Evaluation of Public Housing Authority Efficient Living Program

June 2012 through May 2013

Prepared for:
Illinois Department of Commerce Economic Opportunity

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Executive Summary

This report presents the results of the impact and process evaluations for electric program year five and natural gas program year two (EPY5/GPY2) of the Public Housing Authority Efficient Living Program (Efficient Living Program) offered by the Illinois Department of Commerce and Economic Opportunity (DCEO). EPY5/GPY2 is defined as the period June 2012 through May 2013.

The main features of the approach used for the evaluation are as follows:

- Data for the study were collected through review of program materials and interviews with DCEO staff members, and focus group discussions with residents.
- An engineering desk review of program measures to verify gross savings estimates.

The realized gross and net electric savings of the Efficient Living Program during the period June 2012 through May 2013 are summarized in Table ES-1. For EPY5/GPY2, realized annual gross electric savings total 5,440,987 kWh. For electric savings, the program gross realization rate is 86%. The program net-to-gross ratio is 100% because the Efficient Living Program targets low income residents. The realized net electric savings total 5,440,987 kWh annually. Natural gas savings are shown in Table ES-2. Gross realized natural gas savings total 186,146 therms annually. For natural gas savings, the gross realization rate is 112%. Net therm savings total 186,146 annually.

Table ES-1 Summary of kWh Savings for Efficient Living Program

Utility	*Expected kWh Savings*	*Realized Gross kWh Savings*	*Gross Realization Rate*	*Realized Net kWh Savings**
Ameren	2,278,468	2,075,177	91%	2,075,177
ComEd	4,031,201	3,365,811	83%	3,365,811
Total	6,309,668	5,440,987	86%	5,440,987

**A net-to-gross ratio of 100% is applied because the Efficient Living Program targets low income residents who would not have funded new energy efficiency measures in the absence of the program.*

Table ES-2 Summary of Therm Savings for Efficient Living Program

Utility	*Expected Therm Savings*	*Realized Gross Therm Savings*	*Gross Realization Rate*	*Realized Net Therm Savings**
Ameren	69,849	75,482	108%	75,482
Nicor	80,364	93,635	117%	93,635
North Shore	12,790	14,465	113%	14,465
Peoples	3,615	2,564	71%	2,564
Total	166,618	186,146	112%	186,146

**A net-to-gross ratio of 100% is applied because the Efficient Living Program targets low income residents who would not have funded new energy efficiency measures in the absence of the program.*

The realized gross and net peak kW reductions of the Efficient Living Program during the period June 2012 through May 2013 are summarized in Table ES-3. The achieved net peak demand savings total 947.03 kW.

Table ES-3 Summary of Peak kW Savings for Efficient Living Program

Utility	*Realized Gross kW Savings*	*Realized Net kW Savings**
Ameren	397.24	397.24
ComEd	549.79	549.79
Total	947.03	947.03

**A net-to-gross ratio of 100% is applied because the Efficient Living Program targets low income residents who would not have funded new energy efficiency measures in the absence of the program.*

Interviews with program staff and focus groups with residents who received the energy saving improvements indicate that the Efficient Living Program is operating well and has been effectively delivering energy savings. The following presents a selection of key conclusions from EPY5/GPY2:

- **Energy Efficient Equipment Produced Cost Savings for Residents:** Residents of the housing facilities described several ways in which in the energy efficient upgrades produced noteworthy cost savings. Some of the cost savings resulted from decreased utility bills. Residents who received new air conditioning units and fluorescent lighting were most likely to indicate that they noticed a decrease in their electricity bills. In addition to energy cost savings, residents also noted that they saved money on the replacement costs for light bulbs. The new CFLs installed through the program have considerably longer lifetimes than the incandescent bulbs they replaced and residents mentioned that they would save money on the replacement costs as a result. Some residents indicated that they had already noticed the longer lifetime of the CFLs despite their fairly recent installation.
- **Measures Affected Perceptions of Safety, Comfort, and Convenience:** The fluorescent lighting, HVAC systems, ceiling fans, and refrigerators were most frequently noted for their effect on the residents' safety and comfort. Although residents noted the energy and maintenance cost saving benefits of the new fluorescent lighting, a number also indicated that the new lighting was not as bright and that this felt less safe. Additionally, the dimmer fluorescent lighting was an inconvenience for some residents and some indicated that bathroom lights controlled by occupancy sensors came on at night and woke them up.

  Several residents mentioned benefits stemming from the installation of energy efficient HVAC equipment. One of the perceived benefits was increased feelings of safety. The older HVAC equipment that was replaced omitted odors associated with burning gas, oil leaks, or overheated electrical parts. The new HVAC equipment eliminated these odors. Additionally, several residents reported that their residences were more effectively heated and cooled.

  Some residents also indicated that the ceiling fans improved their comfort of their homes. However, other residents also stated that the ceiling fans were too low and that they hit their heads on the fan or chain.

- **Energy Efficiency Upgrades Produced Few Changes in Behaviors:** Although many residents appreciated the energy upgrades, very few made changes in behavior as a result of those upgrades. The few behavioral changes that did occur included: installing CFLs in other light fixtures, turning off lights when not in use, and using towels to insulate areas within their homes.
- **Timing of Grant Funds Impedes PHA Projects:** To qualify for an Efficient Living Program grant, the participating PHA must commit to completing projects before the program year ends in May. Interested PHAs submit applications between June and September of the program year, receive notice of the award between December and February, and typically receive the grant funds in April or May. Because they typically cannot begin the work until the funds are received, the timing of the grant funds, in conjunction with the 12 month program cycle, limits the scope of the projects. Furthermore, it is likely that the short duration affects the types of measures that participants plan to install through the program. It is likely that participants avoid choosing to install measures that are more prone to logistical challenges such as construction delays in order to ensure that they meet the requirements of the grant agreement.
- **Barriers to Participation Exist in both Northern and Southern Illinois**: Although participation is increasing in the Efficient Living Program, barriers to participation remain. The barriers to participation are different in the northern and southern regions of the state. Northern Illinois is home to the Chicago metropolitan area where competing programs administered by the utilities exist. However, interest from Energy Service Companies (ESCO's) in the Efficient Living Program indicates program awareness is growing and that program impacts will continue to increase in the coming years. In Central and Southern Illinois the PHAs are smaller and more geographically dispersed than in the north. There are also fewer utility dollars available for the Southern part of the state, although there are fewer alternative resources for efficiency improvements available to PHAs. At the end of EPY5/GPY2, the program was under budget in the northern part of the state serviced by ComEd, and needed to request additional funding from Ameren to serve the southern and central parts of the state.
- **Realization Rates varied by Measure Type:** The realization rate for the measures implemented through the Efficient Living Program varied. For some measures, realized savings were lower than expected savings, while for others they were higher. The difference between realized and expected savings generally stemmed from the application of the Illinois Technical Reference Manual (TRM). These differences were due to a variety of factors as shown Table 2-5 and Table 2-7.

The following recommendations are offered as suggestions for the continued development of the program.

- **Continue to Leverage Public-Private Partnerships:** DCEO's energy efficiency programs have provided funding and policy instruments to reduce the barriers to energy efficiency investments, but project development and private financing are going to be necessary to

maintain the scaling-up of energy efficiency investments. An example of these types of partnerships can be found in the success that the Efficient Living Program has had in initiating partnerships between (ESCO's) and the participating PHAs. Efficient Living Staff should continue to facilitate these partnerships because they provide additional funding to facilitate efficiency improvements in PHAs. Partnerships with ESCO's may also encourage the ESCO's to further promote the incentives available through the Efficient Living Program, thereby increasing program awareness. There may also be other public-private partnerships that could be facilitated by program staff. Currently HUD is conducting demonstration programs to attract private dollars. These demonstration projects may provide a good model for how to arrange private-public partnerships for program staff to emulate.

- **Explore the Possibility of Extending the Grant Cycle to Two Years:** This will allow adequate time for PHA's to complete projects and provide program staff with the data necessary to verify the program impacts. PHAs may be more willing to implement additional efficiency improvements if they have sufficient time to complete the projects. Consequently, a longer grant cycle may increase program savings.
- **Continue to Emphasize Responsible Appliance Disposal (RAD) Credentials in the Efficient Living Program Marketing Materials and On the Program Website:** Emphasizing that it is important that appliance recyclers have RAD credentials will help encourage responsible recycling. It but will also educate PHA staff and the public on recycling best practices.
- **Create Educational Materials For Residents To Facilitate Long-Term Energy Conservation:** Residents often favor energy efficient equipment because such equipment can have financial benefits such as lower utility and maintenance costs. However, residents may know very little about the long-term benefits of energy conservation. Creating educational materials with energy-saving tips may encourage residents to participate in conservation behaviors on their own.
- **Emphasize the Importance of Matching Improvements to Original Equipment Specifications:** A mismatch between the characteristics of the installed energy efficient equipment and the replaced equipment was a source of dissatisfaction for some residents. In particular, residents reported dissatisfaction regarding refrigerators that were smaller in size and fluorescent lighting that was not as bright. Program staff should work with PHAs to emphasize the importance of matching the equipment in terms of characteristics such as size and lumens. If equipment is better matched, participants may be more satisfied with it. Greater satisfaction may encourage participants to keep equipment installed that they otherwise might be able to replace with less efficient equipment (e.g., light bulbs).

1. Introduction

This report presents the results of the impact and process evaluations of the Illinois Department of Commerce and Economic Opportunity (DCEO) Public Housing Authority Efficient Living Program. This report presents results for activity during electric program year five and natural gas program year two (EPY5/GPY2), the period June 2012 through May 2013.

1.1 Description of Program

The Efficient Living Program was designed to help improve the energy efficiency of public housing in Illinois. Applicants requesting grant funds for electricity conservation measures must do so for sites serviced by DCEO.

