Energy Efficient Products Program
Evaluation, Measurement, and Verification Report
2015 Participants

Prepared for FirstEnergy Ohio Companies:

Ohio Edison Company
The Cleveland Electric Illuminating Company
The Toledo Edison Company

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1. Executive Summary

In 2014, the Ohio operating companies The Cleveland Electric Illuminating Company ("CEI"), Ohio Edison Company ("OE"), and The Toledo Edison Company ("TE") (collectively "Companies") offered the Energy Efficient Products ("EEP") Program. Through this program, rebates are provided to residential customers to encourage the purchase and installation of energy efficient appliances, heating, ventilation and air conditioning (HVAC) services and equipment. In addition there is an upstream portion of the program where manufacturers are paid to reduce the price of energy efficient lighting and a mid-stream portion where retailers are incented to encourage the sale of energy efficient consumer electronics products. The program was administered by Honeywell, who worked with lighting manufacturers, retailers and HVAC contractors to implement the program.

The program was suspended in 2015 pursuant to the Companies filing and Commission approval of an amended Plan for the 2015-2016 program years.[1] In order to honor outstanding commitments to EEP Program participants from 2014, the Companies allowed participants to submit applications for 2014 rebates during the first quarter of 2015 (2015 Participants). During 2015, ADM performed measurement and verification activities for the 2014 EEP participants with savings reported in 2015.

Table 1-1 shows participation by measure category for each of the companies. For the Appliances and HVAC subprograms, the count shown is unique project numbers. For the Consumer Electronics subprogram, the count shown is the number of qualifying products sold. For the Lighting subprogram, the count shown is individual bulbs or fixtures distributed.

Table 1-1. 2015 Participants by Subprogram

Measure Type	*CEI*	*OE*	*TE*	*Total*
Appliances	1,312	1,860	407	3,579
HVAC	279	427	158	864
Consumer Electronics	10,309	8,076	2,941	21,326
Lighting	108,450	94,542	28,316	231,308

Expected and verified gross energy savings (kWh) and peak demand reductions (kW) for the program in the three service territories are reported in Table 1-2.

[1] See *In the Matter of the Application for Approval of Energy Efficiency and Peak Demand Reduction Program Portfolio Plans for 2013-2015*, Case Nos. 12-2190-EL-POR *et al.,* November 20, 2014 Finding and Order.

Table 1-2. Impact Evaluation Results for the EE Products Program 2015 Participants

Utility	*Ex Ante Expected Savings*		*Ex Post Verified Total Savings*		*Realization Rates*	
	kWh	*kW*	*kWh*	*kW*	*kWh*	*kW*
CEI	6,509,844	870	6,645,378	924	102%	106%
OE	6,740,208	932	7,089,500	1,008	105%	108%
TE	1,894,266	284	2,027,706	303	107%	107%
Total	15,144,317	2,086	15,762,584	2,234	104%	107%

The results in Table 1-2 show a realization rate for kWh savings of approximately 104%, as determined by the ratio of verified total kWh savings to expected kWh savings. The realization rate for kW reductions was approximately 107%. The realization rates are slightly greater than 100% because of use of blended *ex ante* values in the HVAC subprogram and LED portion of the lighting subprogram and a conservative ex ante assumption of dehumidifier capacity in the appliance subprogram.

The *ex ante* and *ex post* kWh savings and realization rates for each measure category are presented in Table 1-3.

Table 1-3. Overall Evaluation Results by Measure Type

Measure Type	*Ex Ante Expected Savings*		*Ex Post Verified Savings*		*kWh RR*	*kW RR*
	kWh	*kW*	*kWh*	*kW*		
Appliances	2,046,080	332	2,063,016	340	101%	102%
HVAC	1,111,705	426	1,633,036	432	147%	101%
Consumer Electronics	604,322	92	635,596	96	105%	104%
Lighting	11,382,210	1,236	11,430,935	1,367	100%	111%
Total	15,144,317	2,086	15,762,584	2,234	104%	107%

2. Introduction and Purpose of Study

Under contract with the Companies, ADM performed evaluation, measurement, and verification (EM&V) services to determine and verify the savings being realized through the EEP Program from participants counted in 2015. This document is the final report on the EM&V for the program. The choice of procedures that was used to perform the EM&V activities has been formed by the State of Ohio Energy Efficiency Technical Reference Manual[2] ("TRM") and ADM's experience in evaluating the prior program years. In addition, the procedures chosen build on information collected from ongoing discussions with the Companies' staff.

