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Energy Efficiency / Demand Response Plan: Plan Year 3 (6/1/2010-5/31/2011)

Evaluation Report: Energy Efficient Affordable Housing Construction

DRAFT

Presented to

The Illinois Department of Commerce and Economic Opportunity

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Table of Contents

Executive Summary

The Illinois Department of Commerce and Economic Opportunity (DCEO) provides grants to non-profit and for-profit affordable housing developers to help offset additional costs for including energy efficient building practices in residential new construction and gut rehab. Supported by funding from a variety of sources, including the Illinois Energy Efficiency Trust Fund and the Energy Efficiency Portfolio Standard Fund, grants are funded through the Energy Efficient Affordable Housing Construction Program (EEAHC). The EEAHC program funds low income new construction and gut rehab projects.

The Program is well known and utilized in the affordable housing field. The EEAHC program has been providing grants for energy efficient upgrades since 1988. Groups such as the Illinois Housing Development Authority, Chicago Department of Housing, and the Community Investment Corporation, as well as project architects, encourage affordable housing developers to seek energy grants from this program.

The program only claims savings from the measures listed below, however, the program requires a longer list of measures be implemented to qualify as a participant.

- Energy STAR® refrigerator
- Interior and exterior fluorescent lighting fixtures
- Efficient central air conditioner or heat pump
- Thermal envelope improvements resulting in a reduction in required central AC or heat pump capacity
- Energy STAR® dishwasher
- Energy STAR® clothes washer
- Energy STAR® rated bathroom exhaust fan
- 92% AFUE furnace with efficient air handler
- Energy STAR® ceiling fan with lighting

These measures will be evaluated in this report.

Evaluation Objectives

The objectives of the PY3 evaluation are to summarize and verify program impact, to provide recommendations to improve impact estimates, provide recommendations to improve program

marketing and administration, and to maintain consistency with building codes and standards. The evaluation also intends to provide a comprehensive assessment of developments in program implementation, program standards, and tracking systems, with a focus on the relationship of those elements to verifiable impact. The intent behind the PY3 evaluation is to:

- Document program accomplishments for PY3,
- Continue to provide feedback and guidance regarding program tracking and verification policies,
- Update the PY2 review of program measures impact assumptions to incorporate newly available information and relevant changes in codes and standards,
- Note current and pending changes to relevant portions of Energy STAR ® standards and building energy codes that may affect measure impacts in future program years,
- Identify areas of impact uncertainty to guide PY4 evaluation activities,
- Assess the current program marketing and outreach tools, and
- Assess the efficiency of the program administration.

Evaluation results are based on electronic and hard copy program documentation as well as in-depth interviews conducted with key program implementation staff and participating builders.

Evaluation Methods

In order to meet the PY3 objectives, the Evaluation Team conducted the following activities:

- Review of verification and due diligence procedures
- Summarize program accomplishments
- Summarize participation and impacts
- Calculate ex-post impacts
- Review application specification sheets
- Review of tracking systems and quality control
- Review of ex-ante impact assumptions
- Evaluation of program implementation issues and concerns
- Evaluation of program marketing and outreach tools

Evaluation results are based on electronic and hard copy program documentation as well as meetings with key program implementation staff.

Key Findings and Recommendations

The Program is administered across both ComEd and Ameren Illinois Utilities service territories. There are two measures of program accomplishments. The first one is the number of units constructed in the program year and the second is the number of units funded in the program year (which may be completed in the following program years).

The programs' expectations[1] were to complete a total of 1,739 units between PY1 and PY3. The number of units that completed construction between PY1 and PY3 was 1,528, of which 829 were in PY3. Energy savings between PY1 and PY3 total 4,101 MWh, and the demand reduction achieved is 1.2 MW.

Table ES-1. PY1 through PY3 Program Accomplishments[2]

Program Year	Ex-Post Accomplishments**		
	Completed Installations^	MWh	MW
PY1	204	430	0.3
PY2	495	1,989	0.4
PY3	829	1,682	0.5
Total (PY1-PY3)	1,528	4,101	1.2

^Sources: MS word and Excel files submitted to EM&V team: 'PY3-CompletedProjects.xls', 'PY2 Projects.doc' and 'retrofit master FY08 recommendations and project 2009.xlsx'
***Source: EM&V analysis.*

[1] Source: *Template - Low Income new construction and gut rehab.pdf*
[2] Overall Program Expectations and Accomplishments reflect the total EEAHC Program, including both ComEd and Ameren Illinois Utilities service territories.

The funding of new projects is an indicator of the volume of upcoming project and unit installations. For this reason it is also an important metric of program accomplishments. Table ES-2 below shows expected and actual accomplishments in terms of the number of units funded. The table shows the annual as well as cumulative project starts between PY1 and PY3. The program project-starts were 1,708 units in PY3, short of the annual expectation by 249, and exceeding the cumulative expectation by 93 units.

Table ES-2. Expected Project Starts versus Program Accomplishments[3]

Program Year	Expected* Funded Units	Actual Funded Units^	Annual Accomplishments Versus Expectations	Cumulative Accomplishments Versus Expectations
PY1	652	753	+101	+101
PY2	1,087	1,328	+241	+342
PY3	1,957	1,708	-249	+93

**Source: pdf file submitted to EM&V Team: 'Template - Low Income new construction and gut rehab.pdf"*
^Source: Excel file submitted to EM&V Team: 'PY3 - FundedProjects.xls'

Key Impact Findings and Recommendations

The EEAHC program allows participants to select from an array of measure choices and select what is appropriate given the particular circumstances of construction. As such, each project has a unique set of measures, and associated energy and demand savings. For this reason, the ex-post impact assessment is based on project specific data regarding the efficiency rating and measure counts of installed equipment.

The PY1 and PY2 Evaluation Reports presented a review of ex-ante impact algorithms and assumptions. For the PY3 Evaluation, these were revisited to ensure consistency with current Energy STAR ® calculators and were compared with applicable efficiency and building standards. Table 3-5 summarizes ex-ante impact per unit, as well as the new recommended values for PY3 projects. Lighting values are presented on a per fixture basis. Actual ex-ante and ex-post figures are based on installed fixture counts. Similarly, the AC savings values reflect minimum qualifying equipment, but ex-post impact will reflect the actual efficiency of installed equipment. While Energy STAR ® clothes washers and dishwashers are not new measures to PY3, the evaluation of appliances using hot water heated by electricity (as opposed to natural gas) is new to PY3. Reviews of Energy STAR ® literature and calculators yielded estimates of kWh savings per appliance per year. In addition, demand impact for clothes washers has been investigated as part of the PY3 evaluation. In PY2 this impact was not evaluated and was set

[3] Overall Program Expectations and Accomplishments reflect the total EEAHC Program, including both ComEd and Ameren Illinois Utilities service territories.

equal to zero. This year, a positive demand impact was found for clothes washers so a retroactive credit for PY2 clothes washers has been applied to the program in PY3.

Current and recommended ex-ante impact values for the Air Conditioning measures (CAC, HP, and building envelope) by building type, cooling type and heating type are shown in Table 3-7. As was done in this evaluation, it is recommended that ex-post impacts associated with AC, HP and building envelope measures be developed using data regarding the specific equipment type, efficiency, building envelope specifications, building type, location and applicable building code. For PY4 planning purposes the program may consider using the values shown in Table 3-7. These values are based on building energy simulations that were performed in support of the engineering reviews presented in the ex-ante impact review in Section 3.1.

Single Family Findings and Recommendations

None of the projects initiated in PY3 were subject to the IECC 2009 building energy code because they were all funded during PY2. However, most projects funded in PY3 and beyond may be subject to this new code. Engineering analysis performed in support of this evaluation indicates that for buildings subject to IECC Residential Code, (single family and small multi-family buildings) there is zero reduced AC tonnage when moving from IECC code to current EEAHC program standards.

- **It is recommended that projects subject to IECC residential code and completed under the current EEAHC program standards, adopt a zero ex-ante impact for reduced AC tonnage for both single-family and small multi-family units.**

- **It is recommended that ex-ante impact associated with AC, HP and building envelope measures take into account data regarding the specific cooling type, heating type and building type**

- **It is recommended that the program consider using, at minimum, CEE Tier 1 equipment efficiency standards for future evaluation years.**

Multifamily Findings and Recommendations

Building Types. One of the previous year's project multifamily buildings was actually two 50-unit low-rise buildings which may not be properly applied to this building type.

- **Recommendation. Consider distinguishing buildings as either low-rise or non low-rise buildings for applicable savings. For example, one and two story buildings have different energy usage than four story buildings with the same square footage. Additionally, the energy impact for building envelope measures varies depending on building geometries. For example, roof insulation is a less significant factor in high-rise buildings than one story buildings.**

Scope of HVAC system types. Previous year project buildings utilized various HVAC system types such as water loop heat pump systems with a central boiler plant and fluid cooler, ground-source heat pumps, and central boiler and chiller systems. These system types are not currently recognized by the program.

- **Recommendation. Consider adapting program qualifications to encompass a broad range of HVAC systems. This will allow the program to take credit for higher efficiency systems.**

Infiltration Requirements. Infiltration requirements are difficult to quantify in high-rise buildings and have a relatively low energy impact due to the control of building pressurization from the central mechanical system which brings in outside air as well as exhaust air.

- **Recommendation. Consider adding program requirements for heat recovery or energy recovery systems on buildings' ventilation and exhaust systems.**

HVAC Data Collection. Much of the data collected regarding HVAC system types is overly simplified and vague.

- **Recommendation. Consider specifying all HVAC system types and which areas of the building they serve as part of the application and/or verification process.**

Key Process Findings and Recommendations

The process evaluation for the EEAHC Program consisted of reviewing program materials and databases in addition to interviewing the three most influential and informed program personnel. In addition, the evaluation team interviewed participating builders.

Key process findings thus far indicate that the program is doing well in terms of marketing and participation. The program staff has made continuous and substantive changes to streamline and improve their application process especially for multifamily rehabilitation projects which are increasingly common for the program. The program staff has done a good job of continuing to meet funding demand with a small administrative and technical staff.

However, one of the greatest program challenges comes down to the need for additional staffing resources, both administrative and technical. Despite its growing demand year to year, units receiving funding grew as much as 187% between the last two fiscal years; the program continues to operate with only one full-time dedicated DCEO manager and one technical consultant. In PY4, the EEAHC program will begin to fund natural gas measures as well as electric measures, meaning the program will have to track and document program activity across six different utilities. This will increase the workload and administrative complexity for the DCEO.

Further, the program plans to create a comprehensive DCEO database that will consolidate the EEAHC data and allow for more careful comparison, tracking, and analysis. Due to constrained

resources to operate this program, this database update is progressing slowly. Finally, the EEAHC implementation plan includes an annual field analysis for the first three years following unit occupancy. These field analyses are to be conducted by the technical contractor, but have not been performed in the last few years, again due to constrained resources.

- **Given these operating conditions, we recommend that the DCEO evaluate its staffing resources relative to anticipated program demand for the next program year and determine whether additional staffing is needed and can be funded or whether program goals should be revised to align with the staffing resources available.**

- **We recommend that the DCEO execute its visions for a comprehensive DCEO database across six different utilities with the understanding that this likely will not happen unless the DCEO is able to gain additional staffing resources, or hires a consultant for this task.**

- **Based on participating builder feedback, we recommend protocols to support increased communication in certain key areas. In particular, to ensure participants are aware of project approval and payment timelines, as well as to acknowledge requests for information**

Program Accomplishments

ComEd Service Territory

Of the 829 installations completed through the EEAHC program, 714 were constructed within ComEd service territory in PY3. These were constructed within 16 building projects. Building projects and their impact information are provided in Table ES-3 below. Nine of the 16 projects are new multi-family buildings, while the remaining seven projects are single- and multi-family rehab projects. The associated ex-ante impact for PY3 is 1,316 MWh energy savings and 0.641 MW demand savings. The evaluation results yield total ex-post energy savings of 1,221 MWh and 0.371 MW for PY3. These ex-post impact results represent 93% of the ex-ante energy savings and 58% of demand savings. The exact causes for the differential in realization rates between energy and demand savings could not be determined as the source of the original savings estimates was not clear. However, it appears that the summer energy and demand savings were less than anticipated. While the energy savings were dramatically increased due to unanticipated savings over the heating season, demand savings are based on summer months only. The heating season energy savings arise from the many buildings found to have electric heating.

Table ES-3. MWh and MW Savings by Tracking Record, ComEd Service Territory

Project Name	Building Type	Units Completed in PY3	Ex-Ante MWh	Ex-Ante MW	Ex-Post MWh	Ex-Post MW
Alexian Brothers	Rehab MF	24	44.1	0.021	89.0	0.026
Brinshore 2800 Corp.	Rehab MF	25	46.0	0.022	106.7	0.032
Chicago Housing Authority	Rehab MF	104	191.3	0.093	187.8	0.037
Community Partners	Rehab SF	2	4.2	0.003	7.1	0.002
Cook County	Rehab MF	52	95.6	0.046	103.5	0.051
Green HFH (Waukegan)	Rehab SF	4	8.4	0.005	10.8	0.004
Green HFH (Kildare)	Rehab SF	6	12.6	0.008	17.5	0.007
Holiness Homes	New MF <80	54	99.3	0.048	65.4	0.033
Interfaith	New MF	100	183.9	0.089	122.6	0.025
Lake County	New MF <80	20	36.8	0.018	50.8	0.015
Lawndale Christian	New MF	42	77.2	0.037	85.8	0.030
NHS Roseland	New MF <80	60	110.3	0.053	79.1	0.011
NHS Wrightwood	New MF <80	76	139.8	0.068	49.7	-0.002
NHS Victory	New MF <80	72	132.4	0.064	78.4	0.045
Senior Suites	New MF <80	32	58.8	0.028	42.9	0.020
St. Edmunds	New MF <80	41	75.4	0.036	123.9	0.034
PY2 clothes washer adjustment		197*	-	-	-	0.001
Total		714	1,316.3	0.641	1,220.8	0.371
Realization Rate					0.93	0.58

**These units were completed in PY2 and are not included in the total number of units completed in PY3.*
Source: Ex ante: Excel file submitted by DCEO to EM&V Team, "PY3-CompletedProjects.xls"
Ex post: EM&V analysis.