The Efficient Living Program is operated in partnership with the School of Architecture-Building Research Council located at the University of Illinois at Urbana-Champaign (UIUC). The program provides grants to Illinois Public Housing Authorities to fund energy efficiency improvements to public housing buildings. The program includes both retrofit and new construction and gut / rehab projects. The program is available to applicants that manage public housing authorities located in Illinois.

Eligible energy efficiency measures can be installed in common areas or in residential units. A wide variety of measures are eligible for incentive funds including exit signs, exterior and interior lighting, controls, ENERGY STAR® appliances and HVAC equipment.

Grant awards include both standard and custom components described as follows:

- The standard component incentivizes the installation or use of energy efficient lighting equipment, HVAC equipment, water heaters, motors and variable frequency drives, appliances, insulation, and duct sealing.
- The custom component incentivizes qualifying energy measures at a rate of $0.20 per projected kWh or $2.00 per projected therms saved during the first program year of operation.

Grants are capped at $350,000 and cover up to, but not exceed, 100% of the total project cost.

1.1.1 Expected kWh and Therm Savings

Expected kWh and therm savings for each utility are shown in Table 1-1 and Table 1-2. There were 209 projects completed through the program during the period June 2012 through May 2013, which were expected to provide annual savings of 6,309,668 kWh and 166,618 therms.

Table 1-1 Expected kWh Savings for Efficient Living Program by Utility

Utility	*Expected kWh Savings*
Ameren	2,278,468
ComEd	4,031,201
Total	6,309,668

Table 1-2 Expected Therm Savings for Efficient Living Program by Utility

Utility	*Expected Therm Savings*
Ameren	69,849
Nicor	80,364
North Shore	12,790
Peoples	3,615
Total	166,618

1.2 Overview of Evaluation Approach

The overall objective for the impact evaluation of the Efficient Living Program was to determine the net electric and natural gas savings and peak demand (kW) reductions resulting from program projects implemented during EPY5/GPY2.

The approach for the impact evaluation included the following main features:

- Available documentation (e.g., invoices, savings calculation work papers, etc.) was reviewed for projects, with particular attention given to the calculation procedures and documentation for savings estimates.
- Gross savings were verified via analytical desk review.

The process evaluation approach involved the following:

- Review of program documentation and prior evaluation reports;
- Focus group discussions with residents on the benefits and dislikes of the energy efficient upgrades in their units; and
- Interviews with program staff members discussing program operations, successes, challenges, and future plans.

1.3 Organization of Report

The evaluation report for the Efficient Living Program is organized as follows:

- Chapter 2 presents and discusses the analytical methods and results of estimating program savings.
- Chapter 3 presents and discusses the analytical methods and results of the process evaluation of the program.
- Chapter 4 presents evaluation conclusions and recommendations resulting from the program evaluation.
- Appendix A provides a copy of discussion topics for focus groups performed with residents.

2. Impact Evaluation

This chapter presents the results of the impact evaluation of the Public Housing Authority Efficient Living Program offered by the Illinois Department of Commerce and Economic Opportunity (DCEO). The overall objective of the impact evaluation was to determine the net electric and natural gas savings, as well as peak demand (kW) reductions resulting from program projects during the period June 2012 through May 2013. Section 2.1 describes the methodology used for estimating gross savings. Section 2.2 presents the results from the effort to estimate savings for a sample of projects.

2.1 Methodology for Calculating Program Savings

The methodology used for calculating program savings is described in this section. The overall objective for the impact evaluation of the Efficient Living Program was to determine the net electric and natural gas savings, as well as peak demand (kW) reductions resulting from projects completed during EPY5/GPY2. When applicable, the measure-level algorithms from the Illinois Statewide Technical Reference Manual (TRM) for Energy Efficiency Version 2.0 (Illinois TRM) were used to estimate savings, see Table 2-1.

Table 2-1 Illinois TRM Sections by Measure Type

Measure	*Section in Illinois TRM*	*Other Resources*
Air Conditioner	5.3.3	-
Air Conditioner Cover	N/A	Engineering review of ex ante calculations
Air Source Heat Pump	5.3.1	Engineering review of ex ante calculations
Attic / Wall Insulation	5.6.4	-
Boiler	5.3.6, 4.4.10	Engineering review of ex ante calculations, Illinois Statewide Draft TRM Version 3.0 ES Calculator
Ceiling Fan with CFLs	5.5.1	-
CFLs / Lighting	5.5.1	-
Clothes Washer	5.1.2	-
Indoor / Outdoor Reset Control	4.4.4	Engineering review of ex ante calculations
Low-Flow Faucet Aerator	5.4.4	-
Low-Flow Showerhead	5.4.5	-
Natural Gas Furnace	4.4.11	Engineering review of ex ante calculations
Occupancy Sensor	4.5.8	-
Package Terminal Heat Pump	4.4.13	-
Packaged Terminal Heat Pump Recycling Savings	-	Engineering review of ex ante calculations
Plug Load Occupancy Sensor	-	Ohio TRM
Refrigerator	5.1.6	-
Refrigerator Recycling Savings	5.1.8	-
Room Air Conditioner	5.1.7	-
Room Air Conditioner Recycling Savings	5.1.9	-
Vending Machine Controls	4.6.2	-
Water Heater	5.4.2	-

2.1.1.1. Air Conditioners

Ex post savings for air conditioners were developed using the following algorithm:

$$\Delta kWH = (FLHcool * BtuH * (1/SEERbase - 1/SEERee))/1000$$

Where,

FLHcool	=	Full load cooling hours
Btuh	=	Size of new equipment in Btuh
SEERbase	=	Seasonal energy efficiency ratio of baseline unit
SEERee	=	Seasonal energy efficiency ratio of efficient unit

2.1.1.2. Air Conditioner Cover

Air conditioner covers are not covered in the Illinois TRM. ADM reviewed the ex ante savings calculations and found them appropriate. Ex post savings for air conditioner covers were developed using the following algorithms:

$$\Delta Therms = Cf * Cd * \Delta U * Area\ in\ ft2 * HDD * (24\ hrs/day) * (1\ therm/100{,}000\ Btu) * (1/Heating\ COP)$$

Where,

$$\Delta U = 1/Rair - 1/Rcover$$

And,

$$\Delta kWh = Cf * Cd * \Delta U * Area\ in\ ft2 * HDD * (24\ hrs/day) * (1\ kWh/3{,}412\ Btu) * (1/Heating\ COP)$$

2.1.1.3. Air Source Heat Pumps

Ex post savings for air source heat pumps were developed using the following algorithms:

$$\Delta kWh = Annual\ kWh\ Savings cool + Annual\ kWh\ Savings heat$$

With,

$$Annual\ kWh\ Savings cool = (kBtu/hcool) * [(1/SEERbase) - (1/SEERee)] * EFLHcool$$

$$Annual\ kWh\ Savings heat = (kBtu/hcool) * [(1/HSPFbase) - (1/HSPFee)] * EFLHheat$$

Where,

kBtu/hcool	=	Capacity of the cooling equipment in kBtu per hour.
EFLHcool	=	Cooling mode equivalent full load hours.

EFLHheat	=	Heating mode equivalent full load hours.
SEERbase	=	Seasonal Energy Efficiency Ratio of the baseline equipment.
SEERee	=	Seasonal Energy Efficiency Ratio of the energy efficient equipment.
HSPFbase	=	Heating Seasonal Performance Factor of the baseline equipment.
HSPFee	=	Heating Seasonal Performance Factor of the energy efficient equipment.

2.1.1.4. Attic / Wall Insulation

Ex post savings were calculated using the following savings algorithm:

$$\Delta kWh = (\Delta kWh\ Cooling + \Delta kWh\ Heating) * ADJ$$

Where,

$$\Delta kWh\ Cooling = (((1/R_{old} - 1/R_{wall}) * A_{wall} * (1 - Framing\ Factor) + (1/R_{old} - 1/R_{attic}) * A_{attic} * (1\text{-}Framing\_factor/2)) * 24 * CDD * DUA) / (1000 * \eta Cool)\ and$$

$$\Delta kWh\ Heating = ((1/R_{old} - 1/R_{wall}) * A_{wall} * (1 - Framing\ Factor) + (1/R_{old} - 1/R_{attic}) * A_{attic} * (1\text{-}Framing\ Factor/2)) * 24 * HDD) / (\eta Heat * 3412)$$

ADJ	=	Adjustment to account for prescriptive engineering algorithms
Rold	=	R-value of existing assembly and any existing insulation
Rwall	=	R-value of new wall assembly
Rattic	=	R-value of new attic assembly
Awall	=	Total area of insulated wall (ft^2)
Aattic	=	Total area of insulated ceiling/attic (ft^2)
Framing Factor	=	Adjustment to account for area of framing;
CDD	=	Cooling Degree Days;
DUA	=	Discretionary Use Adjustment;
ηCool	=	Seasonal Energy Efficiency Ratio of cooling system;
HDD	=	Cooling Degree Days;
ηHeat	=	Efficiency of heating system;

2.1.1.5. Boiler

Ex post savings for commercial boilers installed in multifamily housing were developed using the following Illinois Draft TRM Version 3.0 because an error in Version 2.0 was corrected. The algorithm is as follows:

$$\Delta Therms = EFLH * Capacity * ((EfficiencyRating(actual) - EfficiencyRating(base))/ EfficiencyRating(base)) / 100{,}000$$

Where,

EFLH	=	Equivalent Full Load Hours for boiler heating
EfficiencyRating(base)	=	Baseline Boiler Efficiency Rating
EfficiencyRating(actual)	=	Efficient Boiler Efficiency Rating (actual)
Capacity	=	Nominal Heating Input Capacity Boiler size (Btuh)

For single family serving units (or smaller units), ex post calculations used the following residential boiler savings algorithm:

$$\Delta Therms = Gas\_Boiler\_Load * (1/AFUE(base) - 1/AFUE(eff)).$$

Where,

Gas boiler load	=	Estimate of annual household load for gas boiler.
AFUE(base)	=	Estimate of baseline boiler annual fuel utilization efficiency rating.
AFUE(eff)	=	Efficient boiler annual fuel utilization rating.