The impact evaluation estimates annual gross energy savings and peak demand reduction as framed by the following four research questions:

- How many products and services were sold?
- What is the average annual kWh savings per incentivized product or service?
- What is the average kW reduction per incentivized product or service?
- What fraction of incentivized products or services did not meet program standards?

[2] Vermont Energy Investment Corporation (VEIC), *State of Ohio Energy Efficiency Technical Reference Manual,* Prepared for Public Utilities Commission of Ohio, August 6, 2010.

3. Description of Program

The Companies began to offer the EEP Program to residential customers in 2011. The program offered rebates, product markdowns and incentives through partnerships with lighting, electronics, and appliance retailers and HVAC contractors throughout the Companies' service area.

The EEP Program was designed to provide customer rebates for energy-efficient appliances, HVAC and water heater equipment, and HVAC system tune-ups. Additionally, the program provides incentives to manufactures in order to lower the retail price of lighting and to retailers to promote energy efficient consumer electronics products. Honeywell implements the program on behalf of the Companies.

The EEP Program issued rebates to customers purchasing energy efficient products and services. Appliance rebate customers filled out a paper or online rebate form and sent it to Honeywell, the program's implementation contractor, in exchange for the rebate. HVAC rebate customers worked with their contractor to fill out a paper rebate form, and then mailed the form to Honeywell. The consumer electronics and lighting subprograms were designed using a retailer upstream structure, wherein retailers were compensated in exchange for marking down the prices of qualified products on the shelves.

The program covered the following 19 product categories, split into four subprograms:

Appliances

- ENERGY STAR® clothes washers
- ENERGY STAR® dehumidifiers
- ENERGY STAR® refrigerators and freezers

HVAC & Water Heating

- ENERGY STAR® whole house fans
- Air source heat pumps with SEER ≥ 15
- Central air conditioners with SEER ≥ 15
- ENERGY STAR® ground source heat pumps
- ENERGY STAR® ductless mini-split air conditioners and heat pumps
- ENERGY STAR® heat pump water heaters
- Electric resistance water heaters with EF ≥ 0.93
- Residential HVAC tune-ups

- ENERGY STAR® room air conditioners

Consumer Electronics

- Smart power strips
- ENERGY STAR® televisions
- ENERGY STAR® desktop computers
- ENERGY STAR® computer monitors

Lighting

- CFL bulbs
- LED bulbs
- Ceiling fans with ENERGY STAR® CFL light fixtures
- Torchiere floor lamps

4. Methodology

This chapter provides a description of the methodology applied by ADM in the evaluation of the 2015 participants in the EEP Program.

4.1 Impact Evaluation Methodology

The impact evaluation objectives for each sub program are described below.

Appliances

- Quantify the number of:
  - Customers who applied for ENERGY STAR® rebates
  - ENERGY STAR® Rebates provided
  - Participating ENERGY STAR® retailers
  - Participating ENERGY STAR® contractors
- Calculate the energy savings (kWh)
- Calculate the peak demand savings (kW)

HVAC & Water Heating

- Quantify the number of:
  - Customers who applied for rebates
  - Rebates provided
  - Participating retailers
  - Participating contractors
- Calculate the energy savings (kWh)
- Calculate the peak demand savings (kW)

Consumer Electronics

- Quantify the number of:
  - Customers who purchased consumer electronics
  - Distributed consumer electronics
  - Consumer electronics transactions
  - Participating retailers
- Calculate the energy savings (kWh)

- Calculate the peak demand savings (kW)

Lighting

- Quantify the number of:
  - Customers who purchased lighting products
  - Distributed lighting products
  - Lighting product transactions
  - Participating retailers
- Calculate the energy savings (kWh)
- Calculate the peak demand savings (kW)

4.1.1 Verification of Measures Rebated

ADM's impact analysis was based on data files provided by Honeywell and the Companies' database. The files provided by the Companies database contained model numbers, efficiency ratings, unit specifications, and claimed kW and kWh savings for all sub programs. Data provided by Honeywell includes manufacturer invoices and retailer sales data for the consumer electronics and lighting subprograms.

