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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

Presented to

The Illinois Department of Commerce and Economic Opportunity

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Presented by

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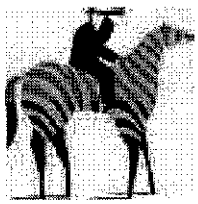

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Executive Summary

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.

E.1. 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.

E.2. 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.

E.3. 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'

E.3.1. 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

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

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 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.

E.3.2. 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.**

E.3.3. 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.**

E.3.4. 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 EAHC 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 requirements and how project milestones affect payment timelines. It may also be helpful to institute a protocol for acknowledging 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-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."

E.4. Cost Effectiveness Review

Cost effectiveness is assessed through the use of the Illinois Total Resource Cost (TRC) test. Table ES-5 summarizes the unique inputs used to calculate the TRC ratio for the Energy Efficiency Affordable Housing Construction Program in PY3. Most of the unique inputs come directly from the evaluation results presented in this report. Measure life estimates were based on similar ComEd programs, third party sources including the California Public Utilities Commission (CPUC) developed Database of Energy Efficiency Resources (DEER) and previous Navigant evaluation experience with similar programs. Program costs data came directly from DCEO. Incremental costs were estimated from program, survey data and similar ComEd

programs. Avoided cost data came from both ComEd and Ameren and are the same for all programs.

Table ES-5. Inputs to TRC Model for Energy Efficiency Affordable Housing Construction Program

Item	Value Used
Measure Life	12 years
Annual Gross Energy Savings	1,682 MWh
Gross Coincident Peak Savings	0.46 MW
Net-to-Gross Ratio	100%
DCEO Administration and Implementation Costs	$134,103
DCEO Incentive Costs	$641,200
Net Participant Costs	$3,320,860

Based on these inputs, the Illinois societal TRC for this program is 0.25 and the program fails the Illinois TRC test. However the low income programs are not required to meet the TRC test.[4]

[4] ILCS 220 5/8-103(a) and 5/8-104(a), which states "The low income measures described in section (f)(4) of this Section shall not be required to meet the total resource cost test."

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Section 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	

Construction Element	Specification	New Single-Family	New Multi-Family	Rehabilitation of Single- and Multi-Family
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
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?

Section 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

2.2.2 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.

2.2.3 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.

2.2.4 Multi-Family, Low Rise Models

2.2.5 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.

2.2.6 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.

2.2.7 Multi-Family, Mid Rise Models

2.2.8 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.

Section 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[5] 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).

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[5] 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.

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 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[6]

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.

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

Table 3-2. Expected Project Starts versus Program Accomplishments[7]

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'

3.1.3 Participation and Impact Summary

3.1.4 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.

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

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.

3.1.5 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'

3.1.6 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.

3.1.7 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.

3.1.8 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[8] incorporates an efficient lighting requirement. The code requires 50% of permanent fixtures be high efficiency. The EEAHC standards indicate a minimum of 6

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

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.

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.

3.1.9 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.

3.1.10 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.

3.1.11 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[9] . 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.

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

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. 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.

3.1.12 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.