2.1.1.6. Ceiling Fan

x post calculations were based on the most recent version of the ENERGY STAR® calculator for fan savings and the Illinois Statewide TRM for CFLs installed with the fans. The most recent ENERGY STAR® calculator recommends annual savings of 11 kWh for the savings resulting from the fan motor. Savings for CFLs installed in the fan were estimated using the procedures in discussed in section.

2.1.1.7. CFLs / Lighting

Ex post savings for lighting were developed using the following Illinois TRM algorithm:

$$\Delta kWh = ((WattsBase - WattsEE) / 1000) * ISR * Hours * WHFe$$

Where,

WattsBase	=	Watts for baseline fixture.
WattsEE	=	Watts for energy efficient fixture.

ISR	=	In-service rate.
WHFe	=	Waste heat factor.
Hours	=	Annual hours of operation.

2.1.1.8. Clothes Washer

Ex post savings were developed using the following Illinois TRM algorithms. For electric savings,

*ΔkWh = [(Capacity * 1/MEFbase * Ncycles)*(%CWbase + (%DHWbase * %Elect_DHW) +(%Dryerbase * %Elect_Dryer)] – [(Capacity * 1/MEFeff * Ncycles) * (%CWeff + (%DHWeff * % Elect_DHW) + (%Dryereff * %Elect_Dryer)]*

For natural gas savings,

*ΔTherm = [(Capacity * 1/MEFbase * Ncycles) * ((%DHWbase * %NG_DHW * R_eff) + (%Dryerbase * %Gas _Dryer)] - [(Capacity * 1/MEFeff * Ncycles) * ((%DHWeff * %NG_DHW * R_eff) + (%Dryereff * %Gas_Dryer)] * Therm_convt*

Where,

MEFbase	=	Modified Energy Factor of baseline unit
MEFeff	=	Modified Energy Factor of efficient unit
Ncycles	=	Number of cycles per year
Capacity	=	Clothes Washer capacity of the new unit
%CW	=	Percentage of energy consumption for Clothes Washer
%DHW	=	Percentage of energy consumption for water heating
%Dryer	=	Percentage of energy consumption for dryer operation
%Elect_DHW	=	Percentage of DHW savings assume to be electric
%Elect_Dryer	=	Percentage of dryer savings assume to be electric
%NG_DHW	=	Percentage of DHW savings assume to be Natural Gas
%Gas_Dryer	=	Percentage of dryer savings assume to be Natural Gas
R_eff	=	Recovery efficiency factor
Therm_convt	=	Conversion factor from kWh to Therms

2.1.1.9. Indoor / Outdoor Reset Control

Ex post savings for indoor / outdoor reset controls were developed using the following algorithm:

*ΔTherms = Binput * SF * EFLH / (Effpre *100)*

Where,

Binput	=	Boiler Input Capacity (kBTU)
SF	=	Savings Factor = .08
EFLH	=	Equivalent Full Load Hours for heating (based on zone)
Effpre	=	Boiler efficiency

2.1.1.10. Low-Flow Faucet Aerator

Ex post savings were developed using the following algorithms:

For units with electric domestic hot water,

*ΔkWh = %ElectricDHW * ((GPM_base * L_base - GPM_low * L_low) * Household * 365.25 *DF / FPH) * EPG_electric * ISR*

For units with natural gas domestic hot water,

*ΔTherms = %FossilDHW * ((GPM_base * L_base - GPM_low * L_low) * Household * 365.25 *DF / FPH) * EPG_gas * ISR*

Where,

%ElectricDHW	=	The proportion of water heating supplied by electricity.
%FossilDHW	=	The proportion of water heating supplied by natural gas
GPM_base	=	Average flow rate, in gallons per minute, of baseline faucet.
L_base	=	Average baseline length faucet use per capita for all faucets in minutes.
GPM_low	=	Average flow rate, in gallons per minute, of the low-flow faucet aerator.
L_low	=	Average length of retrofit faucet use per capita for all faucets in minutes.
Household	=	Average number of people per household.
DF	=	The drain factor.
FPH	=	Faucets per household.

EPG_electric	=	The energy per gallon of water used by faucet supplied by electric water heater.
EPG_gas	=	The energy per gallon of water used by faucet supplied by natural gas water heater.
ISR	=	The in-service rate.

2.1.1.11. Low-Flow Showerhead

Ex post savings were developed using the following algorithms:

For electric savings,

*ΔkWh = %ElectricDHW * ((GPM_base * L_base - GPM_low * L_low) * Household * SPCD * 365.25 / SPH) * EPG_electric * ISR*

For natural gas savings,

*ΔTherms = %FossilDHW * ((GPM_base * L_base - GPM_low * L_low) * Household * SPCD * 365.25 / SPH) * EPG_gas * ISR*

Where,

%ElectricDHW	=	Proportion of water heating supplied by electricity.
%FossilDHW	=	Proportion of water heating supplied by natural gas.
GPM_base	=	Flow rate of the baseline showerhead.
L_base	=	Length of shower in minutes with baseline showerhead.
GPM_low	=	Flow rate of the low-flow showerhead.
L_low	=	Length of shower in minutes with low-flow showerhead.
Household	=	Average number of people per household.
SPCD	=	Showers per capita per day.
SPH	=	Showers per household.
EPG_electric	=	Energy per gallon of hot water supplied by electric.
EPG_gas	=	Energy per gallon of hot water supplied by natural gas.

ISR = The in-service rate.

2.1.1.12. Natural Gas Furnace

Ex post savings were developed using the following TRM algorithm:

*ΔTherms = Furnace capacity (in Btuh) * (1/AFUE(base) - 1/AFUE(eff)) * (FLHw/100,000)*

Savings calculations utilized the following inputs:

- Full load hours (FLHw) are from the commercial furnace section of the Illinois Statewide TRM;
- Annual fuel utilization efficiency (AFUE) for baseline equipment is the existing unit rated efficiency adjusted for age.
- Furnace capacity is based on installed unit capacity.

After performing an engineering review, an error was discovered in the Illinois TRM methodology. The capacity variable of the furnace savings algorithm is specified in the TRM as the input capacity of the installed unit. Based on the equation as written in the current version of the TRM, the capacity variable should be the unit's output capacity.

Ex post kWh savings for furnace motors were based on the Illinois TRM deemed values. Total kWh savings include deemed savings of 469 kWh for the furnace motor and 263 kWh for the air conditioner, if present.

2.1.1.13. Occupancy Sensor

Ex post savings were developed using the following algorithm:

*ΔkWh = KWcontrolled * Hours *ESF * WHFe*

Where,

kW controlled = The total lighting load connected to the controlled lights.

Hours = The total operating hours of the controlled lighting circuit before the lighting controls are installed.

ESF = Energy savings factor representing the percentage reduction to the operation hours from the non-controlled baseline lighting system.

WHFe = Waste heat factor.

2.1.1.1. Package Terminal Heat Pumps

Ex post savings for package terminal heat pumps were developed using the following algorithms:

$$\Delta kWh = Annual\ kWh\ Savings_{cool} + Annual\ kWh\ Savings_{heat}$$

With,

$$Annual\ kWh\ Savings_{cool} = (kBtu/hcool) * [(1/EERbase) - (1/EERee)] * EFLHcool$$

$$Annual\ kWh\ Savings_{heat} = (kBtu/hheat)/3.412 * [(1/COPbase) - (1/COPee)] * EFLHheat$$

Where,

kBtu/hcool	=	Capacity of the cooling equipment in kBtu per hour.
EFLHcool	=	Cooling mode equivalent full load hours.
EFLHheat	=	Heating mode equivalent full load hours.
EERbase	=	Energy Efficiency Ratio of the baseline equipment.
EERee	=	Energy Efficiency Ratio of the energy efficient equipment.
COPbase	=	Coefficient of performance of the baseline equipment.
COPee	=	Coefficient of performance of the energy efficient equipment.

2.1.1.2. Packaged Terminal Heat Pump Recycling Savings

The Illinois TRM does not provide a savings methodology for recycling packaged terminal heat pumps. An engineering review of ex ante calculations was performed and the calculations were deemed reasonable.

Ex post cooling savings were developed using the following algorithm:

$$\Delta kWh = FLH\_RAC * BtuH*(1/EERexist)) /1000$$

Where,

FLH_RAC	=	Full Load Cooling Hours of room air conditioning unit
BtuH	=	Size of retired unit
EERexist	=	Efficiency of existing unit = 7.7

Ex post heating savings were developed using the following algorithm:

$$\Delta kWh = (FLH\_heat/3.412) * BtuH*(1/COPexist)) /1000$$

Where,

FLH_heat = Full Load Heating Hours of packaged terminal heat pump

BtuH = Size of retired unit

COPexist = Efficiency of existing unit

2.1.1.1. Plug Load Occupancy Sensor

Ex post savings were developed using a deemed value of 102.8 from the Ohio TRM.