ADM reviewed a census of invoices and sales data for the lighting and consumer electronics sub programs. ADM's review showed that all quantities and dates from the invoices were 100% accurate. ADM also reviewed a census of model numbers to ensure that all products met program criteria.

4.1.2 Ex-Ante Review

ADM conducted an *ex ante* review of the Program's final 2015 database. In this review, ADM carried out the necessary data cleaning and data editing steps in preparing the data for analysis, including:

- Verification of rebate status as completed
- Verification of measure rebate requirements (e.g., ENERGY STAR® qualified status and high efficiency level) for completed rebates for applicable measures in the appliance and consumer electronics portions.
- Elimination of duplicate data entries
- Elimination of cases with incomplete data (e.g., no model number provided)

Measures verified as passing ADM's rebate screening process were analyzed further for energy and demand savings using the procedures described below. ADM requested

some additional information that was provided by Honeywell, such as invoices and tracking databases. After a thorough review of the documentation provided, ADM verified all measures as passing the above requirements.

Table 4.1 presents the *ex ante* savings per measure:

Table 4-1. Ex Ante Estimates of per unit Annual kWh & kW Savings for Qualified Energy Efficient Products by Type of Measure

Measure	*kWh*	*kW*	*Source*
Energy Efficiency Measures: Appliances			
Dehumidifiers (>25 to 35)	120	0.03	
Dehumidifiers (>35 to 45)	149	0.03	TRM
Dehumidifiers (>45 to 54)	266	0.06	TRM
Dehumidifiers (>54 to 75)	249	0.06	TRM
Freezers	1,131	0.18	TRM Refrigerator Savings modified for Freezers
Refrigerators, bottom freezer	1,219	0.21	TRM
Refrigerators, side by side	1,132	0.20	TRM
Refrigerators, top freezer	1,299	0.23	TRM
Clothes Washers	202	0.02	TRM
Energy Efficiency Measures: HVAC			
Air Source Heat Pumps	1,645	0.58	Blended Value Based on TRM
Central Air Conditioning	595	0.59	Blended Value Based on TRM
Ductless Mini Split Air Conditioner	307	0.25	Blended Value Based on TRM
Ductless Mini Split Heat Pump	1,305	0.37	Blended Value Based on TRM
Electric Water Heater	47	0.04	TRM Algorithm Modified for Electric Savings
Ground Source Heat Pumps	4,047	0.80	Blended Value Based on TRM
Heat Pump Water Heater	1,297	0.18	TRM
HVAC Tune Ups*	162	0.04	TRM
Room Air Conditioners*	86.9	0.11	Blended Value Based on TRM
Energy Efficiency Measures: Consumer Electronics			
Desktops*	122	0.017	Pennsylvania TRM
Monitors*	15	0.002	Pennsylvania TRM
Smart Strips	57	0.006	TRM
Television <40*	54	0.008	Pennsylvania TRM
Television >40*	188	0.029	Pennsylvania TRM
Energy Efficiency Measures: Lighting			
CFLs	52.85	0.01	TRM
LEDs	48.03	0.01	Mid Atlantic TRM
Ceiling Fans	192.00	0.02	TRM
* Starred measures show the average claimed savings per unit. The savings for these measures differ based several variables.			

4.2 Sampling Strategy

ADM completed a census review of all measures listed in the tracking system to ensure appropriate use of deemed savings values, and a census review of all retailer invoices associated with upstream buy-downs (LEDs, CFLs, Televisions, Computers, Monitors, Smart Strips).

4.3 Calculating Gross Annual kWh and kW Savings

Engineering and Deemed savings calculations were performed for a census of program measures. Detailed methodology descriptions are outlined for each subprogram in the sections below.

Senate Bill 310 (SB 310), passed in 2014, states that the following is countable toward compliance requirements:

> Energy efficiency savings and peak demand reduction achieved on and after the effective date of S.B. 310 of the 130th general assembly shall be measured on the higher of an as found or deemed basis, except that, solely at the option of the electric distribution utility, such savings and reduction achieved since 2006 may also be measured using this method.

The incremental savings resulting from using the existing equipment as the baseline were calculated for the 2015 participants. The existing equipment baselines were taken from the Ohio TRM. Some measure baselines have been adjusted as applicable based on the savings provisions of Ohio Senate Bill 310 and are reflected in the sections below.

