   ii. What percentage of your tune-ups is typically done before June 1? Was the June 1 start date too late to affect much of your tune-up business?
   iii. What other factors help to sell the tune-ups?

## II. Current equipment selection, sizing, and installation

8. Approximately how many total AC and heat pump units did your company install in 2008? Approximately what share were high SEER (14+) units? How does 2009 compare to these estimates so far?

9. How do you promote higher efficiency systems to your customers? How do you sell the benefits of higher efficiency units? What materials do you use to help inform eligible customers of high-efficiency AC equipment? How helpful are the materials? How often do you use the information with customers? Do you have any suggestions for marketing or information materials you would like to see? Has the program provided new material or information that helps with HE- AC sales?

10. Can you discuss the differences between the program's Service Assistant tool protocol/quality installation/tune-up and your standard operating procedure before you joined the program? Was the transition easy or difficult? Are there any advantages or drawbacks to the Service Assistant tool protocol? Do you apply the protocol to all accounts or just those eligible ComEd customers?
    a. How do you charge customers for QI (is it a line item? Part of a package?) (If not part of the package) What percentage of customers chooses a QI instead of a regular installation?
    b. [If do not apply protocol to all customers (see Q10)] Do you charge the same price for a tune-up that uses the service protocol as one that doesn't?

11. Do you have any trouble determining the SEER of the existing unit (either by inability of determining nameplate SEER or through broken/dirty system)? In these instances, what do you do to capture the SEER of their existing unit? How well are you able to measure and confirm the performance optimization of the installed equipment?

Do you have any trouble finding ARI or model numbers of the condenser or coil? [For new installations only]
Do you have problems conveying data to the FDSI database or updating data you have uploaded?

**III. Customers**

12. What are the main reasons customers decide to install high efficiency AC systems?

13. What are the main reasons customers decide not to install high efficiency AC systems?

14. How important are the rebates/discounts in the customer's decision to purchase a high efficiency AC as opposed to a standard efficiency AC?

15. How much influence do you/your staff have on a customer's selection of a high efficiency AC system over standard efficiency?

16. Approximately what percentage of your customer's (Tune-up or QI) are referred to you through ComEd?

17. How do customers respond to the use of the Service Assistant? Is it a selling point? Are they impressed by the process or are they indifferent to the use of technology?

18. After completing the job, do you generate a report for the customer? If so, how do you typically give this to the customer? [Probe for mail, email, in person]

**IV. Satisfaction**

19. What is your level of satisfaction with… Why do you say that?
    a. The training received (both technical and business)
    b. The data entry process, including contractor portal
    c. The incentive process
    d. The wait time to receive your incentive
    e. The tune-up requirements
    f. The quality installation requirements
    g. The program implementer (Honeywell)

20. How satisfied are you overall with the ComEd CACES program? Why do you say that?

21. Are there changes that can be made to the program to make it more valuable to you? If yes, what are those changes and why do you feel they are needed?

**V. Marketing**

22. Do you utilize any of the marketing tools or support offered by the program or ComEd? Which tools? Is there any additional support you desire?

**VI. Training**

23. When and where did you/your co-workers receive free training? Do you have any feedback about this training? What could be improved?

24. How much influence did the technical training have on your standard operating procedures for tune-ups and installations? How much did this change from what you were doing before you became a qualified contractor? Did the training cause you to promote high efficiency AC systems more frequently?

    i. [Probe for changes in business practices, both prior to and as a result of the training sessions.]

25. How often do you attend professional training sessions about issues related to AC equipment and heat pumps?

    i. Do you require that your staff attends any periodic training? Please describe.
    ii. Who typically sponsors these trainings?

**VII. Incentive**

26. Have you had any difficulties with the incentive process? Are the incentive requirements clear and easy to understand?

27. Have you had any difficulties with receiving payment from ComEd? How long does it typically take to receive the incentive?

**VIII. Barriers**

28. Have you experienced any issues that have prevented you from promoting or implementing the program as expected? [Probe: availability of high efficiency units, availability of units that meet program requirements, proper sizing/installation, testing the unit and uploading test results, additional time to complete tune-up tests or service assistant customer setup]

**IX. Wrapping up**

I have just a few more questions…

29. How many employees do you have?

30. How long have you been in business?

31. What geographical areas do you serve? [City of Chicago, North/South/West Suburbs, Rockford area, Quad Cities, North Central IL,]

    i. About what percent of your company's business comes from customers in ComEd's service territory?

    ii.