Ameren Illinois Utilities Service Territory

Of the 829 installations completed through the EEAHC program, 115 were constructed within Ameren Illinois Utilities service territory in PY3. These were constructed within five building projects. Building projects and their impact information are provided in Table ES-3Table ES-4 below. All five projects are new single-family buildings. The associated ex-ante impact for PY3 is 242 MWh energy savings and 0.153 MW demand savings. Ex-post impacts for PY3 total 461 MWh energy savings and 0.55 MW demand savings. These ex-post impact results represent 190% of the ex-ante energy savings and 56% of demand savings. The exact causes for the differential in realization rates between energy and demand savings could not be determined as the source of the original savings estimates was not clear. However, it appears that the summer energy and demand savings were less than anticipated. While the energy savings were dramatically increased due to unanticipated savings over the heating season, demand savings

are based on summer months only. The heating season energy savings arise from the many buildings found to have electric heating.

Table ES-4. MWh and MW Savings by Tracking Record, Ameren Illinois Utilities Service Territory

Project Name	Building Type	Units Completed in PY3	Ex-Ante MWh	Ex-Ante MW	Ex-Post MWh	Ex-Post MW
Blackhawk Apts	New SF	32	67.4	0.043	122.7	0.019
East Central Illinois	New SF	25	52.7	0.033	124.8	0.024
HA of Shelby	New SF	30	63.2	0.040	131.9	0.025
Madison County	New SF	5	10.5	0.007	10.7	0.003
Mt. Sinai	New SF	23	48.5	0.031	71.4	0.016
PY2 clothes washers adjustment		3*	-	-	-	0.000
Total		115	242.3	0.153	461.5	0.086
Realization Rate					1.90	0.56

**These units were completed in PY2 and are not included in the total number of units completed in PY3.*
Source for PY3 ex-post impact values: EM&V analysis.
Source for participation records: Excel file submitted by DCEO to EM&V Team, "PY3-CompletedProjects.xls."

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1. Introduction to the Program

1.1 Program Description

The Illinois Department of Commerce and Economic Opportunity (DCEO) provides grants to non-profit and for-profit affordable housing developers to help offset additional costs for incorporating energy efficient building practices in residential new construction. Supported by funding from a variety of sources, including the Illinois Energy Efficiency Trust Fund and the Energy Efficiency Portfolio Fund, grants are funded through the Energy Efficient Affordable Housing Construction Program (EEAHC).

The EEAHC program provides funds to affordable housing developers for both new construction and gut rehab projects. Funding is provided for individual measures; grantees are not required to accept the full set of efficiency measures for funding. The program's objectives are to identify and implement highly cost-effective low-income electric energy efficiency opportunities present only in gut-rehab and new construction projects.

The program has been in existence since 1988. Prior to 2008, the Energy Trust Fund was the only funding source for the EEAHC, covering both gas and electric energy efficiency measures. After 2008, the program was funded by two sources, the Energy Efficiency Trust Fund (now covering only gas measures) and the Energy Efficiency Portfolio Standard Fund (covering only electric measures).

1.1.1 Measures and Incentives

The energy efficient measures available to EEAHC participants in PY3 include Energy STAR ® refrigerator, dishwasher, clothes washer, ceiling fans, fluorescent lighting fixtures, Energy STAR ® bathroom exhaust fan, efficient CAC or Heat Pump, efficient furnace air handler, improved building envelope and resulting reduced AC tonnage. A participating project may install all of these measures, or a subset of these measures, depending upon the circumstances of the construction or rehab project. Typically, the same measures are installed in each unit of a single project. Grant amounts vary with the measures installed, the building type, and whether the project is new construction or gut rehab. Table 1-1 below summarizes the program standards as stated in the Guidelines Document, "EEAHCP_FY12_GUIDELINES_Final.doc".

The 2011-2012 Low Income Energy Efficiency Program has separate minimum energy standard guidelines for new single-family construction, new multi-family construction, and rehabilitation of single- and multi-family housing. Multi-family new construction and rehabilitation follow the ASHRAE 189.1-2009 standard (Standard for the Design of High Performance Green Buildings) while single-family new construction and rehabilitation follow the guidelines set by the 2011-2012 Low Income Program Energy Efficiency Program. Some specifications apply only to rehabilitation projects. For example, sidewall insulation for new construction must be R-21 or higher, but insulation for rehabilitation projects must be R-19 or higher.

Table 1-1. Program Guideline Overview

Construction Element	Specification	New Single-Family	New Multi-Family	Rehabilitation of Single- and Multi-Family
Insulation				
Sidewalls	Full cavity blown insulation (blown, spray and/or rigid foam)	R-21	R-21	R-19
Attic		R-49	R-49	R-49
Foundation				
Slab on Grade	Full slab & perimeter insulation	R-10	R-10	
Basement	Exterior or interior foundation insulation	R-10	R-10	
Basement	Basement band joist if basement is heated			R-10
Foundation Walls	Foundation walls if units are located in basement			R-19
Crawlspace Walls	Exterior or interior foundation wall insulation	R-10	R-10	
Crawlspace Floor	Full cavity joist insulation	X	X	
Crawlspace Floor	Full joist cavity insulation over unconditioned basement			X
Windows	Maximum U-value of 0.30 or rated	X	X	X
Air Sealing	All penetrations through shell sealed with caulk or foam	X	X	X
Air Sealing	Exterior drywall installed in subfloor of unit above			X
Foundation	Caulk top of drywall to subfloor and framing members			X
Foundation	Seal drywall to framing members on exterior walls	X	X	X
Foundation	Caulk base of drywall to subfloor	X	X	X
Foundation	Completed units not to exceed 5.0 air changes/hour at 50 Pa as measured with blower door	X	X	X
Mechanical				
Furnace	Sealed combustion/direct vent, minimum 92% AFUE with an electronically commutated motor or equivalent advanced air handler	X		X
Boiler	Sealed combustion/direct vent minimum 88% AFUE	X		X
Water Heater Gas	Sealed combustion/direct vent, minimum 67% EF and rated or sealed combustion/direct vent 88% for central water heater	X		X
Water Heater Electric	92% EF minimum	X		X
Air Conditioner	14.5 SEER minimum for split systems	X		X
Systems	Meet or exceed ASHRAE 189.1-2009, "Standard for the Design of High Performance Green Buildings"		X	
Duct Sealing	All duct joints (supply & return) sealed with duct mastic	X	X	X
	All ducts and pipes located in conditioned areas	X	X	X

Construction Element	Specification	New Single-Family	New Multi-Family	Rehabilitation of Single- and Multi-Family
Ventilation				
	ASHRAE Standard 62.2-2010, "Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings	X		Up to Three Stories
	Meet or exceed section 8.3.1.1 (Minimum Ventilation Rates) in ASHRAE 189.1-2009, "Standard for the Design of High Performance Green Buildings"		X	Multi-Family Four Stories and Above
Appliances				
Refrigerators	If provided, must be Energy STAR ® rated	X	X	X
Dishwashers	If provided, must be Energy STAR ® rated	X	X	X
Clothes Washers	If provided, must be Energy STAR ® rated	X	X	X
Ceiling Fans	If provided, must be Energy STAR ® rated	X	X	X
Lighting				
Interior Hard-Wired Fixtures	Energy STAR ® rated fluorescent	X	X	X
Common Area	Fluorescent or approved equivalent	X	X	X
Exterior Lighting	Fluorescent or approved equivalent	X	X	X

1.2 Evaluation Questions

The evaluation sought to answer the following key researchable questions:

Impact Questions

1. What are the gross annual energy (kWh) and peak demand (kW) savings achieved by the program?
2. Are the current engineering algorithms and tools for estimating gross energy savings accurate?
3. Do the documentation of measures installed through the program support those referred to in the program standards?
4. Are program standards aligned with applicable building codes and standards? Are the baseline assumptions reasonable?

Process Questions

1. How effective are current marketing and outreach tools? What could be improved?
2. How efficiently is the program being administered both internally and externally?
3. What methods could be implemented to improve the efficiency of program delivery?

2. Evaluation Methods

This section describes the analytic methods and data collection activities implemented as part of the PY3 evaluation of the Energy Efficient Affordable Housing Construction program. Evaluation methods for Program Year 3 (spanning June 2010 through May 2011) leverage program documents and a variety of secondary sources and research. Data was assembled relating to program tracking, verification, implementation procedures and energy impact claims. Evaluation methods include the review of program data and documentation, stipulated savings algorithms, analysis of applicable building energy codes and building simulation modeling. Evaluation methods include the following components:

- Review and update summaries of projects initiated and completed through the program.
- Review and comment on verification procedures and results.
- Review and comment on ex-ante impact claims algorithms and assumptions.
- Calculate energy and demand impact for each project arising from HVAC measures and building envelope using project-specific data relating to the building type, location, and HVAC equipment.
- Review of building codes and standards and evaluation of consistency with program standards.
- Identify program design and implementation issues.
- Conduct staff interviews with both DCEO staff and the program's technical contractor who assists with program implementation.
- Conduct participating builder interviews
- Review program materials.

2.1 Data Sources

Program verification procedures, tracking systems and savings claims are evaluated based on program data and documents provided by program management and implementation staff, as well as interviews with program staff. Specifically, the following data are collected and analyzed in support of this evaluation:

- Program tracking data
- Program standards documents
- Program application details of project 'specifications'

- Relevant engineering algorithms and ex-ante savings calculations
- Secondary sources such as:
- Building codes and standards (IECC 2009)
- Energy STAR ® standards and calculators
- Engineering building simulation tools
- Engineering reference materials, including ASHRAE 90.1 and ARI Unitary Directory Source
- Program staff interviews
- Program materials
- In-depth interviews with participating builders

2.2 *Analysis Methods*

For the shell and HVAC measures available through the program, the evaluation team performed building energy simulations to verify the savings levels. Prototypical models were developed and the energy usage of the simulated building with the measures implemented was compared to the energy usage of the simulated baseline building, without the efficiency measures implemented. Models were developed for each building type and each HVAC system type found in the population. Additional models were developed for specific projects where unique circumstances indicated that the prototypical model would not accurately represent the savings for that project. For this year, only one additional model was completed for a site where the installed HVAC efficiencies did not exceed code levels.

2.2.1 Single Family Models

2.2.1.1 New Construction

The new, single family home analysis was completed using BEopt software, which uses the DOE2.2 simulation engine. Weather data for the hourly analysis was taken from Chicago based weather stations.

The shape of the building was based off of the sampled new-construction, single-family projects completed this program year for which we received floor plans. The resulting home was a 1,450 square foot home with three bedrooms, 1.5 baths, and a two car garage. The shape of the building is rectangular with an aspect ratio of roughly 2:1. Windows were evenly distributed around the building, with 15% of the wall area modeled with windows. The roof was modeled as a gabled roof with a pitch of about 1:2.

For project year three, PY3, new construction homes use the International Energy Conservation Code (IECC) 2006, chapter 4, or the Chicago Building Code for residential measures, as the baseline for efficiency measures. This is because the project files indicated that all of the projects constructed in PY3, were initiated during the previous year and therefore are not subject to IECC 2009. The baseline energy models use the IECC 2006 for the mechanical and lighting systems.

Building schedules and internal load settings are typical values from the Building America (BA) House Simulation Protocols. These BA protocols were developed by the National Renewable Energy Laboratory as a method for standardizing residential energy modeling, and providing benchmark data for building energy model simulations. BEopt calculates infiltration values using the AIM-2 method.

From the PY3 new construction projects, three types of heating systems were encountered: Natural Gas, All Electric Resistance, and Heat Pumps. Three different proposed prototypical buildings were generated to determine savings for each heating system type.

Finally, these prototypical models used weighted values to determine the typical values for each given measure. For instance, roof insulation values varied between R-43 and R-49, with a weighted average of R-46.3. This weighted average was what was used for the prototypical model.

2.2.1.2 Rehab

The rehab homes in PY3 included single family homes, duplexes, and triplexes per the project documentation. The application has an area for each type of selection. To more accurately represent the diverse range of buildings, a 2,400 square foot duplex with one unit per floor was modeled as the baseline. This could also represent a large single family home. A total of 5 bedrooms and two baths were modeled with no attached garage. The floor plan was a total of 2,300 square feet. Windows were evenly distributed around the building, with 15% of the wall area modeled with windows. The roof was modeled as a gabled roof with a pitch of about 1:2.

Heating was only modeled with natural gas because no projects in PY3 used electricity or heat pumps for heating in the rehab sample.

The baseline prototypical building was created by analyzing previous building stock using the residential energy consumption survey (RECS) across as many decades of data as possible.

2.2.2 Multi-Family, Low Rise Models

2.2.2.3 New Construction

The low-rise, multi-family models were developed using eQUEST version 3.64 whole building energy modeling software which uses the DOE 2.2 simulation engine.

A prototypical-baseline energy model of a multi-family new construction building geometry was developed based on several parameters including: creating a building that is considered low-rise (and subject to the residential portion of the IECC energy code), a multi-family building with less than 80 residential units, and previous project year building stock. The ASHRAE energy code 90.1 defines low-rise buildings as single and multi-family structures that are three stories or less. Therefore, the prototypical building model used for estimating impacts for medium sized projects is less than three stories. The PY3 application distinguishes multi-family new-construction buildings that are either less than 80 units or greater than 80 units. The prototype used here to estimate impacts, is a 28-unit, two-story building of approximately 30,000 square feet. Then, building simulations were run with varying numbers of floors, holding all other things equal, including total conditioned building area, to determine which energy model with the least energy consumption. Lastly, an examination of the existing building stock from the previous project year was performed.

Based on the project buildings from the previous year, residential units were typically one or two bedroom apartments ranging from approximately 450 to approximately 1050 square feet per unit. The window-to-wall ratios for multi-family buildings typically range from about 10% to 20% of the gross wall area. The baseline simulation inputs for the prototypical heating, ventilation, and air conditioning (HVAC) system were based on the International Energy Conservation Code (IECC) 2006 because all of these projects were initiated prior to PY3. The baseline HVAC system controls, not specified in the program guidelines, were based on ASHRAE 90.1 2007 Appendix G, Performance Rating Method. The remaining building simulation inputs for internal loading and occupancy are default values based on the building type as specified in eQUEST for a "Multifamily Mid-Rise" building. A summary of the prototypical model is shown below in Table 2-1.