4.3.1 Analysis of Savings for Appliance Measures

A "deem and count" approach was used to analyze the energy savings and demand reductions for the following ENERGY STAR®-rated measures:

- Dehumidifiers
- Refrigerators
- Freezers
- Clothes Washers

ENERGY STAR® Dehumidifiers

Annual kWh savings per unit and average peak kW savings per unit are deemed based on the unit's capacity range in pints per day. Capacity was determined for each ENERGY STAR® qualified dehumidifier based on the model listed in the Honeywell appliance database. Table 4-2 lists the deemed savings values specified in the TRM (p. 64), and updated by ADM to account for changes made to the ENERGY STAR® assumptions of use, for the purchase of an ENERGY STAR® Dehumidifiers.

Table 4-2. Deemed Savings Values for ENERGY STAR® Dehumidifiers

Capacity Range (pints per day)	*Annual kWh Savings per unit*	*Demand kW Reductions per unit*
<25	130	0.03
>25 to 35	120	0.03
>35 to 45	149	0.03
>45 to 54	266	0.06
>54 to 75	249	0.06
>75 to 185	179	0.04

ENERGY STAR® Refrigerators

Annual kWh savings and kW demand reduction are deemed based on the refrigerator door configuration, which is recorded in the Honeywell appliance database. Table 4-3 shows the deemed savings values for ENERGY STAR® qualified refrigerators specified in the TRM (p. 53) with applicable baseline included for the purchase of ENERGY STAR® Refrigerators.

Table 4-3. Deemed Savings Values for ENERGY STAR® Refrigerators

Refrigerator Configuration	*Total Annual kWh Savings per Unit*	*Base Peak kW Reductions per Unit*
Bottom Freezer	1,219	0.21
Top Freezer	1,299	0.23
Side by Side	1,132	0.20

ENERGY STAR® Clothes Washers

ADM verified that the rebated clothes washers were ENERGY STAR® qualified ADM used the deemed calculations for kWh and kW demand reduction cited in the TRM for ENERGY STAR® qualified clothes washers. The listed savings values for ENERGY STAR® clothes washer are 202 kWh per unit and 0.021 kW per unit.

4.3.2 Analysis of Savings for HVAC Measures

The impact methods used to analyze the HVAC measures utilize the formulas specified in the TRM to calculate energy and demand savings. Estimates of savings were calculated for the following HVAC measures that were rebated through the EEP Program for 2015 participants.

- Residential HVAC Maintenance/Tune Up
- Central air conditioning (CAC)
- Air Source Heat Pump (ASHP)

- Ground Source Heat Pump (GSHP)
- Ductless Mini Split Air Conditioner
- Ductless Mini Split Heat Pump
- Electric Water Heater
- Heat Pump Water Heater
- Room Air Conditioners

For each HVAC measure, total kWh savings and total peak demand savings for that measure are determined as a product of the number of measures verified as qualifying for a rebate under the EEP Program and the savings per measure. The methods used to verify rebate qualifications and the per-unit kWh and peak demand savings for the HVAC measures are described in this section.

Residential HVAC Maintenance/Tune Ups

ADM performed an engineering desk review of available data to determine if the savings claims for tune-ups were rational. It was determined that the savings claimed for tune-ups was reasonable and conservative.

Central Air Conditioning

The TRM algorithms for estimating annual energy and demand savings from the purchase of a new central air conditioning ducted split system meeting ENERGY STAR® efficiency standards were used for calculating energy and demand savings in the evaluation of 2015 participants. As specified in the TRM, the formula for calculating annual energy savings for a new ENERGY STAR® central air conditioning system is:

$$\text{kWh Savings} = (FLH_{cool} * BtuH * (1/SEER_{base} - 1/SEER_{ee}))/1000$$

where:

FLH_{cool}	=	Full load cooling hours, which depend on location
BtuH	=	Size of the replaced AC unit in tons (1 ton = 12,000 BtuH)
$SEER_{base}$	=	SEER efficiency of the baseline AC unit = 10[3]
$SEER_{ee}$	=	SEER efficiency rating of the ENERGY STAR® AC unit installed