2.1.1.2. Refrigerators

Ex post savings were developed using the Illinois Statewide TRM. Under this methodology,

$\Delta kWh = UEC_{BASE} - UEC_{EE}$

Where,

UEC_{BASE} = Annual Unit Energy Consumption of baseline unit, and

UEC_{EE} = Annual Unit Energy Consumption of ENERGY STAR unit

Unit energy consumption can be determined by using the algorithms specified in the following table:

Table 2-2 Unit Energy Consumption of Refrigerators

Product Category	NAECA as of July 1, 2001 Maximum Energy Usage in kWh/year	Current ENERGY STAR level Maximum Energy Usage in kWh/year
1. Refrigerators and Refrigerator-freezers with manual defrost	8.82*AV+248.4	7.056*AV+198.72
2. Refrigerator-Freezer--partial automatic defrost	8.82*AV+248.4	7.056*AV+198.72
3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost	9.80*AV+276	7.84*AV+220.8
4. Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service	4.91*AV+507.5	3.928*AV+406
5. Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without through-the-door ice service	4.60*AV+459	3.68*AV+367.2
6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service	10.20*AV+356	8.16*AV+284.8
7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service	10.10*AV+406	8.08*AV+324.8

Where,

*AV = Adjusted_volume = Fresh_volume + (1.63 * Freezer_volume)*

2.1.1.3. Refrigerator Recycling Savings

Ex post savings for refrigerator recycling were based on the following Illinois TRM algorithm.

*ΔkWh = [116.84 + (Age * 10.90) + (Pre-1990 * 431.79) + (Size * 19.42) + (Single-Door * -795.37) + (Side-by-side * 426.41) + (Proportion of Primary Appliances * 170.98) + (CDD/365.25 * unconditioned * 17.34) + (HDD/365.25 *unconditioned *-11.78)] * Part Use Factor*

2.1.1.4. Room Air Conditioner

Ex post savings were developed using the following Illinois TRM algorithm:

$\Delta kWh = (Btuh/1{,}000) * (1/EERexisting - 1/EERnew) * FLH_s$

Where,

FLH_s = Full load cooling hours

EERexisting = Energy efficiency ratio of baseline equipment

EERnew = Energy efficiency ratio of efficient equipment.

Btuh = Unit capacity

2.1.1.5. Room Air Conditioner Recycling Savings

Ex post savings were developed for the recycling of old inefficient refrigerators, packaged terminal heat pumps, and room air conditioners.

For room air conditioners, ex post savings calculations were based on the following algorithm:

*ΔkWh = FLH_RAC * BtuH*(1/EERexist)) /1000*

Where,

FLH_RAC = Full Load Cooling Hours of room air conditioning unit

BtuH = Size of retired unit

EERexist = Efficiency of existing unit = 7.7

2.1.1.1. Vending Machine Controls

Ex post savings were developed using the following Illinois TRM algorithm:

*ΔkWh = WATTSbase / 1000 * HOURS * ESF*

Where,

WATTSbase = The connected watts of the vending equipment.

HOURS = The operating hours of the connected equipment.

ESF = An energy savings factor that represents the percent reduction in annual kWh of the controlled equipment.

2.1.1.2. Water Heater

Ex post therm savings for Natural Gas Water Heaters were calculated using the following algorithm:

$$\Delta Therms = (1/ EFbase - 1/EFefficient) * (GPD * 365.25 * \gamma Water * (Tout – Tin) * 1.0)/100,000$$

Where,

EFbase = Efficiency of the baseline equipment.

EF efficient = Efficiency of the new equipment.

GPD = Gallons of water used per day.

γWater = Specific weight of water.

Tout = Tank temperature.

Tin = Temperature of the incoming supply water.

2.2 Results of Impact Evaluation

This section presents the results of the impact evaluation for the Efficient Living Program during the period of June 2012 through May 2013.

2.2.1 Program-Level Savings Results

This subsection presents the gross and net savings for the Efficient Living Program. A net-to-gross factor of 100% was used because the Efficient Living Program targets low income residents.

The realized net electric savings of the Efficient Living Program during the period June 2012 through May 2013 are summarized by utility in Table 2-3 and Table 2-4. During this period, realized net electric savings were 5,440,987 kWh, and net peak demand reductions were 947.03 kW.

Table 2-3 Summary of kWh Savings by Utility

Utility	*Expected kWh Savings*	*Realized Gross kWh Savings*	*Gross Realization Rate*	*Realized Net kWh Savings**
Ameren	2,278,468	2,075,177	91%	2,075,177
ComEd	4,031,201	3,365,811	83%	3,365,811
Total	6,309,668	5,440,987	86%	5,440,987

**A net-to-gross ratio of 100% is applied because the Efficient Living Program targets low income residents who would not have funded new energy efficiency measures in the absence of the program.*

Table 2-4 Gross Realized Peak kW Savings by Utility

Utility	*Realized Gross kW Savings*	*Realized Net kW Savings**
Ameren	397.24	397.24
ComEd	549.79	549.79
Total	947.03	947.03

**A net-to-gross ratio of 100% is applied because the Efficient Living Program targets low income residents who would not have funded new energy efficiency measures in the absence of the program.*

Measure level savings and realization rates are presented in Table 2-5. For measures with low realization rates, the reason for the discrepancy between expected and realized savings is noted.

Table 2-5 Summary of kWh Savings by Measure Type

Measure	*Expected kWh Savings*	*Realized Gross kWh Savings*	*Gross Realization Rate*	*Realized Gross kW Savings*	*Source of Discrepancy*
A/C cover (electric heating)	16,263	16,263	100%	-	N/A
Air Source Heat Pumps	10,428	10,692	103%	0	Ex ante calculations used the minimum of the installed and existing unit capacities. Savings increased because the installed cooling capacity was smaller.
Attic/Ceiling Insulation	44,178	44,238	100%	1	N/A
Bi-Level Stairwell Fixtures	481,772	250,196	52%	17	Ex ante calculations used higher baseline fixture wattage than the wattage indicated in the project documentation.
CFLs	1,551,235	1,235,320	80%	149	Ex ante calculations used participant reported operating hours instead of deemed TRM deemed hours.
ENERGY STAR® Ceiling Fans	257,761	121,148	47%	12	For the fans, ex ante run hours were used from an older version of the Energy Star calculator. For the lighting, ex ante calculations used participant reported operating hours instead of TRM deemed hours.
ENERGY STAR® Refrigerators	39,350	56,923	145%	9	Ex ante calculations used adjusted volume of baseline equipment instead of adjusted volume of new equipment as per the TRM algorithm.
High Efficiency Furnace & A/C Combos	382,340	396,757	104%	196	Ex ante calculations used minimum of existing unit and efficient unit capacities instead of the efficient unit capacity.
High Efficiency Furnaces	351,568	351,568	100%	3	N/A
High Efficiency Washing Machines	6,438	2,814	44%	0	Ex ante calculations used pre-existing unit capacity for the baseline unit instead of the capacity of the newly installed unit.
High Efficiency Window A/C Units	7,419	6,134	83%	7	Ex ante calculations used the incorrect geographic location for one (large) site.
LED Exit Signs	54,454	54,454	100%	6	N/A
Low-Flow Aerators	42,764	36,585	86%	14	Ex ante calculations used deemed values for unknown locations when location of aerator was documented.
Low-Flow Shower Heads	124,597	150,227	121%	11	Ex ante calculations used different in-service rates due to a change from the TRM Version 1.0 to TRM Version 2.0 ISR value.

Measure	*Expected kWh Savings*	*Realized Gross kWh Savings*	*Gross Realization Rate*	*Realized Gross kW Savings*	*Source of Discrepancy*
Metal Halide	27,453	32,347	118%	-	N/A
Occupancy Sensors	102,313	102,313	100%	25	N/A
Outdoor Lighting	1,084	1,019	94%	-	N/A
Package Terminal Heat Pump	209,213	211,532	101%	78	N/A
Plug Load Occupancy Sensors	103	103	100%	-	N/A
Recycling (Refrigerators and Room ACs)	2,324,384	2,085,803	90%	359	Ex ante calculations for refrigerator recycling savings used an algorithm based on TRM Version 1.0 that differed from the Version 2.0 algorithm.
T8s	265,418	265,418	100%	58	N/A
Vending Machine Controls	9,133	9,133	100%	-	N/A
Total	6,309,668	5,440,987	86%	947	

**A net-to-gross ratio of 100% is applied because the Efficient Living Program targets low income residents who would not have funded new energy efficiency measures in the absence of the program.*

The realized net therm savings of the Efficient Living Program during the period June 2012 through May 2013 are summarized by utility in Table 2-6. During this period, realized net electric savings were 186,146 therms.

Table 2-6 Summary of Therm Savings by Utility

Utility	*Expected Therm Savings*	*Realized Gross Therm Savings*	*Gross Realization Rate*	*Realized Net Therm Savings**
Ameren	69,849	75,482	108%	75,482
Nicor	80,364	93,635	117%	93,635
North Shore	12,790	14,465	113%	14,465
Peoples	3,615	2,564	71%	2,564
Total	166,618	186,146	112%	186,146

**A net-to-gross ratio of 100% is applied because the Efficient Living Program targets low income residents who would not have funded new energy efficiency measures in the absence of the program.*

Measure level savings and realization rates are presented in Table 2-7. For measures with low realization rates, the reason for the discrepancy between expected and realized savings is noted.