Table 2-1. Multifamily Low-Rise New Construction Prototypical Building Parameters

Parameter	Value
Total Number of Residential Units	28
Approximate Area per Residential Unit (Sq. Ft)	1,000
Total Conditioned Area of Building (Sq. Ft.)	30,000
Number of Floors	2
Window-to-wall ratio	17%
Unit Bathroom Exhaust Rates (CFM/unit)	75
Unit Kitchen Exhaust Rates (CFM/unit)	150
Occupancy per Unit (person/unit)	1.5
Lighting Power Density (W/Sq. Ft.)	0.70
Internal Loads (W/Sq. Ft.)	0.57
Infiltration (Air Changes per Hour, ACH)	0.42

The proposed building simulations reflect the Minimum Energy Standards as specified in the June 2009 Illinois Energy Efficient Affordable Housing Construction Program. Shell measures (insulation, efficient windows) were applied to the model first; having the effect of first bringing the shell up to existing DCEO standards. Next, alternative heating and cooling systems were applied to the efficient shell. A baseline and proposed building simulation was modeled for the following HVAC system types:

- **Packaged single-zone natural-gas fired furnaces with direct-expansion air conditioning**
- **Packaged terminal heat pump (PTHP)**
- **Packaged terminal air-conditioner (PTAC) with electric resistance heating**

These system types are representative of what the current program is able to incent for increased HVAC efficiency.

2.2.2.4 Rehab

A literature review of energy use in the existing building stock was performed to create a reasonable baseline for rehab projects. RECS data was examined. However, the typical existing building was not based entirely on this data since RECS does not include energy use in

commons areas such as laundries, corridors, or entries. LBL report 34045 was based on a study of multi-family buildings throughout the country, segregating them into "shell packages" then tallying the proportion of surveyed residential buildings in each package. These shell packages are described in Table 2-2 below, loosely correspond to building vintages indicated. Note that the "tightness of construction," as indicated by infiltration rate, is not included in impacts for these buildings. However, additional energy modeling simulations investigating the effect of the infiltration rates typical of older buildings is significant. Efforts during rehab projects to improve the tightness of the buildings may have a significant effect on the resulting energy performance of the building.

Table 2-2. Multifamily Shell Packages by Building Vintage

Parameter	Ceiling	Walls	Window	Infiltration	Basement
Building Vintage <1970 (Furnace/Boiler)	R-7	R-0	1-G	0.7 ACH	R-0
Building Vintage 1970 - 1985 (Furnace/Boiler)	R-11	R-7	1-G	0.7 ACH	R-0
Building Vintage 1985 - 1990s (Furnace/Boiler)	R-19	R-7	2-G	0.55 ACH	R-10

Each of these shell packages in Table 2-2 was used as a baseline and the impact of upgrading to DCEO shell standards. Naturally, the poorer shells have significantly greater impacts.

2.2.3 Multi-Family, Mid Rise Models

2.2.3.5 New Construction

The new, multi-family mid-rise models were developed using eQUEST version 3.64 whole building energy modeling software which uses the DOE 2.2 simulation engine with Chicago, Illinois climate data.

A prototypical-baseline energy model of a multi-family mid-rise new construction building geometry was developed based on several parameters including: creating a building that is not considered low-rise, a multi-family building with greater than 80 residential units, optimal energy usage based on geometry, and previous project year building stock. The ASHRAE energy code 90.1 defines low-rise buildings as single- and multi-family structures that are three stories or less. Therefore, the prototypical building model is greater than three stories and uses applicable commercial multi-family energy codes. The PY3 application distinguishes multi-family new-construction buildings that are either less than 80 units or greater than 80 units. This multi-family prototype uses a building that has greater than 80 units. Then, building simulations were run with varying numbers of floors, holding all other things equal, including total conditioned building area, to determine which energy model with the least energy

consumption. Lastly, an examination of the existing building stock from the previous project year was performed.

Based on the project buildings from the previous year, residential units were typically one or two bedroom apartments ranging from approximately 450 to approximately 1,050 square feet per unit. The window-to-wall ratios for multi-family buildings typically range from about 10% to 20% of the gross wall area. The baseline simulation inputs for the prototypical building envelope and heating, ventilation, and air conditioning (HVAC) system were based on the International Energy Conservation Code (IECC) 2006 because all of these projects were initiated prior to PY3. The IECC 2006 does not significantly differ from Chicago Building Code. Building foundation is assumed to be slab-on-grade with no baseline insulation requirement. The baseline HVAC system controls, not specified in the program guidelines, were based on ASHRAE 90.1 2007 Appendix G, Performance Rating Method. The remaining building simulation inputs for internal loading and occupancy are default values based on the building type as specified in eQUEST for a "Multifamily Mid-Rise" building. A summary of the prototypical model is show below in Table 2-3.

Table 2-3. Multifamily Mid-Rise New Construction Prototypical Building Parameters

Parameter	Value
Total Number of Residential Units	100
Approximate Area per Residential Unit (Sq. Ft)	800
Total Conditioned Area of Building (Sq. Ft.)	80,000
Unheated Slab-on-Grade Foundation [R-Value]	0.0
Number of Floors	6
Window-to-wall ratio	15%
Unit Bathroom Exhaust Rates (CFM/unit)	75
Unit Kitchen Exhaust Rates (CFM/unit)	150
Occupancy per Unit (person/unit)	1.5
Lighting Power Density (W/Sq. Ft.)	0.70
Internal Loads (W/Sq. Ft.)	0.57
Infiltration (Air Changes per Hour, ACH)	0.42

The proposed building simulations reflect the Minimum Energy Standards as specified in the June 2009 Illinois Energy Efficient Affordable Housing Construction Program. For analysis purposes it was assumed that the generic R-21 wall insulation requirement is for cavity insulation value and a value from IECC 2009 of R-11.4 continuous insulation has been used for mass walls. It was assumed that the proposed R-49 insulation requirement for attics (which is

equivalent to approximately 39% increase in insulation value as compared with the R-30 IECC 2006 baseline for attics) is equivalent to approximately R-33 continuous insulation for the roof construction: "Insulation entirely above deck". The R-33 insulation value is approximate 39% greater than the IECC 2006 code baseline.

Each of the energy efficiency measures were applied to the model cumulatively compared to the prototypical baseline model. For example, shell measures were added first, then efficient heating and cooling equipment were added using the upgraded shell. All other variables such as schedules, internal loads, occupancy building geometry, percent glazing, etc were held constant in both the baseline and proposed energy models as per ASHRAE 90.1 Appendix G. A baseline and proposed building simulation was modeled for the following HVAC system types:

- **Packaged single-zone natural-gas fired furnaces with direct-expansion air conditioning.**
- **Package single-zone air handling units with a hot-water coil (served by a natural gas boiler) and direct-expansion air conditioning.**
- **Water-loop heat pump (HP) system with a central natural gas boiler plant and fluid cooler for heat rejection.**
- **A ground-source heat pump (HP) system.**
- **A boiler and chiller plant system (Assumed: 4-pipe fan coil terminal units).**
- **A Packaged terminal air conditioning (PTAC) unit with hydronic heating section served by a natural gas boiler.**

These system types are representative of what the current program is able to incent for increased HVAC efficiency as well as representative HVAC systems from completed PY3 projects. In some cases the program does not explicitly account for the HVAC system types as used by the PY3 completed projects such as heat pumps systems and central cooling plants.

2.3 Process Methods

The process evaluation efforts for the EEAHC Program for PY3 were designed to answer the following key research questions:

- **How effective are current marketing and outreach tools? What could be improved?**
- **How efficiently is the program being administered both internally and externally?**
- **What methods could be implemented to improve the efficiency of program delivery?**

To answer these questions, we proposed to conduct staff interviews with both DCEO staff and the program's technical contractor who assists with program implementation and a review of

program materials. As such, Opinion Dynamics conducted in-depth interviews with the three most influential and informed program personnel and reviewed the program implementation plan and application package. We conducted these interviews with the technical contractor for the program (Domus PLUS), the DCEO program manager, and the DCEO division manager between June and September 2011. During the interviews, we explored the program's processes and roles of program staff, with a focus on identifying areas of improvement.

In addition to the data collection outlined above, the team conducted in-depth interviews with builder participants to further explore their program experience and identify any issues or areas of improvement from the participant perspective.

3. Program Level Results

This section details the evaluation results for PY3 (June 2010 through May 2011).

3.1 Impact Evaluation Results

3.1.1 Verification and Due Diligence

Verification procedures are documented in the PY1 report. No major changes have been implemented in the interim. Key issues and related developments are summarized in this section. The reader should refer to the PY1 evaluation for additional details.

Grant applicants are required to document compliance with program guidelines in a "specification sheet" that is provided with program application materials. Just prior to the commencement of construction activities, the third party program implementer (Domus PLUS) will review blueprints and other building documents to confirm consistency with program guidelines and the relevant *specification sheet*. As construction begins, the program implementer will almost always[4] visit the site at key points to inspect insulation levels and other key features of construction; the program implementer will also perform a blower door test at project completion. Up to this point, these visits have not been documented, unless a problem is identified. In the event that a problem is identified, a letter is sent to the program manager and is kept with the project file. Grant monies are withheld until the issue is resolved. We recommend going forward that records of passed and failed verification activities be part of the new tracking database.

The program does not have a protocol developed for identifying building projects that meet the low income standard, instead relying on indicators such as project sponsorship by another low income grant provider. This may present a source of uncertainty regarding verification of the program qualifying status of grant applicants.

3.1.2 Summary of Program Accomplishments

There are two measures of program accomplishments. The first one is the number of units constructed in the program year and the second is the number of units funded in the program year (which may be completed in the following program years).

The initial expectation for PY1 through PY3 was to complete a total of 1,739 units. The actual number of units that completed construction was 211 installations short of these expectations. In

[4] Field inspections are performed for most every project, except on occasion if they are geographically inconvenient. In these cases photos are sometimes sent in lieu of the on-site inspection.

PY3 the program was expected to complete 1,087 installations, however only 829 were completed. The expectations and accomplishments for this program for both ComEd and Ameren Illinois Utilities service territories combined are presented in Table 3-1 below.

Table 3-1. Savings Expectations versus Ex-Post Program Accomplishments[5]

Program Year	Expected Installations*	Completed Installations^	MWh**	MW**
PY1	0	204	430	0.3
PY2	652	495	1,989	0.4
PY3	1,087	829	1,628	0.5
Total (PY1-PY3)	1,739	1,528	4,101	1.2

**Source: pdf file submitted to EM&V Team: 'Template - Low Income new construction and gut rehab.pdf"*
^Source: MS Excel file submitted to EM&V team: "PY3-CompletedProjects.xls"
***Source: EM&V analysis.*

The successful funding of new projects is an indicator of the volume of upcoming projects and unit installations. For this reason it is an important metric of program accomplishments. Table 3-2 below shows the annual expectations and accomplishments in terms of the number of units funded. The table shows the annual accomplishments versus expectations, as well as the cumulative accomplishments versus expectations over the PY1 to PY3 period. The program project-starts in PY3 were 1,708 units, short of annual expectations by 249, but in excess of cumulative expectations by 93 units.

Table 3-2. Expected Project Starts versus Program Accomplishments[6]

Program Year	Expected Funded Units*	Actual Funded Units^	Annual Accomplishments Versus Expectations	Cumulative Accomplishments Versus Expectations
PY1	652	753	101	101
PY2	1,087	1,328	241	342
PY3	1,957	1,708	-249	93

**Source: pdf file submitted to EM&V Team: 'Template - Low Income new construction and gut rehab.pdf"*
^Source: Excel file submitted to EM&V Team: 'PY3 - ProjectsFunded.xls'

[5] Overall Program Expectations and Accomplishments reflect the total EEAHC Program, including both ComEd and Ameren Illinois Utilities service territories.
[6] Overall Program Expectations and Accomplishments reflect the total EEAHC Program, including both ComEd and Ameren Illinois Utilities service territories.

3.1.3 Participation and Impact Summary

3.1.3.1 ComEd Service Territory

Of the 829 installations completed through the EEAHC program during PY3, 714 were constructed within ComEd service territory. These were constructed within 16 building projects. Building projects and their impact information are provided in Table 3-3 below. Nine of the 16 projects are new multi-family buildings, while the remaining 7 projects are single- and multi-family rehab projects. The associated ex-ante impact for PY3 is 1,322 MWh energy savings and 0.643 MW demand savings.

Ex-post energy and demand savings for projects completed ComEd service territory total 1,221 MWh and 0.371 MW for PY3, representing 93% of the ex-ante energy savings and 58% of ex-ante demand savings. The exact causes for the differential in realization rates between energy and demand savings could not be determined as the source of the original savings estimates was not clear. However, it appears that the summer savings were less than anticipated, however, the energy savings were dramatically increased due to many of the buildings being all electric facilities, with heating being provided by electric resistance or heat pumps.

Table 3-3. MWh and MW Savings by Tracking Record, ComEd Service Territory

Project Name	Building Type	Units Completed in PY3	Ex-Ante MWh	Ex-Ante MW	Ex-Post MWh	Ex-Post MW
Alexian Brothers	Rehab MF	24	44.1	0.021	89.0	0.026
Brinshore 2800 Corp.	Rehab MF	25	46.0	0.022	106.7	0.032
Chicago Housing Authority	Rehab MF	104	191.3	0.093	187.8	0.037
Community Partners	Rehab SF	2	4.2	0.003	7.1	0.002
Cook County	Rehab MF	52	95.6	0.046	103.5	0.051
Green HFH (Waukegan)	Rehab SF	4	8.4	0.005	10.8	0.004
Green HFH (1305 Kildare)	Rehab SF	6	12.6	0.008	17.5	0.007
Holiness Homes	New MF <80	54	99.3	0.048	65.4	0.033
Interfaith	New MF	100	183.9	0.089	122.6	0.025
Lake County	New MF <80	20	36.8	0.018	50.8	0.015
Lawndale Christian	New MF	42	77.2	0.037	85.8	0.030
NHS Roseland	New MF <80	60	110.3	0.053	79.1	0.011
NHS Wrightwood	New MF <80	76	139.8	0.068	49.7	-0.002
NHS Victory	New MF <80	72	132.4	0.064	78.4	0.045
Senior Suites	New MF <80	32	58.8	0.028	42.9	0.020
St. Edmunds	New MF <80	41	75.4	0.036	123.9	0.034
PY2 clothes washer adjustment		197*	-	-	-	0.001
Total		714	1,316.3	0.641	1,220.8	0.371
Realization Rate					0.93	0.58

**These units were completed in PY2 and are not included in the total number of units completed in PY3.*
Source for PY3 ex-post impact values: EM&V analysis.
Source for participation records: Excel file submitted by DCEO to EM&V Team, 'PY3 - ProjectsFunded.xls'

The savings for some of the projects in the table above, such as Brinshore 2800 Corp, is much higher than expected based on the original savings estimates. This site is an all-electric building that has the heating needs met by heat pumps. Therefore, in addition to cooling savings, the heating efficiency savings are shown in the electric savings as well.