The formula for calculating demand savings for the purchase of a central air conditioning unit meeting ENERGY STAR® standards is specified as follows in the TRM:

[3] Ohio TRM Early Replacement Assumption

$$kW\ Savings = (BtuH * (1/EER_{base} – 1/EER_{ee}))/1000 * CF$$

where:

BtuH	=	Size of the new AC unit in tons (1 ton = 12,000 BtuH)
EER_{base}	=	EER efficiency rating of the baseline AC unit = 9[4]
EER_{ee}	=	EER efficiency rating of the ENERGY STAR® AC unit installed
CF	=	Peak Coincidence Factor for a CAC measure = 0.5 (TRM specified)

Full load cooling hours were determined from the customer's zip code. The values for other variables in the equation (e.g., BtuH, SEER, and EER) were determined for a given central air conditioning system model by looking up the values for a given model number in the AHRI database.

Air Source Heat Pump

In the evaluation of the 2015 participants, the annual energy and demand savings from the purchase of a new air source heat pump were calculated using the TRM algorithms. As specified in the TRM, the formula for calculating annual energy savings for a new air source heat pump meeting minimum ENERGY STAR® efficiency level standards is:

$$kWh\ Savings_{AS\ Heat\ Pump} = ((FLH_{cool} * BtuH * (1/SEER_{base} – 1/SEER_{ee}))/1000 + (FLH_{heat} * BtuH * (1/HSPF_{base} – 1/HSPF_{ee}))/1000$$

where:

FLH_{cool}	=	Full load cooling hours, which depend on location
FLH_{heat}	=	Full load heating hours, which depend on location
BtuH	=	Size of the HVAC equipment in tons (1 ton = 12,000 BtuH)
$SEER_{base}$	=	SEER efficiency rating of the baseline unit = 10[5]
$SEER_{ee}$	=	SEER efficiency rating of the new ASHP installed
$HSPF_{base}$	=	Heating Season Performance Factor for baseline unit = 7.7[6]
$HSPF_{ee}$	=	Heating Season Performance Factor for efficient unit installed

The formula for calculating demand savings for the purchase of a new air source heat pump meeting ENERGY STAR® standards is specified as follows in the TRM:

[4] Ohio TRM Early Replacement Assumption

[5] Ohio TRM Early Replacement Assumption

[6] Minimum Federal Standard

$$kW\ Savings = BtuH * (1/EER_{base} – 1/EER_{ee}))/1000 * CF$$

where:

BtuH	=	Size of the new ASHP unit in tons (1 ton = 12,000 BtuH)
EER_{base}	=	EER efficiency rating of the baseline ASHP unit = 9[7]
EER_{ee}	=	EER efficiency rating of the ENERGY STAR® ASHP unit installed
CF	=	Peak Coincidence Factor for measure (TRM specifies CF = 0.5)

Full load cooling and heating hours were determined from the customer's zip code. The values for other variables in the equation (e.g., BtuH, SEER, EER, and HSPF) were determined for a given air source heat pump model by looking up the model number in the AHRI database.

Ground Source Heat Pump

The TRM algorithms for estimating annual energy and demand savings from the purchase of a new ground source heat pump were used for calculating energy and demand savings in the evaluation of 2015 participants. As specified in the TRM, the formula for calculating annual energy savings for a ground source heat pump meeting ENERGY STAR® efficiency level standards is:

$$kWh\ Savings\ GS\ Heat\ Pump = ((FLH_{cool} * BtuH * (1/SEER_{base} – 1/EER_{ee} *1.02))/1000 + (FLHheat * BtuH * (1/HSPF_{base} – 1/COP_{ee} * 3.412))/1000$$

where:

FLH_{cool}	=	Full load cooling hours, which depend on location

[7] Ohio TRM Early Replacement Assumption

FLH_{heat}	=	Full load heating hours, which depend on location
BtuH	=	Size of the HVAC equipment in tons (1 ton = 12,000 BtuH)
$SEER_{base}$	=	SEER efficiency rating of the baseline unit = 10[8]
EER_{ee}	=	EER efficiency rating of the new GSHP installed
1.02	=	Constant used to estimate SEER based on efficient unit's EER
$HSPF_{base}$	=	Heating Season Performance Factor for baseline unit = 7.7[9]
COP_{ee}	=	Coefficient of Performance for efficient unit installed
3.413	=	Constant to convert the COP of the unit to HSPF