Table 2-7 Summary of Therm Savings by Measure Type

Measure	*Expected Therm Savings*	*Realized Gross Therm Savings*	*Gross Realization Rate*	*Source of Discrepancy*
Attic/Ceiling Insulation	107	107	100%	N/A
High Efficiency Boilers	37,436	50,695	135%	Ex ante calculations applied commercial boiler algorithm to small boilers installed in single family housing, where it would be more appropriate to use the residential methodology. Ex ante calculations used unknown area type for EFLH because EFLH for multifamily was not available in TRM Version 1.0.
High Efficiency Furnace & A/C Combos	1,221	1,185	97%	N/A
High Efficiency Furnaces	72,671	76,238	105%	Ex ante calculations used the minimum of the baseline and efficient unit capacities instead of the TRM specified efficient unit capacity.
High Efficiency Water Heaters	29,443	25,982	88%	Ex ante calculations used residential water heater algorithm for large water heater instead of TRM deemed value for a commercial gas water heater. Additionally, a people served factor was included in ex ante calculations where the TRM algorithm does not include this factor.
Indoor/Outdoor Reset Controls	2,532	4,064	161%	Ex ante calculations used unknown space type for deemed EFLH because the TRM Version 1.0 did not include multifamily as a space type.
Low-Flow Aerators	7,608	9,813	129%	Ex ante calculations used unknown locations for Lbase and Llow (length faucet use) when the location of aerator was documented (bathroom or kitchen). Also, ex ante used the actual number of faucets per household (FPH) where the TRM specifies to use deemed values by space type and building type.
Low-Flow Shower Heads	14,207	16,360	115%	Ex ante calculations used the in-service rate provided in TRM Version 1.0. Ex post used the in-service rate provided in TRM 2.0.
Window A/C Covers	1,393	1,702	122%	Ex ante calculations mistakenly used the incorrect geographic location for two sites.
Total	166,618	186,146	112%	

3. Process Evaluation

This chapter presents the results of the process evaluation for the DCEO Efficient Living Public Housing Authority Program. The process evaluation focuses on the effectiveness of program policies and organization, as well as the program delivery framework. The purpose of the process evaluation is to assess the design and recent results of the program in order to determine how effectively it is achieving its intended outcomes. This evaluation is based upon analysis of program structure, focus group discussions with residents who received low energy efficiency improvements, and interviews with program staff.

The chapter begins with a discussion of the overall progress of the program, followed by an examination of certain issues that are critical to the future success of the program. This chapter also presents strategic planning and process recommendations, and highlights key findings from residents who have had energy efficient improvements. Conclusions, recommendations, and other findings from the process evaluation may be useful in conducting planning efforts for future program years.

3.1 Evaluation Objectives

The purpose of the process evaluation is to examine program operations and results, and to identify potential program improvements that may increase program efficiency or effectiveness in terms of levels of participation and program satisfaction.

Key research questions to be addressed by this evaluation of EPY5/GPY2 activity include:

> *Was the Efficient Living Program delivery effective and successful?*
>
> *Did the Efficient Living reduce barriers to increased energy efficiency project implementation?*
>
> *What non-energy benefits were realized by residents who received the energy efficiency improvements?*

During the evaluation, data and information from numerous sources are analyzed to achieve the stated research objectives. Insight into the resident experience with the Efficient Living Program is developed from focus group discussions of residents experience with the measures installed. The internal organization and operational efficiency of program delivery is examined through analysis of interviews conducted with DCEO program managers and with the DCEO's implementation partner, the School of Architecture-Building Research Council located at the University of Illinois at Urbana-Champaign (UIUC).

3.2 Summary of Primary Data Collection

The primary data collection activities completed for the program evaluation effort were as follows:

- **Resident Focus Groups:** Focus groups were conducted with residents who received energy efficient upgrades to their homes. Residents were asked the financial, comfort, safety, health, and aesthetic benefits of the upgrades as well as aspects of the measures that they disliked.

- **Program Staff Interviews:** At various times during the evaluation effort, program staff was interviewed about the program operations. Program staff responded to questions about program procedures and policies, their perception of motivation to participate in the program, and processes for tracking program activity.

- **Review of Program Documentation**: Documentation of program activities including reports, tracking data, savings calculations, the program website and informational materials were reviewed.

3.3 Summary of Conclusions and Recommendations

Resident focus group responses and interviews with program staff indicate that the Efficient Living Program is operating well and effectively delivering energy savings. The following presents a selection of key conclusions from EPY5/GPY2:

- **Energy Efficient Equipment Produced Cost Savings for Residents:** Residents of the housing facilities described several ways in which in the energy efficient upgrades produced noteworthy cost savings. Some of the cost savings resulted from decreased utility bills. Residents who received new air conditioning units and fluorescent lighting were most likely to indicate that they noticed a decrease in their electricity bills. In addition to energy cost savings, residents also noted that they saved money on the replacement costs for light bulbs. The new CFLs installed through the program have considerably longer lifetimes than the incandescent bulbs they replaced and residents mentioned that they would save money on the replacement costs as a result. Some residents indicated that they had already noticed the longer lifetime of the CFLs despite their fairly recent installation.
- **Measures Affected Perceptions of Safety, Comfort, and Convenience:** The fluorescent lighting, HVAC systems, ceiling fans, and refrigerators were most frequently noted for their effect on the residents' safety and comfort. Although residents noted the energy and maintenance cost saving benefits of the new fluorescent lighting, a number also indicated that the new lighting was not as bright and that this felt less safe. Additionally, the dimmer fluorescent lighting was an inconvenience for some residents and some indicated that bathroom lights controlled by occupancy sensors came on at night and woke them up.

  Several residents mentioned benefits stemming from the installation of energy efficient HVAC equipment. One of the perceived benefits was increased feelings of safety. The older HVAC equipment that was replaced omitted odors associated with burning gas, oil leaks, or

overheated electrical parts. The new HVAC equipment eliminated these odors. Additionally, several residents reported that their residences were more effectively heated and cooled.

Some residents also indicated that the ceiling fans improved their comfort of their homes. However, other residents also stated that the ceiling fans were too low and that they hit their heads on the fan or chain.

- **Energy Efficiency Upgrades Produced Few Changes in Behaviors:** Although many residents appreciated the energy upgrades, very few made changes in behavior as a result of those upgrades. The few behavioral changes that did occur included: installing CFLs in other light fixtures, turning off lights when not in use, and using towels to insulate areas within their homes.
- **Timing of Grant Funds Impedes PHA Projects:** To qualify for an Efficient Living Program grant, the participating PHA must commit to completing projects before the program year ends in May. Interested PHAs submit applications between June and September of the program year, receive notice of the award between December and February, and typically receive the grant funds in April or May. Because they typically cannot begin the work until the funds are received, the timing of the grant funds, in conjunction with the 12 month program cycle, limits the scope of the projects. Furthermore, it is likely that the short duration affects the types of measures that participants plan to install through the program. It is likely that participants avoid choosing to install measures that are more prone to logistical challenges such as construction delays in order to ensure that they meet the requirements of the grant agreement.
- **Barriers to Participation Exist in both Northern and Southern Illinois**: Although participation is increasing in the Efficient Living Program, barriers to participation remain. The barriers to participation are different in the northern and southern regions of the state. Northern Illinois is home to the Chicago metropolitan area where competing programs administered by the utilities exist. However, interest from Energy Service Companies (ESCO's) in the Efficient Living Program indicates program awareness is growing and that program impacts will continue to increase in the coming years. In Central and Southern Illinois the PHAs are smaller and more geographically dispersed than in the north. There are also fewer utility dollars available for the Southern part of the state, although there are fewer alternative resources for efficiency improvements available to PHAs. At the end of EPY5/GPY2, the program was under budget in the northern part of the state serviced by ComEd, and needed to request additional funding from Ameren to serve the southern and central parts of the state.
- **Realization Rates varied by Measure Type:** The realization rate for the measures implemented through the Efficient Living Program varied. For some measures, realized savings were lower than expected savings, while for others they were higher. The difference between realized and expected savings generally stemmed from the application of the Illinois TRM. These differences were due to a variety of factors as shown Table 2-5 and Table 2-7. In general, the explanations are explained by the use of different baseline equipment

specifications than called for by the TRM algorithms or not utilizing all of the information available in the project documentation.

The following recommendations are offered as suggestions for the continued development of the program.

- **Continue to Leverage Public-Private Partnerships:** DCEO's energy efficiency programs have provided funding and policy instruments to reduce the barriers to energy efficiency investments, but project development and private financing are going to be necessary to maintain the scaling-up of energy efficiency investments. An example of these types of partnerships can be found in the success that the Efficient Living Program has had in initiating partnerships between (ESCO's) and the participating PHAs. Efficient Living Staff should continue to facilitate these partnerships because they provide additional funding to facilitate efficiency improvements in PHAs. Partnerships with ESCO's may also encourage the ESCO's to further promote the incentives available through the Efficient Living Program, thereby increasing program awareness. There may also be other public-private partnerships that could be facilitated by program staff. Currently HUD is conducting demonstration programs to attract private dollars. These demonstration projects may provide a good model for how to arrange private-public partnerships for program staff to emulate.
- **Explore the Possibility of Extending the Grant Cycle to Two Years:** This will allow adequate time for PHA's to complete projects and provide program staff with the data necessary to verify the program impacts. PHAs may be more willing to implement additional efficiency improvements if they have sufficient time to complete the projects. Consequently, a longer grant cycle may increase program savings.
- **Continue to Emphasize Responsible Appliance Disposal (RAD) Credentials in the Efficient Living Program Marketing Materials and On the Program Website:** Emphasizing that it is important that appliance recyclers have RAD credentials will help encourage responsible recycling. It but will also educate PHA staff and the public on recycling best practices.
- **Create Educational Materials For Residents To Facilitate Long-Term Energy Conservation:** Residents often favor energy efficient equipment because such equipment can have financial benefits such as lower utility and maintenance costs. However, residents may know very little about the long-term benefits of energy conservation. Creating educational materials with energy-saving tips may encourage residents to participate in conservation behaviors on their own.
- **Emphasize the Importance of Matching Improvements to Original Equipment Specifications:** A mismatch between the characteristics of the installed energy efficient equipment and the replaced equipment was a source of dissatisfaction for some residents. In particular, residents reported dissatisfaction regarding refrigerators that were smaller in size and fluorescent lighting that was not as bright. Program staff should work with PHAs to emphasize the importance of matching the equipment in terms of characteristics such as size and lumens. If equipment is better matched, participants may be more satisfied with it.

Greater satisfaction may encourage participants to keep equipment installed that they otherwise might be able to replace with less efficient equipment (e.g., light bulbs).