The savings for NHS Wrightwood are much lower than the original savings estimates. This site has PTAC units with hydronic heat. However the installed units are lower than the required efficiency for these units.

3.1.3.2 Ameren Illinois Utilities Service Territory

Of the 829 installations completed through the EEAHC program during PY3, 115 were constructed within Ameren Illinois Utilities service territory. These were constructed within 5 building projects. Building projects and their impact information are provided in Table 3-3

below. All 5 projects considered are new single-family buildings. The associated ex-ante impact for PY3 is 242 MWh energy savings and 0.153 MW demand savings.

Ex-post energy and demand savings for projects completed Ameren Illinois service territory total 461 MWh and 0.086 MW for PY3, representing 190% of the ex-ante energy savings and 56% of ex-ante demand savings. The exact causes for the differential in realization rates between energy and demand savings could not be determined, as the source of the original savings estimates was not clear. However, it appears that the summer energy and demand savings were less than anticipated. While the energy savings were dramatically increased due to unanticipated savings over the heating season, demand savings are based on summer months only. The heating season energy savings arise from the many buildings found to have electric heating.

Table 3-4. MWh and MW Savings by Tracking Record, Ameren Illinois Utilities Service Territory

Project Name	Building Type	Units Completed in PY3	Ex-Ante MWh	Ex-Ante MW	Ex-Post MWh	Ex-Post MW
Blackhawk Apts	New SF	32	67.4	0.043	122.7	0.019
East Central Illinois	New SF	25	52.7	0.033	124.8	0.024
HA of Shelby	New SF	30	63.2	0.040	131.9	0.025
Madison County	New SF	5	10.5	0.007	10.7	0.003
Mt. Sinai	New SF	23	48.5	0.031	71.4	0.016
PY2 clothes washer adjustment		3*	-	-	-	0.000
Total		115	242.3	0.153	461.5	0.086
Realization Rate					1.90	0.56

**These units were completed in PY2 and are not included in the total number of units completed in PY3.*
Source for PY3 ex-post impact values: EM&V analysis.
Source for participation records: Excel file submitted by DCEO to EM&V Team, 'PY3 - ProjectsFunded.xls'

3.1.4 Ex-Ante Impact Review

The PY2 Evaluation Report presented a review of ex-ante impact algorithms and assumptions that resulted in a recommendation to revise the impact related to a reduced required AC capacity, as well as to add a heat pump option to the list of measures. For the PY3 Evaluation, algorithms and assumptions were revisited to ensure consistency with any changes in Energy STAR ® calculators or other applicable efficiency and building standards.

The measures available for electric savings incentives and their associated ex-ante energy and demand impacts are shown in Table 3-5 below. These ex-ante impact values are consistent with PY1 and PY2 evaluation results, with the exception of the air conditioning, heat pump and shell measure and the new electric water heating measures.

Table 3-5. Ex-Ante vs. Recommended Ex-Ante Per-Unit Impact Values

Measure	Ex-Ante (Single and Multi-Family)		Recommended Ex-Ante	
	kWh/Unit	kW/Unit	kWh/Unit	kW/Unit
Interior fluorescent fixtures	87	0.01	87	0.01
Exterior fluorescent fixtures	133	0.02	133	0.02
90% AFUE furnace with efficient air handler	400	0.05	400	0.05
Energy STAR ® rated bathroom exhaust fan	89	0.01	89	0.01
Energy STAR ® refrigerator	95	0.01	95	0.01
Energy STAR ® dishwasher with electric water heating	-	-	74	0.01
Energy STAR ® dishwasher with natural gas water heating	33	0.01	33	0.01
Energy STAR ® clothes washer with electric water heating, no dryer	-	-	141	0.02
Energy STAR ® clothes washer with natural gas water heating, no dryer	24	-	24	0.00
Energy STAR ® ceiling fan with lighting (per unit)	54	0.01	54	0.01
SEER 14 central air conditioner w/ programmable thermostat	94	0.160	Varies*	Varies*
SEER 14 heat pump w/ programmable thermostat	456	0.160	Varies*	Varies*
Single Family - Reduce required tonnage as a result of thermal envelope improvements	608	1.010	Varies*	Varies*
Multi Family - Reduce required tonnage as a result of thermal envelope improvements	340	0.570	Varies*	Varies*

**The impacts for CAC, HP and shell measures vary by building type, cooling type, heating type.*

An engineering review and recommendations are made below for each program measure and ex-ante savings value. Table 3-5 above summarizes the findings from the lighting and appliance engineering reviews. There are no recommended changes to the lighting and Energy STAR ® appliance measures reviewed in PY2. While Energy STAR ® clothes washers and dishwashers are not new measures to PY3, the evaluation of appliances using hot water heated by electricity (as opposed to natural gas) is new to PY3. Reviews of Energy STAR ® literature and calculators yielded estimates of kWh and kW savings per appliance per year. In addition, demand impact for clothes washers has been investigated as part of the PY3 evaluation. In PY2 this impact was not evaluated and was set equal to zero. This year, a positive demand impact was found for clothes washers so a retroactive credit for PY2 clothes washers has been applied to the program in PY3.

3.1.4.3 Energy STAR ® Refrigerator

- **Impact Assumptions**

Savings should be calculated based on existing national comparisons between standard and Energy STAR ® certified appliances.

- **Engineering Review**

Energy STAR ® refrigerator ex-ante impact claims are 95 kWh per unit per year based on the Energy STAR ® savings calculator. This calculation was reviewed and confirmed based on the current version of the calculator.

- **Recommendations**

Based on this finding, we recommend making no change to the impact claim of 95 kWh/0.01 peak kW.

3.1.4.4 Fluorescent Lighting

- **Impact Assumptions**

Savings should be calculated based on existing national comparisons between standard and Energy STAR ® certified lighting.

- **Engineering Review**

A review of the Energy STAR ® calculator confirmed no change relative to the findings presented in the PY2 engineering reviews. As such, the ex-ante impact remains at 87 kWh/0.01 peak kW per indoor fixture and 133 kWh/0.02 peak kW per outdoor fixture.

The IECC 2009 building code[7] incorporates an efficient lighting requirement. The code requires 50% of permanent fixtures be high efficiency. The EEAHC standards indicate a minimum of 6 interior fixtures be fluorescent. It is not readily apparent what changes the new code might have on the program fluorescent lighting measure impact. Understanding total lighting requirements, common area lighting requirements and baseline practices would help to inform such an assessment.

- **Recommendations**

It is recommended that impact from fluorescent fixture installation continue to be credited at a rate of 133 kWh/0.02 peak kW per outdoor fixture and 87 kWh/0.01 peak kW per indoor fixture per year.

As the 2009 IECC code begins to be relevant to program construction, evaluation activities will need to address the potential effects of the code on the fluorescent lighting program measure impact.

[7] Adopted in Illinois, effective January 2010 for residential structures, and August 2009 for commercial structures.

As of December 2, 2008, Energy STAR ® has revised their CFL certification to contain performance requirements to ensure a consistent and reliable experience for the consumer and packaging requirements to ensure accurate marketing. Key lamp performance requirements include: efficiency, lumen maintenance over the lamp's lifetime, longevity, start-up and warm-up times, safety and reliability, color, warranty, mercury control, and compliance with federal and industry standards. Energy STAR ® requires CFLs to have a rated lifetime of 6,000 hours or greater with 80 percent of their initial light output at 40 percent of their rated lifetime. The potential impacts of using Energy STAR ® certified CFLs over noncertified CFLs include a potentially longer life of the lamp as well as greater customer satisfaction with CFLs in general, which may lead to energy efficient replacements when the CFL burns out. The energy consumption difference between certified and noncertified CFLs is negligible. Therefore, the potential impacts of using certified CFLs affect long-term energy consumption, but do not affect the calculations of this evaluation.

3.1.4.5 Energy STAR ® Dishwasher

- **Impact Assumptions**

  - Impact should be calculated based on existing national comparisons between standard and Energy STAR ® certified appliances

  - A household runs 215 dishwasher loads each year, according to the Energy STAR ® calculator

  - Current market averages for dishwasher energy use should be used for savings comparisons instead of minimum efficiency standards

- **Engineering Review**

The evaluation approach has been revised since PY2 to distinguish impacts from Energy STAR ® dishwashers using water heated by electricity between impacts from those using water heated by natural gas. PY2 focused on Energy STAR ® dishwashers using water heated by natural gas and claimed ex-ante impacts of 33 kWh/0.010 peak kW per unit. Since the Energy STAR ® calculator did not change since PY2, the impact for natural gas dishwashers remains the same in PY3. In addition to this, Energy STAR ® dishwashers using water heated by electricity claim 74 kWh/0.01 peak kW per unit.

- **Recommendations**

It is recommended that the expected impact for dishwashers using water heated by natural gas funded in PY3 remain at 33 kWh/0.01 peak kW per year. In addition to this, the expected impact for dishwashers using water heated by electricity is 74 kWh/0.01 peak kW per year.

3.1.4.6 Bathroom Exhaust Fans

- **Impact Assumptions**
  - Savings should be calculated based on existing national comparisons between standard and Energy STAR ® certified appliances
  - Bathroom exhaust fans operate 2 hours per day on average
  - Standard bathroom exhaust fans are 150 W, and efficient bathroom exhaust fans are 28 W
- **Engineering Review**

A review of the current Energy STAR ® standards confirmed that Energy STAR ® qualifying bathroom exhaust fans remain at 1.4 CFM per watt for fans between 10-89 CFM and 2.8 CFM per watt for fans 90 CFM and above, the same values used in the PY2 calculation.

The specifications provided by the program participants in some of the projects state the exhaust fans shall be rated no less than 75 CFM. A 75 CFM fan that meets the minimum Energy STAR ® requirement of 1.4 CFM per watt draws 54 watts. A 90 CFM fan that meets the minimum Energy STAR ® requirement of 2.8 CFM per watt draws 32 watts. However, a review of Energy STAR ® qualifying fans shows that the average 80 CFM fan goes beyond these minimum requirements and draws 24.2 watts. These values corroborate the 28 watt assumption for efficient fans.

Table 3-6 below presents the bathroom fan descriptions from the engineering review checklists. Five projects used 75 CFM continuous ventilation fans. No energy savings for bathroom fans were achieved for these five projects.

Table 3-6. Bathroom Fan Descriptions in Tracking Data

Bathroom Fan Description	Projects	Number of Fans
Energy STAR ® rated, 75 CFM	6	154
Energy STAR ® rated	5	206
Energy STAR ® rated, 2 CFM/ft2	1	25
Bath and kitchen exhaust (20 CFM continuous from baths)	2	91
No CFM information provided	2	103
Continuous ventilation through heat recovery	1	-
Continuous ventilation from rooftop fans, 75 CFM	1	-
Continuous ventilation from rooftop fans, 10 CFM continuous, 75 CFM occupant boost switch	1	-
Continuous ventilation from rooftop fans, 80 CFM	1	-
Fans were not ES rated	1	-
Total	21	579

The language regarding bathroom exhaust fans in the EEAHC guideline should be updated to specify energy consumption requirements for exhaust fans in addition to air flow requirements. The specifications provided in ASHRAE Standard 62.2-2010 and ASHRAE Standard 189.1-2009 Section 8.3.1.1 do not provide sufficient specificity for the wattage of efficient fans. This makes it difficult to confirm or deny the existing savings claim, as wattage is a critical component of the calculation.

Additional updates to this calculation in PY4 may include analysis of hours of use for bathroom fans and analysis of the distribution of fan sizes in residential bathrooms. According to a paper that cites unpublished data from Lawrence Berkeley National Lab, average residential fan use in the U.S. is 350 hours per year, or approximately 1 hour per day. Also, approximately 38% of residential bathroom fans are less than or equal to 75 CFM, while 62% are greater than 75 CFM.

- **Recommendations**

The recommended impact value for bathroom exhaust fans remains at 89 kWh/0.01 peak kW per year.

It is also recommended that the EEAHC guideline for bathroom exhaust fans be revised to include a specific size and wattage range for efficient fans.

3.1.4.7 90% AFUE Furnace with Efficient Air Handler

- **Impact Assumptions**

An Electricity Use Ratio (see below) of 6 represents baseline energy usage for furnaces.

- **Engineering Review**

The ex-ante per unit claimed impact from installation of 90%AFUE Furnace with efficient air handler is 400 kWh per year.

Program standards require that installed furnaces be designated as an electrically efficient furnace by the Gas Appliance Manufacturers Association (GAMA). A GAMA certified energy efficient air handler will consume less than 2% of the total energy used by the furnace during a typical heating season. While there is no minimum efficiency standard provided in these same terms, ranges in kWh consumption from fans within a set heating capacity can easily yield this magnitude of impact.

As noted above, direct address of air handler efficiency in relation to this requirement is not included in the specification documentation for sites, and some of the heating systems are electric (4 of 21) or geothermal (1 of 21).

Often the air handler energy rating is expressed in Eae, a measure of absolute energy consumption of the air handler. The Eae is not a relative measure. The larger the unit for heating purposes, the larger the Eae will be. This makes the Eae statistic hard to compare across units.

A review of the literature finds a publication addressing the potential energy savings of efficient air handlers by ACEEE[8] . The publication calculates savings for heating and separately for cooling from efficient air handlers, which they define through a statistic called "EUR", or Electricity Use Ratio. Although the EUR is not commonly published it can be readily calculated from the furnace capacity and Eae. The EUR is the ratio of the annual electricity use divided by the furnace capacity expressed in thousands of Btuh (kBtuh). The publication finds what is termed a natural delineation of EUR at a value of 6, with efficiency air handlers defined as those with an EUR of less than or equal to 6.

The report finds the average savings for air handlers with EUR less than 6 across all capacities to be 511 kWh per year. Savings for furnaces with capacity at the lower end (between 26 and 76 kBtuh) range between 351 and 440 kWh per year. The report also publishes an average kWh per year associated with efficient furnace fans and motors equal to 500 kWh per year, and regional specific values for New England at 679 kWh per year, and Wisconsin at 742 kWh per year.