The formula for calculating demand savings for the purchase of a ground source heat pump meeting ENERGY STAR® standards is specified as follows in the TRM:

kW Savings = BtuH * (1/EERbase – 1/(((EERee * 1.02) * 0.37) + 6.43))/1000 * CF

where:

BtuH	=	Size of the new GSHP unit in tons (1 ton = 12,000 BtuH)
EERbase	=	EER efficiency rating of the baseline GSHP unit = 9[10]
EERee	=	EER efficiency rating of the ENERGY STAR® GSHP unit installed
1.02	=	Constant used to estimate the unit's equivalent AC EER to enable comparisons to the baseline unit[11]
CF	=	Peak Coincidence Factor for measure = 0.5 (TRM specified)

Full load cooling and heating hours were determined from the customer's zip code. The values for other variables in the equation (e.g., BtuH, SEER, EER, and CF) were determined for a given ground source heat pump model by looking up the model number in the AHRI database.

ENERGY STAR® Room Air Conditioners

For base savings, ADM used a deemed energy savings value of 22 kWh per qualified ENERGY STAR® room air conditioner, per the approved VEIC replies to the Joint Utility Comments document which recommended adjusting the size of the average rebated

[8] Ohio TRM Early Replacement Assumption

[9] Minimum Federal Standard

[10] Ohio TRM Early Replacement Assumption

[11] Using the algorithm EERac = (SEER * 0.37) + 6.43

unit from 8,500 BtuH to 10,000 BtuH. Base peak demand savings of 0.028 kW per unit was used, as specified in the TRM (p.67).

For total savings, ADM used a deemed energy savings value of 86.9 kWh per qualified ENERGY STAR® room air conditioner per the allowed early replacement baseline in the TRM. Base peak demand savings of 0.11 kW per unit was used, as specified in the TRM (p.70).

4.3.3 Analysis of Savings for Consumer Electronics Measures

Annual *ex post* savings was determined separately for each category of electronics that were eligible for retailer rebates under this program, but the methodology for calculating *ex post* energy savings is the same for each category. ADM reviewed program tracking data, invoices, and the ENERGY STAR® database to verify validity of deemed values used for purposes of determining energy savings and peak summer demand reduction per unit.

Smart Strips

Energy and demand savings are deemed based on the plug size (5-plug or 7-plug) of the smart strip purchased. Table 4-4 shows the deemed savings values specified in the TRM (p. 76) for the purchase of Smart Strip.

Table 4-4. Deemed Savings Values for Smart Strips

Plug Size	*Annual kWh Savings per Unit*	*Peak Demand kW Reduction per Unit*
5-Plug	56.5	0.0063
7-Plug	102.8	0.012

Honeywell's appliance database uses the deemed savings values for 5-plug smart strips as the *ex ante* values. ADM similarly used the 5-plug values to determine *ex post* savings.

Televisions, Monitors, and Computers

ADM used the deemed values for energy savings and peak demand reduction Pennsylvania TRM. These deemed values are detailed in the tables below:

Table 4-5: Deemed Savings Values for ENERGY STAR® Televisions

Diagonal Screen Size in Inches	Annual kWh Savings per unit	*Peak Demand kW Reduction per Unit*
< 20	2	0.000
20 < 30	18	0.003
30 < 40	22	0.003
40 < 50	35	0.005
50 < 60	29	0.005
> 60	16	0.003

Table 4-6: Deemed Savings Values for ENERGY STAR® Computers and Monitors

Equipment Type	Annual kWh Savings per unit	*Peak Demand kW Reduction per Unit*
Computer	133	0.018
Monitor	15	0.002

4.3.4 Analysis of Savings for Lighting Measures

As detailed in section 4.1.1, ADM analyzed data from invoices to verify quantities rebated. The verified quantities were multiplied by the per unit savings calculated as described below.