3.4 Public Housing Authority Efficient Living Program

The Public Housing Authority Efficient Living Program (Efficient Living Program) is operated in partnership with the School of Architecture-Building Research Council located at the University of Illinois at Urbana-Champaign (UIUC). The program provides grants to Illinois Public Housing Authorities to make energy efficiency improvements to public housing buildings. The program includes both retrofit and new construction and gut / rehab projects.

3.4.1.1. Participant and Measure Eligibility Requirements

The program is available to Illinois PHAs that house residences at 30%, 50% or 80% of the average median income. Average median incomes are defined by the individual counties where the properties are located.

The program covers a wide variety of energy saving measures including efficient appliances, lighting, and HVAC equipment. Grant funds may not be used for fuel switching, personnel expenses, purchase of property, operating expenses, projects that repair existing equipment or replace existing equipment with the same equipment, used equipment, or custom projects with simple paybacks greater than the equipment life.

3.4.1.2. Program Incentives

Grant awards include standard and custom components described as follows:

- Standard incentives, which are payments for the installation or use of energy efficient lighting equipment, HVAC equipment, water heaters, motors and variable frequency drives, appliances, insulation, and duct sealing;
- Custom incentives, which are payments for qualifying energy measures at a rate of $0.20 per projected kWh or $2.00 per projected therm saved during the first program year of operation.

Grants are capped at $350,000 and cannot exceed 100% of the total project cost.

3.4.1.3. Program Participation Process

Applying and receiving a grant through the program is a multistep process. Applicants begin by completing and signing an application to receive grant funds. Upon review of the applications, a conference call is scheduled with the applicant to review the details of the proposal. The conference call informs the final determination of the projects scope and advises on necessary equipment replacement inventory which will be used to determine the final grant award. This information is reviewed by program staff who issues a Pre-Award Letter once all inventory of existing equipment has been submitted. Program staff determines which items are eligible for replacement based on program guidelines. A Sub Award Agreement is then sent to the applicant; it lists specific eligible measures with corresponding award amounts and payment

terms. Once the grant amounts are determined the program staff and participants wait for funds to be allocated and for grant dollars to become available. Upon receipt of grant funds, the grantee installs the energy efficiency measures and reports the final installation costs to program staff.

3.4.1.4. Reporting and Verification

Program tracking data is maintained in a series of spreadsheets. Grantees submit documents that identify what measures were installed, building locations, and a certification of proper disposal of refrigerators and window air conditioning units, when applicable. Additionally, invoices for measures implemented are submitted. Program staff uses this information to determine measure costs, numbers installed, and to estimate savings. A program staff member enters this information into the DCEO's tracking database.

Quality assurance site visits occur during the summer months. Program staff visits every PHA that participated to verify measure installation and get feedback from PHA staff about residents' perceptions of the energy efficiency improvements. Photographs are taken by either the program staff or by PHA staff. The results of the site visits are combined into an annual quality assurance report and submitted to DCEO by the end of the fiscal year.

3.5 Public Housing Authority Efficient Living Program Grant Recipient Expected Savings

During EPY5/GPY2, 29 public housing authorities received grant funds through the Efficient Living Program. An additional two housing authorities applied for funds and then withdrew their applications. In total 42 sub grants were awarded including 26 electric grants and 16 natural gas grants.

As shown in

Table 3-1, a variety of building types received energy efficiency measures during EPY5/GPY2. The majority of sites were multifamily housing.

Table 3-1 Building Types Receiving Energy Efficiency Measures

Building Type	*Number of Sites*	*Total Units*
High-Rise (7+ Floors)	25	2,609
Mid-Rise (4-6 Floors)	13	1,226
Low-Rise (2-3 Floors)	21	974
Row Homes, Garden Apts.	256	1,858
Duplexes	157	314
3-Plexes & 4-Plexes	33	129
Offices, Community Centers., Warehouses	2	2
Scatter Sites (Single Family)	298	298
Total	805	7,410

Source: Efficient Living: Illinois Public Housing Authority Energy: Program Year Five Final Reports

Table 3-2 displays the age of the housing stock that received efficiency upgrades through the Efficient Living Program. The buildings that received upgrades were generally older. The majority of residences were older than 30 years.

Table 3-2 Housing Age for Buildings Receiving Energy Efficiency Measures

Housing Age (Years)	*Number of Sites*	*Total Units*
0 - 20	35	98
21 - 30	15	187
31 - 40	376	2,167
41 +	377	4,956
Unknown	2	2
Total	805	7,410

Source: Efficient Living: Illinois Public Housing Authority Energy: Program Year Five Final Reports

Table 3-3 presents the expected kWh and therm savings for projects completed by each of the PHAs that participated in the Efficient Living Program during EPY5/GPY2.

Table 3-3 Expected kWh and Therm Savings by Participating Public Housing Authority

Public Housing Authority	*Expected kWh Savings*	*Expected Therm Savings*
Aurora	96,000	7,875
Bloomington	-	30,670
Calhoun County	72,395	5,365
CHA	67,317	3,615
City of Danville	497,056	-
City of Elgin	961,360	-
City of Freeport	365,243	16,379
City of Marion	-	1,661
City of Rockford	1,181,848	-
Decatur	115,236	31,496
DeKalb	553,845	-
Franklin County	115,721	-
Fulton County	162,185	6,833
Greene County	-	4,209
Jackson County	49,709	-
Jo Daviess	-	13,508
Knox County	38,640	5,923
Lee County	48,752	6,567
Macoupin County	155,846	11,592
Mt. Vernon	21,063	-
North Chicago	487,098	12,790
Peoria	42,994	-
Pike County	270,872	-

Public Housing Authority	*Expected kWh Savings*	*Expected Therm Savings*
Pope County	-	1,163
Saline County	47,656	-
St. Clair County	105,417	6,972
Vermillion County	533,601	-
Warren County	50,077	-
Winnebago County	269,737	-
Total	6,309,668	166,618

3.6 Resident Outcomes

A series of six focus groups were conducted with residents from PHA facilities that received DCEO grants for energy efficiency upgrades during EPY5/GPY2. Each focus group was conducted on-site at the PHA facility with approximately four to twelve residents. Group discussions lasted 60 to 90 minutes and were facilitated by a professional focus group moderator. Focus groups were conducted in October through November 2013.

3.6.1 Observed Differences of Upgrades

Residents noted several differences between the new product and the version it was replacing. For example, some of the bulbs installed had a pin base instead of the traditional screw base. This difference made replacing the bulbs more challenging and more expensive for residents.

Other residents noted that the refrigerator they received was noticeably smaller than their older refrigerator. Consequently, they had to change their food storage habits as a result of the new appliance. One resident elaborated:

> *I had the fridge, which I didn't like either because that fridge was so small compared to what I had. That fridge and the vegetable drawer literally was half of what we had…I was disappointed in the features, the quality and the quantity of the features of the refrigerator. It was much smaller.*

Many residents noted that the new bulbs tended to last longer. They also noticed that, while the bulbs were often dimmer, they slowly became brighter after a few minutes.

> *The light bulbs are really nice…some good light bulbs….lasts a long time.*
>
> *They replaced the bulbs after that I haven't replaced a light bulb since they put them in. And the old light bulbs, standard light bulbs, very short life, obviously, higher consumption if you run them. And something I mentioned when I first noticed that they didn't seem to be as bright, I didn't realize it. Larry told me the longer they stay on, the brighter they get.*

3.6.2 Effects of Energy Efficient Upgrades on Finances

Residents commented on the energy savings aspects of the efficiency improvements. Most residents stated that they had not seen effects of the energy efficiency upgrades on their monthly

finances. However, many have not had the upgrades long enough to have had time to notice any changes.

A few residents, especially those with new A/C units, noticed monthly savings on their electricity bills. Other residents installed CFLs throughout their apartment also noticed small savings in their monthly bills.

> *And then the air conditioner- the new air conditioner and the fans and everything, it's just the whole thing saves me money. And I'm all for that.*

> *They changed the lights up in our apartment, my bill went from 30-some dollars down to 19 now. So they really did a good job there.*

Residents with the CFLs commented that, while the bulbs are more expensive, they do not have to be replaced as often, which saves them money.

> *I think one thing we're forgetting when you ask about have we noticed any change is the fact that we forget how much we spend on the old incandescent bulbs over a year's period. And now with the newer bulbs, it costs us a little more to put them in, but we don't have that added expense every two or three months that we had before and we just forget about it because we're not doing it.*

3.6.3 Effects of Energy Efficiency Measures on Comfort

When asked about the effects of the energy efficient equipment on comfort levels, the most common complaint from residents who received the CFLs was that the new bulbs are dimmer than the old bulbs. Especially in the bathrooms, male residents complained that the new bulbs are not bright enough for shaving.

> *And I like the fluorescents. I had to get used to them because they were dimmer than the regular light bulb and stuff.*

> *I think they're okay except they're not as bright and I can't use them in the bathroom over my mirror. I have to have good light to shave.*

Residents who received new A/C units or new furnaces were very complimentary. They believed the new units improved their ability to control the temperature indoors; which made their home more comfortable.

> *Well before we had to have window units in the summer our living room would get freezing cold and then my mother's bedroom, which is in the back would be frying hot. And now with central air it's all nice and cool.*

The new high efficiency furnaces are smaller and have created additional space for living or storage.

It's [the furnace] given us more space. The first thing somebody said was the pipes, but now that we've gotten used to them, there is more room.

Residents felt that the new ceiling fans have made their bedrooms, more comfortable at night.

They put the energy ceiling fan, they put it in my bedroom, which I like it better because sleeping at night it makes me more comfortable.

3.6.4 Effects of Energy Efficient Upgrades on Safety and Security

When asked about feelings of safety and security as a result of the new energy efficient measures, several residents expressed concerns that the front porch light was not bright enough to create a secure atmosphere on their property. Likewise, participants complained that the exterior lights using CFLs or LEDs were not bright enough for them to feel that the property is safe.