[8] Saving Energy with Efficient Residential Air Handlers. by Harvey M. Sachs and Sandy Smith, April 2003

Savings for the cooling season are also reported, and could be invoked if the system installed is used for both heating and cooling.

The publication states, "We suspect that almost all furnaces for which EUR < 6 have advanced motors, but that some furnaces with EUR greater than 6 also have ECM [Electronically Commutated Motor] systems, but in combination with very high internal status pressures that require higher wattages to move enough air."

- **Recommendations**

Since the ex-ante impact assumptions are in line with the smaller capacity impact estimates published in the ACEEE study, no change is recommended to the ex-ante impact assumptions.

The EEAHC might consider adopting the EUR in measure specifications and recording, as it represents a measure of the Eae in relation to capacity.

3.1.4.8 Energy STAR ® Clothes Washer

- **Impact Assumptions**
  - Savings should be calculated based on existing national comparisons between standard and Energy STAR ® certified appliances
  - A household will run 392 loads per year, or 7.5 loads per week
- **Engineering Review**

A review of the Energy STAR ® clothes washer calculator shows an annual impact of 23.8 kWh for an efficient clothes washer with gas fueled water heating and no drying and 141 kWh for efficient clothes washers utilizing electric water heating and no drying. It should be noted that the predominant water heater fuel type for water heating in Illinois is gas.

In some cases participating multi-family buildings may install somewhat fewer clothes washers than the number of dwelling units. If these are installed in common areas, the impact should reflect 23.8 or 141 kWh per dwelling, since the impact is based on the number of wash loads and this is a function of occupancy. However, if the washers are installed within a subset of units, the impact should reflect the number of units in which washers were installed.

Out of the 15 projects that included washing machines, 13 of these projects utilize natural gas and 2 utilize electricity for their water heating needs. Peak demand savings for clothes washers differs depending on the water heating fuel type. A review of the Mid-Atlantic Technical Reference Manual and Energy STAR ® clothes washer calculator shows a peak demand savings of 0.003 kW for natural gas and 0.017 kW for electricity per dwelling unit.

The Energy STAR ® clothes washer measure was introduced in PY2. In the PY2 evaluation, peak demand savings for clothes washers was unknown. In the PY3 evaluation, peak demand

savings as well as energy savings for clothes washers that use electrical water heating were researched. PY3 impact results include an adjustment factor for the small amount of savings not credited in PY2.

- **Recommendations**

Based on this finding, we recommend an impact of 23.8 kWh/0.003 peak kW per dwelling unit serviced by washers with natural gas water heating and 141 kWh/0.017 peak kW per dwelling unit serviced by washers with electric water heating.

3.1.4.9 Energy STAR ® Ceiling Fan with Lighting

- **Impact Assumptions**

Savings should be calculated based on existing national comparisons between standard and Energy STAR ® certified appliances.

- **Engineering Review**

The Energy STAR ® ceiling fans measure was introduced in PY2. Energy savings from this measure arises from the efficient fan motor and efficient lighting technology.

The Energy STAR ® calculator for efficient ceiling fans provides estimates of the hours per day the fan is run at high, medium and low speed (40%, 40% and 20%, respectively). The operating hours estimates are provided regionally; an estimate of 2.8 hours per day is provided for the East North Central area which includes Illinois. The Energy STAR ® calculator also provides expected wattage for standard efficiency and Energy STAR ® certified fans at each speed. Using this information, annual kWh savings associated with an upgrade from a standard efficiency fan to an Energy STAR ® fan is estimated at 3.03 kWh per year.

The ceiling fans come with efficient lighting. The Energy STAR ® calculator assumes the efficient lighting will be a 20 watt CFL replacing a 60 watt standard incandescent, and running 3.5 hours per day for 365 days per year. The assumption of a single bulb per fixture is used for the calculation.

Since the impact is largely driven by the lighting, the demand impact for the ceiling fan measure is estimated by applying the demand to energy ratio for the efficient lighting measure discussed above, which yields 0.006 peak kW per ceiling fan fixture.

- **Recommendations**

Based on this finding, we recommend an energy impact of 30.3 kWh per ceiling fan per year, and a demand impact of 0.006 peak kW per fixture per year.

3.1.4.10 CAC, Heat Pump, and Shell Measures

The recommended ex-ante values for HVAC measures (CAC and HP) and the reduced required capacity resulting from building envelope measures is summarized in Table 3-7 below. The recommended ex-ante values are a function of the installed equipment, the type of building constructed and the applicable building codes. Ex-post values are based on project-specific data relating to the building type, location, applicable codes and equipment installed.

Table 3-7. Recommended Ex-Ante Per-Unit Impact Values for HVAC and Building Envelope Measures

Building	Cooling Type	Cooling Efficiency	Heating Type	Ex-Ante*		Recommended Ex-Ante**	
				kWh/ Unit	kW/ Unit	kWh/ Unit	kW/ Unit
New SF	Central AC	14 SEER	Electric Heat	702	1.17	538	0.00
New SF	Heat Pump (HP)	15 SEER	Heat Pump	702	1.17	115	0.00
New SF	Central AC	14 SEER	Natural Gas	702	1.17	-1	0.00
Rehab SF	Central AC	14 SEER	Natural Gas	702	1.17	1,568	0.00
New MF	DX	14 SEER	Natural Gas	434	0.73	181	0.00
New MF	Packaged Terminal HP	15 SEER	Heat Pump	434	0.73	504	0.00
New MF	Packaged Terminal AC	14 SEER	Electric Heat	434	0.73	519	0.00
Rehab MF	Packaged Terminal AC	14 SEER	Natural Gas Boiler	434	0.73	256	0.76
Rehab MF	Packaged Terminal HP	15 SEER	Heat Pump	434	0.73	2,239	1.00
Rehab MF	Packaged Terminal AC	14 SEER	Electric Heat	434	0.73	2,569	0.93
New MF>80	DX	14 SEER	Natural Gas Furnace	434	0.73	70	0.15
New MF>80	DX	14 SEER	Natural Gas Boiler	434	0.73	250	0.10
New MF>80	Ground Source HP	14 EER	Heat Pump	434	0.73	344	0.13
New MF>80	Water Source HP	14.7 EER	Natural Gas Boiler + Fluid Cooler	434	0.73	366	0.23
New MF>80	Central Chiller		Natural Gas Boiler	434	0.73	15	0.02
New MF>80	Packaged Terminal AC	9.35 EER	Hydronic Heating	434	0.73	281	0.09

**Building Shell for the ex-ante is relative to IECC 2006 and includes current program infiltration standards*
***Building Shell for the recommended ex-ante is relative to IECC 2009 and has a program infiltration standard conforming to ASHRAE 62.2*

- **Engineering Review: Single Family Buildings**

Infiltration is an important issue to cover for upcoming projects using the latest energy code, IECC 2009. The code requires (with a second optional route) air sealing to 7 air changes per hour (ACH), which translates to a natural ventilation rate of approximately 0.31 ACH (0.38 for a two story home). However, this is tighter than the requirements for ventilation under ASHRAE

standard 62.2, which requires 0.35 ACH. So, to meet the tightness requirements, additional ventilation is required. The program already has a tighter requirement at 5.0 ACH50.

Adding an energy recovery ventilator (ERV) to provide the additional ventilation air solves this issue, and provides significant energy savings across all building types. However, for buildings heated with natural gas, the electrical penalty of running the additional ventilation fans continuously throughout the year actually yields negative electrical savings. This penalty should wash with the cooling penalty associated with directly ducting additional outside air into the air handling system without tempering that air.

Additionally, projects initiated in PY3 and beyond will be subject to the IECC 2009 building energy code. In subsequent Program Years, there will be no impact, or substantially reduced impacts for the following measures:

- Higher efficiency furnaces, air conditioners, or heat pumps
- Reduced equipment capacity (R-49 roof insulation, R-20 wall insulation, R-10 slab insulation are all baseline)
- Higher efficiency domestic hot water heaters

- **Recommendations: Single Family Buildings**

- It is recommended that future project years include more strict building tightness requirements. A building tightness of less than 7 ACH when pressurized to 50 Pa is required by code, and requires a project ERV. Results for a natural ventilation rate of 0.2ACH (4 ACH @ 50 Pa) indicate good electrical savings for buildings conditioned by electric furnaces and heat pumps.
- It is also recommended to specify on the application the minimum required heat pump efficiency as this is a commonly installed central air unit.
- Engineering Review: Multifamily Low-Rise Buildings
- Additional building description data would help characterize the potential impact of energy conservation measures. For example: number of floors and, for rehabs, building vintage are key indicators of building shell energy impact.
- U.S. Department of Housing and Urban Development (HUD) report "Benchmarking Utility Usage in Public Housing" describes a model of multi-family building energy use based on a survey of thousands of HUD properties. The outcome of the report is a tool that quickly estimates existing building energy use. This tool might be useful in vetting rehab projects.
- Energy modeling simulations suggest that controlling infiltration is quite important to reducing winter heating costs.

- Shell impacts in buildings heated by electric resistance coils (some PTAC's, for example) are significantly greater than for fossil fuel heat sources.

- Shell impacts for rehab projects are significantly greater than for new buildings.

- Applications sometimes identified the heating or cooling type but not the efficiency and vice versa.

- **Recommendations: Multifamily Low-Rise Buildings**

- It is recommended that the DCEO recognize electric heating and incent projects incrementally based on the electric heating unit's coefficient of performance (COP) such as air-source, water-source, and ground-source heat pumps.

- It is recommended that the DCEO properly distinguish a building as either low-rise or non low-rise buildings for applicable savings. More specifically, one and two story buildings have different energy usage than four story buildings with the same square footage. Additionally, the energy impact for building envelope measures varies depending on building geometries. e.g. Roof insulation is a less significant factor in high-rise buildings than one story buildings.

- It is recommended that the DCEO establish building sealing requirements that reduce infiltration rates. If possible, require tests for tightness as required for single family dwellings.

- It is recommended that the DCEO add additional information to the application form: Perhaps give system options that applicants can circle or check followed by a space for the equipment efficiency.

- **Engineering Review: Multifamily New Construction Mid-Rise Buildings**

- A six story building is the optimal building geometry for energy usage.

- Foundation insulation is not required by code. However, the program requires that an R-10 insulation level be installed on below grade walls and slab-on-grade foundations. In several cases this foundation insulation caused a net energy loss (which was essentially zero) in the mid-rise building models. This may arise from the insulation trapping heat inside the building, which results in increased cooling load. This may be why the latest building codes still do not require foundation insulation for this building type and climate.

- One of the two previous year project buildings was actually two 50-unit low-rise buildings which may not be properly applied to this building type.

- One of the two previous year project buildings utilized a water loop heat pump system with a central boiler plant and fluid cooler with terminal water-source heat pumps for

each residential unit. This is a system type that is not currently recognized by the program.

- Air-source heat pumps are not recognized as part of the current program.
- Program requirement for window U-value is equal to IECC 2006 which yields no savings.

- **Recommendations: Multifamily New Construction Mid-Rise Buildings**

- It is recommended that the DCEO recognize electric heating and incent projects based on the electric heating units' coefficient of performance (COP) such as air-source, water-source, and ground-source heat pumps.
- It is recommended that the DCEO properly distinguish buildings as either low-rise or non low-rise buildings for applicable savings. More specifically, one and two story buildings have different energy usage than four story buildings with the same square footage. Additionally, the energy impact for building envelope measures varies depending on building geometries. For example, roof insulation is a less significant factor in high-rise buildings than one story buildings.
- It is recommended that the DCEO consider incenting air-to-air energy recovery systems on buildings that meet infiltration requirements.
- It is recommended that the DCEO provide more detailed information for completed projects regarding system type and basic operation.
- It is recommended that the DCEO specify what areas systems are serving. For example PTACs serve residential units only, boilers serve common areas, entire building, etc.
- It is recommended that the DCEO consider adapting a specific, established energy code for proposed building envelope measures such as ASHRAE standard 189.1-2009. For example, stating that walls require "R-21 full cavity blown insulation" is ambiguous considering the construction and thermal behavior of various common wall types such as mass wall, metal studs, wood studs, etc. are not accounted for in the Minimum Energy Standards for the current program requirements.

3.1.5 Ex-Post Impact Assessment

3.1.5.11 ComEd Service Territory

Table 3-8 below presents the number of installed units in each project. The clothes washer column notes the number of clothes washers as well as the number of dwelling units served by the washers. Since clothes washer impact is dependent upon usage, the number of dwelling units served by the washers is used to derive the clothes washer savings. The lighting columns

note the actual number of fixtures installed. All of the completed units received impact credit for reduced required capacity associated with the building envelope improvements.

Table 3-8. Installed Measures (Counts) by Project, ComEd Service Territory

Project	Refrig-erator	Dish Washer	Clothes Washer	Air Handler	Bath-room Fan	Efficient AC/HP	In Unit Lighting Fixtures	Common Space / Outdoor Lighting Fixtures	Reduced AC/HP Capacity	Ceiling Fan
Alexian Brothers	24	0	4/24	0	24	24	144	64/10	24	0
Brinshore 2800	25	25	0/0	0	25	25	248	156/22	25	0
Chicago Housing Auth	104	104	8/104	0	0	104	1,008	310/0	104	0
Community Partners	2	2	2/2	2	4	2	31	0/0	2	1
Cook County	52	0	6/52	0	52	52	450	250/52	52	0
Green HFH (Waukegan)	0	0	0/0	4	6	4	28	0/4	4	0
Green HFH (Kildare)	0	0	0/0	6	6	6	56	0/8	6	0
Holiness Homes	54	0	3/54	0	0	54	270	188/0	54	0
Interfaith	100	0	12/100	0	0	100	1,000	38/0	100	0
Lake County	20	20	20/20	20	28	20	220	46/0	20	20
Lawndale Christian	42	42	0/0	42	42	42	474	0/46	42	82
NHS Roseland	60	0	16/60	0	60	60	360	208/0	60	120
NHS Wrightwood	76	0	2/76	0	0	0	340	110/6	76	0
NHS Victory	72	0	8/72	0	0	72	360	76/0	72	72
Senior Suites	32	32	9/32	0	38	32	255	15/32	32	0
St. Edmunds	41	41	41/41	41	82	41	875	0/41	41	82
PY2 clothes washers			129/197*							
Total	**704**	**266**	**131/637**	**115**	**367**	**638**	**6,119**	**1,461/221**	**714**	**377**

**These units were installed in PY2 and are not included in the total count.*

Table 3-9 below shows the energy (kWh) savings per project by measure category. The largest energy savings arise from efficient lighting and reduced required AC/ heat pump capacity. Together these two measure categories make up about 76% of the total kWh savings.