Residents with new furnaces believed the upgrade also made them feel safer in their homes. A few complained that they had smelled gas from the old furnace, but have not experienced the same with their new furnaces.

The only thing I can think of like with the older one, there would be a lot of times when you would smell gas and stuff in there. And I haven't noticed any gas smell in there since we got the new [furnace] in there. That could be both a health hazard and it could explode. So I mean I've noticed that with the safety.

A few residents complained that the new ceiling fans are too low for taller residents; they often hit their heads or hands on the fan or on the pull cords.

It [the fan] is lower so I mean I have to watch out, but for someone who is a little shorter it might make it a little easier to access the fan cords.

3.6.5 Effects of Energy Efficient Upgrades on Health and Sleep

HVAC upgrades have improved the lives of many residents. Residents indicated that the new furnaces and A/C units filter dust more efficiently, which improves their indoor air quality. As a result residents felt healthier, were sleeping better, and were generally happy with the efficiency improvements. Some even noticed a difference in the cleanliness of their living space.

I breathe better. Because the old furnace, it was putting out like really dry heat.

I have asthma and I haven't had any problems really since with the new one as I much as I do with the old one.

I can sleep, it's great for me. You know, because I have insomnia but that air – but them putting in central air it helps me sleep so much better.

One of my main benefits is I have been able to sleep when it's hot. With the central air on I was able to sleep. You can't sleep while it's too hot. It is relaxing.

I think it's cleaner. It's a lot cleaner. And like I said, not the dust. From the old furnace, it was a lot of dust and lint. And that's pretty dangerous too with the lint."

Residents complained about the bathroom light sensors causing the overhead lights to turn on in the middle of the night; making it difficult for the residents to go back to sleep easily.

I don't like the sensors because if I get up in the middle of the night and I don't have it taped up, the overhead light above the sink comes on and it's real bright, two fluorescent lights. And I don't need a bright fluorescent two lights on in the middle of the night when I'm trying to go to the bathroom and it blinds you and you can't get back asleep because you're wide awake again.

3.6.6 Effects of Energy Efficient Upgrades on Noise Level

Residents identified positive and negative effects of the upgrades on the noise level in their homes. Residents primarily commented on the noise levels of their refrigerators, fans, and furnaces. While some residents complained that their furnace was loud, others explained that their new furnaces were much quieter than their old ones.

The new fridge makes more noise than my old one did… [I check] my door and see if anyone is there. I'm like who is knocking?

The bedroom fan, I turned it on and went to sleep and I've got an earache from that fan.

From the old fans to the new ones, definitely [quieter]. The new ones are very quiet.

It's kind of loud. It's just a sort of get-used-to-it thing.

The sound [of the new furnace] is wonderful. It's a lot better. Basically now, all you hear is a click to click on [the new furnace] and that's all you hear.

Whenever the older one would kick in, it almost sounded like a vehicle running or something a lot of the times. And now, I mean the only thing you can hear is that little bit of the air blowing out. That's all you can hear.

3.6.7 Effects of Energy Efficient Upgrades on Home Décor

Residents agree that the light fixtures chosen were a positive addition to the décor of the apartment. Most also liked the ceiling fans and the new look.

My daughter came home and said, 'Oh, they got new lights, why'd they do that, but they're cute.' So they look nice, they really do. They complement the apartment.

I always say, 'Oh, come on in the bedroom and look at my new fan we've got.' I think it's wonderful.

Some residents complained that their kitchen is not bright enough after the new lights were installed. They want the kitchen to look brighter.

> *But I must admit, I was at somebody's apartment and she had- she must have asked for the bigger bulbs because her kitchen is real bright and I miss that.*
>
> *I guess I have to get in the habit of turning on the light over the stove because it's really dark in there. When you're cooking, if you don't turn on all the lights then you can't really see how clean the kitchen floor is.*
>
> *It's a little dark back there, because of the new lights. I need a light back there just to see the plug in the wall so I could plug something in. I mean like a toaster… I would either have to use a flashlight or something to get light back there.*

3.6.8 Effect of Energy Efficient Upgrades on Energy Usage Behavior

Upgrades have had limited impact on residents' other energy usage behaviors. Some have upgraded to CFLs in other light fixtures. Others have recommended CFLs to friends or family members.

> *I'm very satisfied and I think I've learned one thing, to go around and replace my lamps. If these bulbs truly last longer, I'm very much interested in doing that….*
>
> *I did get my daughter to change her light bulbs. My brother did his too at his place. I recommend them...I'm very satisfied with my apartment and my lights and everything like that. To me, I don't think I've used as much with these as I did with the others. And that's why I recommended them to my brother and he agrees with me too. He liked them in his house. He put them all in his house.*

More generally, residents noted a few energy savings habits, primarily driven by a desire to save money or maintain their comfort. Typically, residents will be careful about turning off lights and will also use towels or other materials to insulate windows or around their A/C units.

> *From what I've watched too is if you're conscientious and you turn the light switch off like you should and I do so I can save the replacement cycle on my lights in my bathroom. So I turn them off every time when I go out and on when I go back in again. So I'm trying to be conservative that way.*
>
> *Now I've got two [A/C covers]. So what really helps is put one on the outside, put the other one on the inside. I'll tell you that really does help. You know what I put on my inside? I put a towel and I drape a towel over the front of my air conditioner. And it saves on the cold air.*
>
> *I don't know, but I always turn my lights off. If I'm in a room and I leave the room, I make sure the light's off.*

3.7 Program Operations Perspective

ADM staff conducted interviews with the two key program staff at the School of Architecture, Building Research Council who are responsible for administering and implementing DCEO's Efficient Living Program. The interviews were designed to explore trends in program uptake, understand barriers to participation, and understand project tracking and verification procedures. The following summary highlights primary findings from those interviews.

3.7.1 Summary of Interview Findings

Key trends and issues addressed by respondents include:

- **Prominence of Energy Service Companies (ESCOs)**: DCEO's Efficient Living Program has drawn attention to a well-established, yet underserved sector of the Low Income Housing market. Due to the aggregated nature of the living units, PHAs are an ideal candidate for the broad range of energy savings projects and funding strategies offered by ESCOs. The DCEO grant funds in combination with the ESCO services are a way for the Efficient Living Program to diversify its capital sources and make a greater impact on the PHAs of Illinois. Feedback from staff indicated that several PHAs are committed to using ESCOs for the upcoming program year.
- **Low Participation in ComEd Service Territory:** ComEd administers the Multi-Family Comprehensive Energy Efficiency Program (MCEEP). According to staff interviewed, this program has a greater visibility in the Chicago metropolitan area and competes directly with the DCEO's Efficient Living Program. Also competing with the Efficient Living Program are other private funding sources that are critical to the financing strategies of HUD. These private financers invest in the projects to supply capital while taking advantage of the tax equity created. While staff indicated that program awareness is increasing; reaching the appropriate audience in the Northern Illinois remains a challenge. Conversely, Southern Illinois participation is steadily increasing; a region where there seems to be a greater need and fewer financial resources for efficiency improvements. During EPY5/GPY2, some ComEd grant funds had to be returned to DCEO due to low participation, while additional Ameren dollars were needed.
- **Timing of Grant Payments Resulted in Planning Uncertainties and Project Delays:** Staff indicated that the majority of grant funds were not available until the second quarter of the fiscal year in EPY5/GPY2 (April 2013 – May 2013). The pre-award letters were issued between December 2012 and February 2013. PHAs that received award letters used the time between notice of the award and receipt of the funds to elicit bids from contractors and approve the project scope. However, most PHAs will not begin work until the first grant funds are received, which leaves approximately six to eight weeks to complete the work on-site. PHAs are required to purchase all the equipment by the end of the program year. Installation may continue beyond the end of the program year. Additionally, most of the projects include some degree of HVAC work, which can only be completed when air temperatures are less extreme.

- **Equipment is Recycled to Permanently Remove it From the Grid:** The Efficient Living Program currently requires the recycling of any equipment that contains Freon such as air conditioners, refrigeration, and packaged terminal heat pumps. The use of companies that are RAD (Responsible Appliance Disposal) certified is highly recommended, although not all PHAs have access to a RAD certified contractor in their area. Responsible recycling of equipment to remove old, out-of-date equipment from the grid is critical to the success of the program and to ensure the expected energy savings are achieved.
- **Several Outreach Events Held During the Program Year:** Efficient Living Program staff hosted 13 events during EPY5/GPY2. These events are targeted at PHA administrators, city officials, and trade allies. The purpose of these events is to provide education about energy efficiency and increase awareness of the program. EPY5/GPY2 outreach activity increased slightly from EPY4/GPY1. Table 3-4 is a list of outreach activities for EPY5/GPY2.

Table 3-4 Public Housing Authority EPY5/GPY2 Program Outreach Efforts

Date	*Location*	*Outreach/ Training Title*
7/20/2012	Rend Lake, IL	New Technology Lighting Demonstration
8/16/2012	Springfield, IL	NAHRO 2012 Annual Meeting – Program Year 5 Guidelines and Application
10/6/2012	Chicago ,IL	Retrofitting Rental: Energy Savings and Multifamily Housing
11/15/2012	Springfield, IL	Trade Ally Trade Show- Program Year 5 Guidelines and Incentives
1/18/2013	Mount Vernon, IL	ECHO (IL Southern Council of Housing Authorities) meeting: Program Year 5 Guidelines and Application
2/20/2013	Rosemont, IL	Trade Ally Trade Show- Program Year 5 Guidelines and Incentives
2/25/2013	Kankakee, IL	Lunch & Learn: HUD's Energy Efficiency Initiatives, Update on Program Year 5 Guidelines and Incentives
3/4/2013	Rockford, IL	Lunch & Learn: HUD's Energy Efficiency Initiatives, Update on Program Year 5 Guidelines and Incentives
4/25/2013	Chicago ,IL	Private Financing for PHA and Assisted Housing: Round Table Discussion
5/30/2013	Oak Brook, IL	Trade Ally Rally
4/17-18/2013	Decatur, IL	IAHA 2013 Maintenance Management Clinic
4/23-24/2013	Chicago, IL	2013 Illinois Governor's Conference on Affordable Housing
7/23-24/12	Chicago, IL	ESCO Training

4. Conclusions and Recommendations

The interviews and focus groups that were conducted provide perspective on the operations of the Efficient Living Program. The findings suggest that the program is operating effectively and that staff are focused on its continual improvement. Focus group responses provided insight into the benefits of the efficiency measures and aspects of the measures that were disliked. These efficiency measures not only reduce energy demand, but also reduce public housing authorities operating costs and generally improved living conditions for residents.

4.1 Key Conclusions

The following presents a selection of key conclusions from electric program year five and gas program year two (EPY5/GPY2):

- **Energy Efficient Equipment Produced Cost Savings for Residents:** Residents of the housing facilities described several ways in which in the energy efficient upgrades produced noteworthy cost savings. Some of the cost savings resulted from decreased utility bills. Residents who received new air conditioning units and fluorescent lighting were most likely to indicate that they noticed a decrease in their electricity bills. In addition to energy cost savings, residents also noted that they saved money on the replacement costs for light bulbs. The new CFLs installed through the program have considerably longer lifetimes than the incandescent bulbs they replaced and residents mentioned that they would save money on the replacement costs as a result. Some residents indicated that they had already noticed the longer lifetime of the CFLs despite their fairly recent installation.
- **Measures Affected Perceptions of Safety, Comfort, and Convenience:** The fluorescent lighting, HVAC systems, ceiling fans, and refrigerators were most frequently noted for their effect on the residents' safety and comfort. Although residents noted the energy and maintenance cost saving benefits of the new fluorescent lighting, a number also indicated that the new lighting was not as bright and that this felt less safe. Additionally, the dimmer fluorescent lighting was an inconvenience for some residents and some indicated that bathroom lights controlled by occupancy sensors came on at night and woke them up.

  Several residents mentioned benefits stemming from the installation of energy efficient HVAC equipment. One of the perceived benefits was increased feelings of safety. The older HVAC equipment that was replaced omitted odors associated with burning gas, oil leaks, or overheated electrical parts. The new HVAC equipment eliminated these odors. Additionally, several residents reported that their residences were more effectively heated and cooled.

  Some residents also indicated that the ceiling fans improved their comfort of their homes. However, other residents also stated that the ceiling fans were too low and that they hit their heads on the fan or chain.
- **Energy Efficiency Upgrades Produced Few Changes in Behaviors:** Although many residents appreciated the energy upgrades, very few made changes in behavior as a result of those upgrades. The few behavioral changes that did occur included: installing CFLs in other

light fixtures, turning off lights when not in use, and using towels to insulate areas within their homes.

- **Timing of Grant Funds Impedes PHA Projects:** To qualify for an Efficient Living Program grant, the participating PHA must commit to completing projects before the program year ends in May. Interested PHAs submit applications between June and September of the program year, receive notice of the award between December and February, and typically receive the grant funds in April or May. Because they typically cannot begin the work until the funds are received, the timing of the grant funds, in conjunction with the 12 month program cycle, limits the scope of the projects. Furthermore, it is likely that the short duration affects the types of measures that participants plan to install through the program. It is likely that participants avoid choosing to install measures that are more prone to logistical challenges such as construction delays in order to ensure that they meet the requirements of the grant agreement.
- **Barriers to Participation Exist in both Northern and Southern Illinois**: Although participation is increasing in the Efficient Living Program, barriers to participation remain. The barriers to participation are different in the northern and southern regions of the state. Northern Illinois is home to the Chicago metropolitan area where competing programs administered by the utilities exist. However, interest from Energy Service Companies (ESCO's) in the Efficient Living Program indicates program awareness is growing and that program impacts will continue to increase in the coming years. In Central and Southern Illinois the PHAs are smaller and more geographically dispersed than in the north. There are also fewer utility dollars available for the Southern part of the state, although there are fewer alternative resources for efficiency improvements available to PHAs. At the end of EPY5/GPY2, the program was under budget in the northern part of the state serviced by ComEd, and needed to request additional funding from Ameren to serve the southern and central parts of the state.
- **Realization Rates varied by Measure Type:** The realization rate for the measures implemented through the Efficient Living Program varied. For some measures, realized savings were lower than expected savings, while for others they were higher. The difference between realized and expected savings generally stemmed from the application of the Illinois TRM. These differences were due to a variety of factors as shown Table 2-5 and Table 2-7. In general, the explanations are explained by the use of different baseline equipment specifications than called for by the TRM algorithms or not utilizing all of the information available in the project documentation.

4.2 Program Recommendations

The following recommendations are offered as suggestions for the continual development of the program.

- **Continue to Leverage Public-Private Partnerships:** DCEO's energy efficiency programs have provided funding and policy instruments to reduce the barriers to energy efficiency

investments, but project development and private financing are going to be necessary to maintain the scaling-up of energy efficiency investments. An example of these types of partnerships can be found in the success that the Efficient Living Program has had in initiating partnerships between (ESCO's) and the participating PHAs. Efficient Living Staff should continue to facilitate these partnerships because they provide additional funding to facilitate efficiency improvements in PHAs. Partnerships with ESCO's may also encourage the ESCO's to further promote the incentives available through the Efficient Living Program, thereby increasing program awareness. There may also be other public-private partnerships that could be facilitated by program staff. Currently HUD is conducting demonstration programs to attract private dollars. These demonstration projects may provide a good model for how to arrange private-public partnerships for program staff to emulate.

- **Explore the Possibility of Extending the Grant Cycle to Two Years:** This will allow adequate time for PHA's to complete projects and provide program staff with the data necessary to verify the program impacts. PHAs may be more willing to implement additional efficiency improvements if they have sufficient time to complete the projects. Consequently, a longer grant cycle may increase program savings.
- **Continue to Emphasize Responsible Appliance Disposal (RAD) Credentials in the Efficient Living Program Marketing Materials and On the Program Website:** Emphasizing that it is important that appliance recyclers have RAD credentials will help encourage responsible recycling. It but will also educate PHA staff and the public on recycling best practices.
- **Create Educational Materials For Residents To Facilitate Long-Term Energy Conservation:** Residents often favor energy efficient equipment because such equipment can have financial benefits such as lower utility and maintenance costs. However, residents may know very little about the long-term benefits of energy conservation. Creating educational materials with energy-saving tips may encourage residents to participate in conservation behaviors on their own.
- **Emphasize the Importance of Matching Improvements to Original Equipment Specifications:** A mismatch between the characteristics of the installed energy efficient equipment and the replaced equipment was a source of dissatisfaction for some residents. In particular, residents reported dissatisfaction regarding refrigerators that were smaller in size and fluorescent lighting that was not as bright. Program staff should work with PHAs to emphasize the importance of matching the equipment in terms of characteristics such as size and lumens. If equipment is better matched, participants may be more satisfied with it. Greater satisfaction may encourage participants to keep equipment installed that they otherwise might be able to replace with less efficient equipment (e.g., light bulbs).

Appendix A: Resident Focus Group Topics

Introductions & Rules *10 minutes*	Today we're going to be talking about something that you all have in common – energy efficiency upgrades! Who doesn't love upgrades! Before we go through some of the ground rules for our discussion, let's go around the table and introduce yourself. Please tell us a little about yourself, how long you have lived here, and other than the upgrades, what steps you do to help save energy. Ground Rules: • Sharing opinions – No right or wrong answers • Everyone needs to participate • Be polite – no side conversations; don't interrupt • My job as moderator is to keep us on time and on topic • Audio recording
Energy Efficiency in General *15 minutes*	Let's start by talking about energy efficiency in general. What words come to mind when you hear the words "energy efficiency?" • What products are or can be energy efficient in your home? • What benefits do energy efficient products have for you? *[Probe: comfort, finances, safety, health, noise, looks]*

Improvements in Your Home
 	
20 minutes
	What improvements have been made in your homes? *[Probe list]*
	• What is your overall opinion of the improvements? Like best? Dislike?
	• How are the new appliances different than the ones they replaced?
	• *[New features (remotes, timers, temp control]* – What is your opinion of the new features?
	• Overall, how satisfied are you with the improvements?
	  • What are you most satisfied with?
	  • What don't you like about the improvements?
	  • Have you removed any of the new equipment?
	• What have you told other people about the changes?
	• What maintenance have you had to do on the new equipment?
	• What differences have you seen in the reliability of the new

	equipment?

Product Performance
 	
30 minutes
	Overall, how do you think the new equipment performs compared to the old equipment? How is it better/worse?
	
	What benefits have you seen from the new appliances? *[Probe: comfort, finances, safety, health, noise, looks]*
	
	How have the changes affected…
	• Comfort:
	  • How affected comfort of your home?
	  • Which had biggest impact on home comfort?
	• Finances:
	  • Easier to pay utility or other bills?
	  • Do you have more/less money left over each month than before the improvements?
	• Safety
	  • How have they affected the safety of your home?
	• Health
	  • What health benefits have you seen in your home?
	  • How have the improvements affected your health?
	• Noise
	  • What changes to the noise level have you noticed?
	  • How does the noise level compare of the new vs old appliances?
	  • Any differences in street noise, wind noise?
	• Looks of your home
	  • How affected the looks of your home?
	  • What have guests said about it?
	  • Have the improvements affected the about the about of space?

Other Behaviors *5 minutes*	Have you noticed any other changes in the ways you are using energy since the energy efficiency improvements were installed? More aware of energy usage? Changes to your energy usage?
Wrap-Up	That's all the questions I have. Is there anything else you think we ought to know?