The savings for some of the projects in the table below, such as Brinshore 2800 Corp, is much higher than expected based on the original savings estimates. This site is an all-electric building that has the heating needs met by heat pumps. Therefore, in addition to cooling savings, the heating efficiency savings are shown in the electric savings as well.

The savings for NHS Wrightwood are much lower than the original savings estimates. This site has PTAC units with hydronic heat. However the installed units are lower than the required efficiency for these units.

Table 3-9. Ex-Post kWh Energy Impact by Measure and Project, ComEd Service Territory

Project	Refrig-erator	Dish Washer	Clothes washer	Air Handler	Bath-room Fan	Efficient AC/HP	Efficient Lighting	Reduced AC/HP Capacity	Ceiling Fan
Alexian Brothers	2,280	0	571	0	2,136	3,583	22,370	58,080	0
Brinshore 2800	2,375	825	0	0	2,225	6,750	45,250	49,225	0
Chicago Housing Authority	9,880	3,432	2,475	0	0	33,863	128,926	9,214	0
Community Partners	190	66	48	800	356	966	2,697	1,904	54
Cook County	4,940	0	1,238	0	4,628	7,894	79,316	5,439	0
Green HFH (Waukegan)	0	0	0	1,600	534	1,932	2,968	3,808	0
Green HFH (1305 Kildare)	0	0	0	2,400	534	2,898	5,936	5,712	0
Holiness Homes	5,130	0	1,285	0	0	10,222	48,494	232	0
Interfaith	9,500	0	2,380	0	0	5,995	92,054	12,646	0
Lake County	1,900	660	476	8,000	2,492	3,714	25,258	7,214	1,080
Lawndale Christian	3,990	1,386	0	16,800	3,738	7,951	47,368	181	4,428
NHS Roseland	5,700	0	1,428	0	5,340	0	58,984	1,138	6,480
NHS Wrightwood	7,220	0	1,809	0	0	-10,214	45,008	5,892	0
NHS Victory	6,840	0	1,714	0	0	18,317	41,428	6,221	3,888
Senior Suites	3,040	1,056	762	0	3,382	6,058	28,436	138	0
St. Edmunds	3,895	1,353	976	16,400	7,298	7,761	81,578	176	4,428
Total	**66,880**	**8,778**	**15,161**	**46,000**	**32,663**	**107,689**	**756,071**	**167,220**	**20,358**

Table 3-10 below shows the total demand (kW) impact associated with each project by measure. The largest contributor to demand savings is from lighting and efficient AC/HP. These two measures make up 86% of total PY3 demand reduction associated with projects in ComEd service territory.

Table 3-10. Ex-Post kW Demand Impact by Measure and Project, ComEd Service Territory

Project	Refrig-erator	Dish Washer	Clothes washer	Air Handler	Bath-room Fan	AC/HP	Lighting	Reduced AC/HP Capacity	Ceiling Fan
Alexian Brothers	0.24	0.00	0.07	0.00	0.24	19.92	2.92	2.51	0.00
Brinshore 2800	0.25	0.25	0.00	0.00	0.25	22.50	6.04	2.62	0.00
Chicago Housing Authority	1.04	1.04	0.29	0.00	0.00	17.68	16.28	1.04	0.00
Community Partners	0.02	0.02	0.01	0.09	0.04	0.84	0.31	1.02	0.01
Cook County	0.52	0.00	0.14	0.00	0.52	34.32	10.54	5.44	0.00
Green HFH (Waukegan)	0.00	0.00	0.00	0.18	0.06	1.68	0.36	2.04	0.00
Green HFH (1305 Kildare)	0.00	0.00	0.00	0.28	0.06	2.52	0.72	3.06	0.00
Holiness Homes	0.54	0.00	0.15	0.00	0.00	25.92	6.46	0.00	0.00
Interfaith	1.00	0.00	0.28	0.00	0.00	6.00	10.76	7.00	0.00
Lake County	0.20	0.20	0.06	0.93	0.28	10.00	3.12	0.00	0.20
Lawndale Christian	0.42	0.42	0.00	1.93	0.42	20.16	5.66	0.00	0.82
NHS Roseland	0.60	0.00	0.17	0.00	0.60	0.00	7.76	0.60	1.20
NHS Wrightwood	0.76	0.00	0.21	0.00	0.00	-10.64	5.72	1.52	0.00
NHS Victory	0.72	0.00	0.20	0.00	0.00	38.16	5.12	0.00	0.72
Senior Suites	0.32	0.32	0.09	0.00	0.38	15.36	3.49	0.00	0.00
St. Edmunds	0.41	0.41	0.11	2.05	0.82	19.68	9.57	0.00	0.82
PY2 clothes washers			0.55						
Total	**7.04**	**2.66**	**2.32**	**5.29**	**3.67**	**224.10**	**94.83**	**26.84**	**3.77**

3.1.5.12 Ameren Illinois Utilities Service Territory

Table 3-11 below presents the number of installed units in each project. The clothes washer column notes the number of clothes washers as well as the number of dwelling units served by the washers. Since clothes washer impact is dependent upon usage, the number of dwelling units served by the washers is used to derive the clothes washer savings. The lighting columns note the actual number of fixtures installed.

Table 3-11. Installed Measures (Counts) by Project, Ameren Illinois Utilities Service Territory

Project	Refrig-erator	Dish Washer	Clothes washer	Air Handler	Bath-room Fan	AC/HP	Indoor Lighting Fixtures	Outdoor Lighting Fixtures	Reduced AC Capacity	Ceiling Fan
Blackhawk Apts	32	36	32/32	0	64	32	488	96	32	64
East Central Illinois	25	25	25/25	25	32	25	577	125	25	50
HA of Shelby	30	30	0/0	30	43	30	595	120	30	30
Madison County	5	5	5/5	0	10	5	50	10	5	30
Mt. Sinai	23	23	0/0	0	63	23	199	77	23	46
PY2 clothes washers			3/3*							
Total	115	119	62/62	55	212	115	1,909	428	115	220

**These units were installed in PY2 and are not included in the total count.*

Table 3-12 below shows the energy (kWh) savings per project by measure category. The largest contributor to energy savings is from lighting. This measure makes up nearly 50% of the total kWh savings.

Table 3-12. Ex-Post kWh Energy Impact by Measure and Project, Ameren Illinois Utilities Service Territory

Project	Refrig-erator	Dish Washer	Clothes washer	Air Handler	Bath-room Fan	AC/HP	Lighting	Reduced AC Capacity	Ceiling Fan
Blackhawk Apts	3,040	2,664	4,512	0	5,696	11,008	55,224	37,088	3,456
East Central Illinois	2,375	1,850	3,525	10,000	2,848	23,850	66,824	10,825	2,700
HA of Shelby	2,850	2,220	0	12,000	3,827	28,620	67,725	12,990	1,620
Madison County	475	165	119	0	890	1,605	5,680	160	1,620
Mt. Sinai	2,185	1,702	0	0	5,607	21,942	27,554	9,959	2,484
Total	10,925	8,601	8,156	22,000	18,868	87,025	223,007	71,022	11,880

Table 3-13 below shows the total demand (kW) impact associated with each project by measure. The largest contributor to demand savings is from lighting and efficient AC/HP. These two measures make up 88% of total PY3 demand reduction associated with projects in Ameren Illinois Utilities service territory.

Table 3-13. Ex-Post kW Demand Impact by Measure and Project, Ameren Illinois Utilities Service Territory

Project	Refrig-erator	Dish Washer	Clothes washer	Air Handler	Bath-room Fan	AC/HP	Lighting	Reduced AC Capacity	Ceiling Fan
Blackhawk Apts	0.32	0.36	0.53	0.00	0.64	13.44	6.80	0.00	0.64
East Central Illinois	0.25	0.25	0.41	1.15	0.32	10.50	8.27	0.00	0.50
HA of Shelby	0.30	0.30	0.00	1.38	0.43	12.60	8.35	0.00	0.30
Madison County	0.05	0.05	0.01	0.00	0.10	2.10	0.70	0.00	0.30
Mt. Sinai	0.23	0.23	0.00	0.00	0.63	9.66	3.53	0.00	0.46
PY2 clothes washers			0.01						
Total	1.15	1.19	0.96	2.53	2.12	48.30	27.65	0.00	2.20

3.1.6 Application Specification Sheet Review

Specification sheets are a required component of the grant application. The sheets are used to verify that the building plans will conform to program standards. Specification sheets were provided for 11 sites in PY1, 6 sites in PY2, and an additional 21 are analyzed for the PY3 evaluation. These are summarized in the appendix in Table 5-1.

There have been some notable and positive changes to the content of the program specification sheets in PY3. PY3 measures provide more detailed specifications compared to PY1 and PY2 resulting in new specifications. Some notable new specifications include: three separate slab-on-grade specifications that appear in eight projects; drywall specification that appears in 18 projects; "All exterior doors shall be insulated and have door sweeps and weatherstripping" appears in 15 projects; "Heating systems shall be sized to maintain 70 °F indoors when the temperature outdoors is -10 °F", "Water heaters shall be sealed combustion direct vent with a minimum Energy Factor of 0.88", "Ceiling fans shall be Energy STAR ® rated" and "All stoves to be provided with range hoods that vent directly to the outside with a minimum 150 CFM exhaust capacity. Recirculating range hoods are not permitted" all appear in ten projects; and "Washing machines shall be Energy STAR ® rated" appears in 11 projects.

Another improvement in PY3 is that the sampled specification sheets specify the capacity or efficiency of the units installed, with the exception of lighting. The largest kWh impact is from the lighting measure. The specification sheets often specify fluorescent fixtures but not Energy STAR ® certified fluorescent fixtures. The differences between Energy STAR ® and non-Energy STAR ® fluorescent fixtures were assessed. The main difference that was found was that there are performance and packaging criteria for CFLs to qualify for the Energy STAR ®

certification. However, the energy consumption between Energy STAR ® CFLs and non-Energy STAR ® CFLs is comparable.

3.1.7 Tracking System Review

Tracking of this program is kept in site-specific electronic Excel files. Data structured in a relational database format that provide records for all participants in a single file is a valuable asset to any energy efficiency program, and is particularly useful for M&E activities. The data submitted in summary electronic format in support of this evaluation consisted of a list constructed in Excel files that contained the following:

- For projects completed during PY3:
- Grantee
- Project name
- Project location, city, zip
- Grant amount
- Estimated start and completion dates
- Total square footage
- The number of dwelling units included
- The building type (single-family, multi-family or rehab)
- Per-unit kWh savings values for lighting and refrigerator measures
- Grant amount paid for by Trust Fund/ComEd/Ameren Illinois utilities and in PY10/PY11
- For projects funded during PY3:
- Non-Profit Grantee (Participant Business Name)
- The name of project
- The amount of funding received
- The estimated start date
- The number of dwelling units included

The contents of the tracking data submitted in support of the PY3 evaluation is substantially more comprehensive than what was provided in support of the PY2 evaluation. Unlike PY2,

when all of the tracking documents provided to the Evaluation Team related to information collected prior to construction, in PY3 the measure counts and specifications were provided by the program manager for each project. It is recommended that the program maintain ongoing records of these data and use them to estimate an ex-ante impact estimate customized to each particular project. Ideally, these details would be used to construct a customized ex-ante estimate prior to determining grant amounts, to better optimize allocation of available electric energy savings funding.

3.2 Process Evaluation Results

3.2.1 Process Themes

3.2.2 Program Participation and Demand

The DCEO EEAHC has been running for over 20 years. Over that time, a large network of builders, developers, and government and nonprofit agencies have learned of the program and have told other agencies about it. While the DCEO has marketed the program at a handful of workshops and conferences, almost all grantees in PY3 are or have been referred by past participants. The program administrators feel that their limited marketing efforts drive more than enough demand for this program and thus are sufficient for the program to meet its savings goals.

Over its lifetime, the EEAHC has distributed more than $14 million in funds for over six million square feet of housing. The program's participation has grown substantially over the years, though interestingly, staffing levels for the program have remained constant. Therefore, the program finds itself often constrained by its ability to keep up with the program's demand. According to program staff, in fiscal year 2008, the EEAHC funded 297 units. The next fiscal year, the program funded 622 units, and in fiscal year 2010, this figure almost doubled to 1,164 units. Since the program's inception in 1988, it has funded a combination of rehabilitation, new multi-family, and new single-family sites totaling 6,849 units, most of which were treated in the last few years. Despite its growing size year to year, the program continues to operate with only one full-time dedicated DCEO manager and one technical consultant.

3.2.3 Application Process

There have been few changes to the program in PY3. The application forms have changed slightly, and the codes and standards associated with eligible measures have been updated. Other than these minor changes in PY3, the program is much like PY2.

In the past, the EEAHC application form has been a brief one-page form. The DCEO has moved to standardize application forms across programs, so the EEAHC application form has increased to 10 pages and requires much more information. Despite this change, the program staff has heard that most participants think the application process is still simple and relatively easy.

One change in the PY3 application process has been the addition of a third set of measure guidelines. Previously, there were only two: rehabilitation and new construction. The required measures listed in these guidelines focused on the requirements for single-family sites. DCEO architects and technical consultants then had to interpret these measures to determine eligible multi-family measures. This year, another set of pre-determined multi-family requirements was added. According to program staff, this reduced workload and processing time for multi-family projects.

In PY3, the EEAHC funded over 800 units within 20 completed projects, with an increasing number of large multi-family rehabilitation project sites. The program is increasingly seeing builders apply more for rehabilitation grants than new construction. This could be due to the economic climate.

3.2.4 Program Tracking Databases

The DCEO has a variety of program participant information within multiple databases. One database contains the contact information for each participant, while another summarizes every project completed within 2010. Under the current system, it may be difficult to match contact information with specific projects. There is an ongoing plan to create a comprehensive DCEO database that will include data about the EEAHC. This would consolidate the EEAHC data and allow for more careful comparison, tracking, and analysis. Due to constrained resources to operate this program, this database update is progressing slowly.

3.2.5 Participation Timing

The DCEO program schedule aligns with the approval schedule for IHDA and programs administered by the city of Chicago. Since builders receive funds from those programs along with the DCEO, application approvals generally occur in late spring/early summer.

Most new-construction projects that are awarded EEAHC funds take more than 12 months to complete. To accommodate this, the EEAHC has encouraged participants to request grant money across multiple years. This change, partially made in response to a suggestion brought forth in the PY1 evaluation, gives partner organizations the ability to plan ahead and to simplify the application process required for multiple small projects.

3.2.6 Program Challenges

In PY4, the EEAHC program will begin to fund natural gas measures as well as electric, meaning the program will now have to track and document program activity across six different utilities. While this will add greater flexibility for participants and open up the program to a number of newly eligible projects, it will also increase the workload and administrative complexity for the DCEO.

The DCEO EEAHC program has grown significantly in recent years, though the resources allocated to manage the program have not. Further, in PY3, the DCEO experienced a loss in

their key staff managing the program prompting them to hire and train new staff. According to program staff, these obstacles have led to some participants raising concerns about the responsiveness of the DCEO, as well as the long time period needed to approve requested funds. In some cases, this has affected the building schedules of builder grantees.

The EEAHC implementation plan includes an annual field analysis for the first three years following unit occupancy. These field analyses are to be conducted by the technical contractor, but have not been performed in the last few years. This is due to a larger than expected workload for the technical consultant. The consultant only has the bandwidth to focus on processing, monitoring, and tracking new projects -- not for the additional task of monitoring the energy savings of completed projects. This situation is not likely to change going forward without additional staff.

3.2.7 Participating Builder Experience

As part of the process evaluation for the PY3 Energy Efficient Affordable Housing Construction (EEAHC) program, the evaluation team conducted in-depth interviews with builder participants to explore their program experience and identify any issues or areas of improvement from the participant perspective.

- **Methodology**

DCEO interacted with 20 different participants throughout PY3 to help fund new construction and gut rehabilitation projects for low-income residents. In October 2011, we conducted a census of these participants asking them to engage in a 20-minute in-depth interview regarding their experience with the program. We completed 12 total in-depth interviews with participants: 8 builders, 3 nonprofit developers, and one financial consulting firm (referred to henceforth as "builders"). Most of the people we interviewed were Project or Senior Project Managers within their organizations, though some were at an executive level. The findings below summarize the outcome of these interviews.

- **Participant Characteristics**

Participants are predominantly general contractors who conduct business within Illinois; however, some contractors are part of larger organizations that build throughout the United States. Other participants include nonprofit developers and financial consulting firms. The participants range vastly in company size and the geographic area in which they work. Most builders were knowledgeable about the EEAHC program and the participation process while others relied upon nonprofit organizations or financial consulting companies to apply to the program.

These builders construct an average of 6 projects per year, though this varies widely (between 1 and 15). Roughly 60% to 70% of these projects are either low-income or affordable housing, though some partners specialized in exclusively low-income projects. All builders reported that

their workload has included a mixture of single-family, multi-family, new construction, and gut-retrofit. Most reported an overall increase in gut-rehabilitation over new construction projects in recent years.

We asked builders to provide an average length of a project from start to finish. The typical reported time period for project completion ranged widely. Some builders can complete a single-family home in as little as four to five months while multi-family projects average as much as 16 months.

Builders had a wide range of experience, both in the building industry and in the EEAHC program. Some participants had just finished their first project with DCEO in the last year, while others had been working with DCEO to fund low-income building projects for over a decade.

The program requires that projects have a mix of end-uses (building shell, HVAC and appliances) to quality for project funding. Most of the low-income projects that the builders are involved with are eligible for the EEAHC program funds. However, there are two primary situations in which a builder may choose to forgo installing some energy efficient measures (and thus forgo the EEAHC grant) in favor of a lower upfront cost.

The first situation is atypical structural circumstances such as modular housing, structural thermal envelope limitations, or gut-retrofit projects in which a significant portion of the existing appliances are still operational. In these cases, builders may forego participating in the program because they do not plan to upgrade the appliances even though they plan to address the building shell and HVAC system. The second situation involves rate-of-return. A property owner considers the additional upfront cost of energy-efficient measures as an investment, which lowers the long-term operating costs of the site. Nonprofits that are developing sites for immediate sale to low-income families will never have the opportunity to recuperate this investment. They also find it difficult to pass these costs on to low-income consumers.

- **Overall Program Impression**

One primary goal of the builder interviews was to explore the builders' experience and satisfaction with the program. Builders have a very favorable view of the program overall. They are very appreciative of the funding and technical support. They find the application process and requirements for eligibility very clear. Builders were also happy that the DCEO program focuses on high rate-of-return measures. Further, all builders agree that the program is having a very positive impact in the construction of low-income dwellings. The program is helping to create more energy efficient residences for low-income customers and to lower the financial burden of energy costs for these customers.

Though they generally characterized the program as effective, clear, and a positive experience, several builders mentioned some issues with being unaware of funding approval and dispersal status and delayed program response to inquiries. Further, multifamily, gut-retrofit projects

have become increasingly common in the program and this trend will likely continue in the next program cycle.

- **Application Process**

Most general contractors felt that the application compared favorably to applications from other funding sources and that the application process was clear and simple. Some builders noted that while the application requirements and processes were simple, there were times when DCEO lost applications and the builders had to resubmit forms. Notably, the builders who cited these delays as a problem also said that the process has since improved.

While some partners found the list of required measures limiting for some projects, builders who suggested alternative measures found the process to be smooth. They considered this a strength over programs that cover a larger geographic area and have less flexibility.

"DCEO looks at each building individually and will adjust accordingly. I've always admired that about the program."

- **Program's Technical Resource**

The program is implemented with the support of a technical consultant who reviews applications, conducts quality control, and shepherds participants through the participation process. Builders repeatedly cited this consultant as a responsive, highly knowledgeable, and useful resource.

- **Marketing Effectiveness**

The program's reliance on word of mouth, recurring participants, and other low-income agencies to promote the program appears to be effective. Some builders have been working with DCEO to fund projects for over a decade. Less experienced builder partners had heard of the program through word of mouth – either through informal discussion with others in the industry or through other nonprofit or government agencies. Participants believe that contractors and developers who work in the Chicago area generally know about the program.

- **Program Impact**

All builders agree that the program is having a very positive impact in the construction of low-income dwellings. The program is helping to create more energy efficient residences for low-income customers and to lower the financial burden of energy costs for these customers.

"Jobs completed with DCEO funding are tighter environmentally, are less expensive to operate in the long term, and are more likely to succeed as an affordable housing project."

Builder partners are aware that the goals of energy efficiency and low-income housing are complementary: lower energy bills help to reduce the cost of living for low-income residents. While builders try to maximize energy efficiency in each of their low-income projects, they also

must work within financial and market constraints that often lead to them favoring whatever will provide the lowest up-front costs. As such, most builders (10 of 12) said that without the program they would likely only build to basic efficiency codes and standard with some efficiency but not nearly as much as they would with program assistance, especially for higher-cost measures such as insulation. Two builders stated that they would likely still build energy efficient homes for low-income residents without the DCEO funds by seeking the funding from other sources.

"[Without the program] we would have obviously built to practical standards, with some efficiency, but [the DCEO funds] have definitely reduced [energy] consumption."

"Would it affect the quality of the projects? Absolutely. Jobs completed with DCEO funding are tighter environmentally, are less expensive to operate in the long term, and are more likely to succeed as an affordable housing project."

The DCEO funds often increase the rate-of-return for energy efficiency such that long-term investment in energy efficiency is sufficiently attractive for developers to take action. This is especially true for thermal-envelope measures like insulation, which can be prohibitively expensive, especially in gut-retrofit projects.

Some participants feel that the effect of the DCEO grants had a larger benefit than the modest funding levels would suggest because it helps them to acquire other funding sources. Many funding sources consider a diverse base of funding as a positive sign and so are more likely to award funds to projects that have already been able to secure funds elsewhere. The EEAHC program fills this role for many builders.

- **Program Challenges/Areas of Improvement**

Though they generally characterized the program as effective, clear, and a positive experience, the builders did identify three areas of improvement: (1) Increased communication regarding timing for when their project might be approved for funding and when they can expect to receive the funding; (2) Faster response time to requests for information; and (3) Re-examination of program requirements for applicability to multi-family gut-retrofit projects.

- **Communication with Participants**

Most builders, especially those that have been working with DCEO for several years, were satisfied with the amount of communication they received from DCEO. However, some builders expressed dissatisfaction with the lack of communication throughout the two critical periods in the participation process. The first critical period of the grant award process is between proposal submission and award notification. The second is between award notification and fund disbursal. Some builders have cited both of these periods as problematic. They have had to expend extra effort and resources to prevent these delays from impacting project timelines. More than one partner has had to close a project before the funds were transferred,

and to trust that the funds would eventually be received. This is especially problematic for nonprofit builders or developers that do not have large cash reserves.

"It might be a matter of setting expectations. If we knew that the grant money was coming in May, we could plan for that."

One participant noted that DCEO has often not been responsive regarding projects that have closed in February or March. This has led them to believe that the DCEO funds are dependent upon the yearly fiscal schedule of the state of Illinois, and so are disbursed in May more easily. Builders noted that the delay would not be a problem if DCEO communicated as early as possible when builders can expect funds.

Further, some builders were dissatisfied with the slow response time when requesting documentation from DCEO for other purposes. Many grant or loan programs look favorably upon proof that a given project has been able to secure a variety of other funding sources. The DCEO grant funds often serve this important function, especially for nonprofit organizations that frequently fund projects through grants or loans. In these cases, the builders request documentation of awarded funds from DCEO well before DCEO has disbursed the funds. Some partners found that DCEO has been slow to respond to these requests.

Many builders commented on the long period of time between award announcement and disbursal. Those that did not comment on this issue said they had expected and planned for this delay because they understand that the EEAHC program is a government program that must deal with a high workload and a particular funding schedule. Some partners suggested that the problem was not necessarily the long delay, but the lack of effective communication concerning this period. If DCEO can set realistic expectations at the start of an application, builders may find it easier to plan around the timeline.

- **Measure Eligibility Requirements**

Builders do not seek DCEO funding for energy efficiency measures for some low-income projects due to the participation requirements. A frequent comment concerning the list of measures was that it seemed more appropriate for single-family rather than multi-family projects. The PY3 program recently addressed this issue by adding an approved list of multi-family appropriate measures; therefore, the concerns below may reflect builders' experiences with the program prior to these changes.

One concern is that the program has a per-unit spending cap for multi-family projects. However, builders noted that units can vary in size such that thermal envelope improvements increase in price for larger spaces.

Another concern expressed was that the program requires a set of measures (appliances, building shell and HVAC) for each project it funds. Builders consider the set of measures required by the EEAHC program to be reasonable, though not every measure is always appropriate for every project. This is especially true for gut-retrofit projects when the builder

believes replacement of slightly less efficient existing appliances is often not worth the money or time. They believe this can also be true for insulation requirements, due to the high cost of replacing these measures in some structures. This requirement leads to builders forgoing program participation more than any other aspect of the program.

Builders suggested some solutions to this problem including attaching funding to an efficiency test (i.e., a blower door test), or breaking the package into three or four sets of measures that could be considered independently.

3.3 Cost Effectiveness Review

[To be added after impact results are finalized.]

4. Conclusions and Recommendations

4.1 Key Impact Conclusions and Recommendations

4.1.1 Impact Conclusions

The EEAHC program completed electrically efficient construction of 714 low income dwellings in ComEd's service territory during PY3, generating 1,221 MWh of energy savings, and 371 kW of demand reduction. These accomplishments represent 93% and 58% of the ex-ante energy and demand impact, respectively. The program as a whole –including ComEd and Ameren Illinois Utilities service territories—completed construction of 829 program funded dwelling units during PY3, and 1,528 units over the combined PY1 through PY3 periods. The associated ex-post energy savings totals 4,101 MWh and 1.2 MW.

4.1.2 Impact Recommendations

4.1.2.1 Single Family Impact recommendations

Single Family HVAC Equipment. The IECC 2009 methodology does not allow credit for high efficiency HVAC equipment.

- **Recommendation. DCEO may consider using, at a minimum, CEE Tier 1 equipment efficiency standards for future evaluation years.**

4.1.2.2 Multi Family Impact recommendations

- **Building Types.** In at least one case a building was classified as mid-rise based on the number of dwelling units when it was actually made up of multiple low-rise buildings. Recommendation. Consider distinguishing building as either low-rise or non low-rise buildings for applicable savings. For example, one and two story buildings have different energy usage than four story buildings with the same square footage. Additionally, the energy impact for building envelope measures varies depending on building geometries. For example, roof insulation is a less significant factor in high-rise buildings than one story buildings.

Scope of HVAC system types. Previous year project buildings utilized various HVAC system types such as water loop heat pump systems with a central boiler plant and fluid cooler, ground-source heat pumps, and central boiler and chiller systems. These system types are not currently recognized by the program.

- **Recommendation. Consider adapting program qualifications to encompass a broad range of HVAC systems. HVAC system types and requirements should continue to be based on ASHRAE 189.1 (2009) or IECC 2009 to ensure quantifiable impact..**

Scope of Building Wall and Roof Constructions. Current recommendations for wall and roof constructions are reasonable, however, the description in the program guidelines may be confusing to some users.

- **Recommendation.** Consider revising and expanding the current description to properly describe exactly what the program expects regarding insulation relative to continuous and non-continuous insulation.

Program Window Requirements. The current Minimum Energy Standards for window U-value is equal to IECC 2006 which yields no savings.

- **Recommendation.** PY3 uses a more realistic U-value relative to the new code, so no recommendation to modify that. However, specify a suitable solar heat gain coefficient for windows.

Infiltration Requirements. Infiltration requirements are difficult to quantify in high-rise buildings and have less of an energy impact due to the control of building pressurization from the central mechanical system which brings in outside air as well as exhaust air.

- **Recommendation. Consider adding program requirements for heat recovery or energy recovery systems on buildings' ventilation and exhaust systems.**

HVAC Data Collection. Much of the data collected regarding HVAC system types is overly simplified and vague.

- **Recommendation. Consider specifying all HVAC system types and which areas of the building they serve as part of the application and/or verification process.**

4.1.2.3 Verification recommendations

- We recommend that verification activities and results be documented in the new tracking database.

- We recommend that the program guideline for bathroom exhaust fans be revised to include a specific size and wattage range for efficient fans. As it is currently stated, the specification in the guidelines that bathroom exhaust fans "shall be rated no less than 75 CFM" does not provide sufficient specificity for the wattage of efficient fans.

4.1.2.4 *Tracking system recommendations*

- We recommend that the new tracking system database be constructed with standardized variables that can be manipulated with database tools, such as SAS or MS ACCESS.
- We recommend the new tracking system hold records of participation and verification activities, and the specific measures associated with each project.

4.1.2.5 *Recommendations for Evaluation, Measurement and Verification*

- **We recommend that the PY4 evaluation apply engineering principals and detailed information regarding building projects to produce customized impacts associated with the efficient HVAC and building envelope measures.**
- **We recommend that further research be conducted regarding new IECC 2009 commercial code lighting requirements, as well as national lighting efficiency requirements. The potential implications of these regulations on program standards and associated energy and demand impact are critical to adopting appropriate and timely program design adjustments.**

4.2 *Key Process Conclusions and Recommendations*

Key process findings thus far indicate that the program is doing well in terms of marketing and participation. The program staff has made continuous and substantive changes to streamline and improve their application process especially for multifamily rehabilitation projects which are increasingly common for the program. The program staff has a done a good job of continuing to meet funding demand with a small administrative and technical staff.

One of the greatest program challenges comes down to the need for additional staffing resources, both administrative and technical. Despite its growing demand year to year, units receiving funding grew as much as 187% between the last two fiscal years; the program continues to operate with only one full-time dedicated DCEO manager and one technical consultant. In PY4, the EEAHC program will begin to fund natural gas measures as well as electric measures, meaning the program will have to track and document program activity across six different utilities. This will increase the workload and administrative complexity for the DCEO.

Further, the program plans to create a comprehensive DCEO database that will consolidate the EEAHC data and allow for more careful comparison, tracking, and analysis. Due to constrained resources to operate this program, this database update is progressing slowly. Finally, the EEAHC implementation plan includes an annual field analysis for the first three years following unit occupancy. These field analyses are to be conducted by the technical contractor, but have not been performed in the last few years, again due to constrained resources.

- **Given these operating conditions, we recommend that the DCEO evaluate its staffing resources relative to anticipated program demand for the next program year and determine whether additional staffing is needed and can be funded or whether program goals should be revised to align with the staffing resources available.**

- **We recommend that the DCEO execute its visions for a comprehensive DCEO database with the understanding that this likely will not happen unless the DCEO is able to gain additional staffing resources, or hires a consultant for this task.**

- **We recommend developing formalized protocols for communication with participants on status regarding timing for when their project might be approved for funding and when they can expect to receive the funding. This could be in the form of an email that is generated within 14 days of receiving an application that gives the participant expected timelines for these milestones. General expectations on timeline could be communicated to potential participants through the program guidelines.**

- **We recommend developing formalized protocols for responding to participant requests. For example, DCEO could develop a protocol that they will acknowledge a request for information by email or phone within a certain time period (e.g., 5 business days) and that they will fulfill the request for information by email or phone within another certain time period (e.g., 30 days).**

- **Builders expressed concern that the per-unit spending cap for multi-family projects is too low. Another concern is that the program has a required set of measures however not every measure is always appropriate for every project and can lead to builders forgoing program participation. The Program recently addressed this issue by adding an approved list of multi-family appropriate measures; we recommend that the program continue to monitor this issue proactively, as they have been, and consider additional changes if needed.**

5. Appendices

Data Collection Instruments

5.1.1 New Construction Staff Interview Guide

DCEO EEAHC_ Staff Interview Guide.docx

5.1.2 New Construction Builder Interview Guide

DCEO EEAHC_Builder Interview Guide.docx

Specification Sheet Content

Table 5-1 Specification Sheet Content

Measure and Specification	PY1 Sample	PY2 Sample	PY3 Sample
Energy STAR ® Refrigerator			
If supplied, refrigerators shall be Energy STAR ® rated.	11	6	18
Lighting: 6 Interior and 2 Exterior Fluorescent Fixtures			
All hard-wired lights in each unit shall be fluorescent fixtures. All common area lighting shall be fluorescent.	5	2	7
A minimum of six fluorescent lighting fixtures shall be installed in high use areas of the home. All common area lighting shall be fluorescent.	4	3	4
A minimum of six fluorescent lighting fixtures shall be installed in high use areas of the home.	2	1	6
Air Conditioning: SEER 14 Central Air Conditioner			
Heating and cooling shall be provided by a geothermal system	4	2	0
Air conditioners shall have a minimum SEER value of 14	3	2	5
Air conditioners shall have a minimum SEER value of 14.5	0	0	1
Air conditioners shall have a minimum SEER rating of 15.	1	0	0
If air conditioning is provided, it shall be have a minimum SEER value of 14 and be Energy STAR ® rated.	1	1	3
VRF heat pump system shall have a minimum SEER rating of 14.	1	1	0
All air conditioners shall be Energy STAR ® rated.	0	0	1
Primary heating and cooling is being done with packaged terminal air conditioning units (PTAC). Units shall have a minimum EER value of 10.5	1	0	0
Through-the-wall air conditioning units shall be Energy STAR ® rated with a minimum 10.0 EER	0	0	0
Reduced AC Tonnage: as a result of thermal envelope improvements			
Slab-on-Grade			
First 6 feet of slab perimeter shall be insulated with a minimum r10 extruded polystyrene insulation	0	0	8
A thermal break (minimum R5) shall be provided between slab edge and foundation wall	0	0	8
A capillary break shall be provided beneath the entire slab. Alternately, a polyethylebe vapor diffusion retarder (minimum 6 mil) shall be installed beneath entire slab	0	0	8

Measure and Specification	PY1 Sample	PY2 Sample	PY3 Sample
Exterior wall insulation			
R15	1	0	1
R19	0	0	1
R21	9	6	12
R24	1	0	1
R26	0	0	1
Attic/Roof insulation			
R44	8	5	3
R49	3	1	16
Attic Access Panel(s) shall be weatherstripped and insulated. Insulation R-value shall be equivalent to the R-value of the insulation on the surrounding surfaces.	0	0	3
Insulation shall be placed under attic walkways or storage area. Attic scuttle panel should be weatherstripped and insulated with a maximum R21.	0	0	2
Crawl Space--Interior Foundation Wall Insulation	0	0	
A minimum R10 insulation shall be installed along entire face of interior crawl space walls. A minimum R21 insulation shall be installed in crawl space rim. Unfaced batt insulation is not permitted for rim joist insulation.	0	0	3
A minimum R21 insulation shall be installed between floor joists. If crawl space access is through floor, hatch shall be insulated to a minimum R10 and weatherstripped.	0	0	1
Conditioned wall insulation			
R13	8	6	8
R15	1	0	0
R21	2	0	3
Masonry Fin Wall Insulation			
Spray foam insulation or 3/4" polyisocyanurate rigid insulation shall be installed between new or existing furring strips. Insulation shall extend 4'-0" in from exterior walls	0	0	3
Drywall			
Drywall shall be installed tightly to all framing members to assure adhesion between drywall and framing members. A continuous bead of sealant shall be applied to corner studs, top and bottom plates, rough opening members and corners of interior partition studs on exterior and perimeter walls to seal drywall to framing. "Spot" gluing is not acceptable.	0	0	18
Drywall on exterior, conditioned and perimeter walls to be installed to subfloor of unit above on first floor.	0	0	1

Measure and Specification	PY1 Sample	PY2 Sample	PY3 Sample
Basement Wall Insulation			
Foundation wall to be insulated to minimum R5. Rim joist cavity on exterior walls to be insulated to R10.	0	0	1
Basement wall insulation shall be minimum R10. A minimum R21 insulation shall be installed in basement rim.	0	0	3
Floor			
A minimum R5 thermal break shall be installed at floor perimeters	0	0	4
Windows			
maximum U-value of 0.34, low-E double glazed	8	1	1
maximum U-value of 0.35	0	0	1
maximum U-value of 0.35, low-E double glazed	0	5	8
maximum U-value of 0.35, low-E double glazed, SHGC shall not exceed 0.55	1	0	3
maximum U-value of 0.40, low-E double glazed	1	0	1
maximum U-value of 0.47, low-E double glazed	0	0	2
maximum U-value of 0.48, low-E double glazed	1	0	0
Low-E, double-glazed, storm windows with a maximum U-value of 0.65.	0	0	1
Maximum U-value of 0.30.	0	0	2
Low-E, double glazed and Energy STAR ® rated. Maximum U-value of 0.32, Solar Heat Gain Coefficient (SHGC) shall not exceed 0.55	0	0	1
Doors			
All exterior doors shall be insulated and have door sweeps and weatherstripping.	0	0	15
Air Infiltration			
All completed homes must have not more than 5.0 air changes per hour at 50 pascals as measured with a blower door.	11	6	17
All completed units must have not more than 3.0 air changes per hour at 50 pascals as measured with a blower door.	0	0	1
A continuous air barrier shall be installed on all exterior and conditioned walls in accordance with manufacturer's installation guidelines. Air barrier shall not restrict the passage of moisture.	0	0	6
Energy STAR ® **Dishwasher**			
If supplied, dishwashers shall be Energy STAR ® rated.	11	6	9

Measure and Specification	PY1 Sample	PY2 Sample	PY3 Sample
Energy STAR ® Bathroom Exhaust Fan			
All bathroom(s) to be equipped with exhaust fans that are Energy STAR ® rated. Fans shall be rated no less than 75 CFM at 0.25" of static pressure. Bathroom fans shall have a sone rating no higher than 1.5 and shall be vented directly outdoors.	7	4	12
A continuous central exhaust system shall be utilized to vent all bathrooms and kitchens. Alternately, all bathrooms to be equipped with ENERGY STAR® rated exhaust fans vented directly outdoors. Bathroom fans shall have a sone rating no higher than 1.5	0	0	0
A continuous central exhaust system shall be utilized to vent all bathrooms. Ventilation shall provide a minimum 75 CFM.	3	1	2
Ventilation shall be provided to patient rooms using outside air conditioned with a heat recovery system utilizing general exhaust from the building	1	1	0
A mechanical timer shall be used for the fan if the fan is controlled separately from the light. A fan-delay timer shall be used if the fan and ceiling light are controlled together.	8	4	9
All bathrooms to be vented with roof-top exhaust fans. Bathrooms shall be exhausted at a continuous flow rate no less than 10 CFM. A wall mounted switch shall be provided for occupant control that will boost the exhaust to a minimum 75 CFM.	0	0	1
A continuous central exhaust system shall be utilized to vent all bathrooms. Ventilation shall provide a minimum of 20 CFM. An occupant override switch shall be provided to increase ventilation during periods of showering	0	0	1
Bathrooms shall be continuously ventilated per the Chicago Building Code with central toilet exhaust through an HRV system	0	0	1
Bathroom exhaust fans shall be controlled with 60 minute mechanical timers.	0	0	1
90% AFUE Furnace with Efficient Air Handler			
Patient rooms shall be conditioned with a Variable Refrigerant Flow (VRF) heat pump system with a minimum SEER rating of 14.0.	1	1	0
All furnaces are electric. If gas or propane-fired furnaces are substituted, they shall have a minimum AFUE rating of 90% and shall be direct vent sealed combustion units.	2	0	5
Furnace shall have a minimum AFUE rating of 90% and shall be direct vent sealed combustion, unless an electric furnace is used.	1	1	2
Furnaces shall have a minimum AFUE rating of 90% and shall be direct vent sealed combustion units.	2	2	0
A geothermal system may be utilized for primary heating and cooling. Alternately, boilers used for heating (either primary or back-up for the geothermal system) shall be direct vent sealed combustion with a minimum efficiency of 88%.	1	0	0
Heating and cooling shall be provided by a geothermal system.	1	1	2
Boilers shall be direct vent sealed combustion with a minimum efficiency of 88%.	0	0	7
Primary heating and cooling is being done with a geothermal system. Boilers shall be direct vent sealed combustion with a minimum efficiency of 88%.	2	1	0

Measure and Specification	PY1 Sample	PY2 Sample	PY3 Sample
Primary heating and cooling is being done with packaged terminal air conditioning units (PTAC). Units shall have a minimum EER value of 10.5.	1	0	0
Mechanical			
PTAC units shall have a minimum EER rating of 10.5	0	0	2
PTAC units shall have a minimum EER rating of 9.3.	0	0	1
Heating systems shall be sized to maintain 70 °F indoors when the temperature outdoors is -10 °F.	0	0	10
Heating systems shall be sized to maintain 72 °F indoors when the temperature outdoors is -10 °F.	0	0	1
All heating systems shall be sized to maintain 70°F indoors when the temperature outdoors is -3°F	0	0	1
Water heaters shall be sealed combustion direct vent with a minimum Energy Factor of 0.88.	0	0	10
Water heaters are electric and shall have a minimum Energy Factor of 0.93.	0	0	3
Gas-fired water heaters shall be Energy STAR ® rated and be sealed combustion direct vent with an Energy Factor (EF) equal to or greater than 0.62. If electric water heaters are use, they shall have a minimum EF of 0.93.	0	0	2
Water heaters shall have a minimum thermal efficiency of 88%	0	0	1
Water heaters shall be sealed combustion direct vent with a minimum GAMA energy factor of .62 and be Energy STAR ® rated.	0	0	1
Water heaters shall be sealed combustion direct vent and shall be Energy STAR ® rated	0	0	1
Proposed water heaters are electric. Should gas or propane-fired water heaters be substituted, water heaters shall be sealed combustion direct vent with GAMA energy factor greater than or equal to 0.60.	0	0	1
Heat pumps shall be Energy STAR ® rated and shall have HSPF=8.2, SEER=14.5, EER=9.5	0	0	1
Heat pumps shall have a minimum SEER value of 15.0 with ECM motors.	0	0	1
RTU units shall have a minimum ER of 9.6	0	0	1
Room air conditioners shall be Energy STAR ® rated with a minimum EER value of 10.7	0	0	1
Washing machines shall be Energy STAR ® rated.	0	0	11
Water source heat pumps shall have a minimum EER of 14.7 and a minimum COP of 3.0.	0	0	1
Ceiling fans shall be Energy STAR ® rated.	0	0	10
All stoves to be provided with range hoods that vent directly to the outside with a minimum 150 CFM exhaust capacity. Recirculating range hoods are not permitted.	0	0	10