The following formula was used to calculate annual kWh *ex post* savings in accordance with the formula specified in the TRM and modified for LED bulbs as specified in the Mid-Atlantic[12] TRM. As set out in the TRM,

$$\text{kWh Savings} = (\Delta\text{Watt}*1{,}000)*\text{ISR}*\text{Hours}*\text{WHFe}$$

Where:

ΔWatts for CFLs = CFL watts * delta watts multiplier;

CFL watts = wattage of installed CFL, as verified

Delta watts multiplier = factor to account for baseline Conditions = 3.25 (from TRM)

ΔWatts for LEDs = Baseline Watts - LED watts;

Baseline watts = wattage of baseline bulbs determined by lumen output using the guidelines set forth in the Mid-Atlantic TRM.

[12] Shelter Analytics, *Mid-Atlantic Technical Reference Manual Version 4.0,* Prepared for Northeast Energy Efficiency Partnerships (NEEP), June, 2014.

LED watts = wattage of installed LED, as verified.

ISR = In Service Rate = 0.86 (From TRM)

Hours = Average hours of use per year = 1,040 (from TRM)

WHFe = Waste Heat Factor for energy =1.07 (from TRM)

The formula for calculating demand (kW) savings for the purchase of efficient lighting is specified as follows in the TRM:

$$\Delta kW = ((\Delta Watts) /1000) * ISR * WHFd * CF$$

Where:

∆Watts for CFLs = CFL watts * delta watts multiplier;

CFL watts = wattage of installed CFL, as verified

Delta watts multiplier = factor to account for baseline conditions = 3.25 (from TRM)

∆Watts for LEDs = Baseline Watts - LED watts;

Baseline watts = wattage of baseline bulbs determined by lumen output using the guidelines set forth in the Mid-Atlantic TRM.

LED watts = wattage of installed LED, as verified.

ISR = In Service Rate = 0.86 (From TRM)

WHFd = Waste Heat Factor for Demand = 1.21 (from TRM)

CF = Peak Demand Coincidence Factor = 0.11(from TRM)

Ceiling Fans

Energy and demand savings for the purchase of efficient ceiling fans (with compact fluorescent lights) was calculated using a deemed savings approach, as specified in the Ohio TRM. Deemed energy savings per unit is 192 kWh and demand savings is 0.024 kW.

4.4 Calculation of Lifetime kWh Savings per Measure

Lifetime kWh savings for lighting, appliance and HVAC measures were calculated by multiplying annual kWh savings for each measure by the deemed effective useful life for each measure, as specified in the TRM.

5. Detailed Evaluation Findings

The findings from the impact evaluation efforts are presented in this chapter.

5.1 Impact Evaluation Findings

The number of energy efficient products that were qualified to receive a rebate from the EEP Program for 2015 participants is shown in Table 5-1 for each utility service territory and for the total program.

Table 5-1. Number of Rebates for Qualified Measures in the Energy Efficient Products Program (2015 Participants)

Measure Type	*CEI*	*OE*	*TE*	*Total*
Appliances	1,312	1,860	407	3,579
HVAC	279	427	158	864
Consumer Electronics	10,309	8,076	2,941	21,326
Lighting (total bulbs/fixtures)	108,450	94,542	28,316	231,308

Table 5-2 shows the quantities of energy efficient products for which rebates were paid per operating company and for the 2015 participants. Applying the methods described in Chapter 4 produced estimates of savings per unit on a measure-by-measure basis. Multiplying the verified quantities by the per-measure savings estimates produced the program-level estimates of kWh energy savings, which are reported in Table 5-3, and peak kW demand reductions, which are reported in Table 5-4.

Table 5-2. Quantities of Qualified Energy Efficient Products Rebated through EE Products by Type of Measure and Operating Company - 2015 Participants

Measure Type	*CEI*	*OE*	*TE*	*Total*
Energy Efficiency Measures: Appliances				
Dehumidifiers (>25 to 35)	5	21	3	29
Dehumidifiers (>35 to 45)	39	65	7	111
Dehumidifiers (>45 to 54)	59	78	10	147
Dehumidifiers (>54 to 75)	57	78	11	146
Freezers	33	74	17	124
Refrigerators, bottom freezer	268	402	87	757
Refrigerators, side by side	83	114	22	219
Refrigerators, top freezer	106	100	28	234
Clothes Washers	662	928	222	1,812
Total Rebated Products, Appliances	1,312	1,860	407	3,579
Energy Efficiency Measures: HVAC				
Air Source Heat Pumps	49	93	14	156
Central Air Conditioning	125	124	88	337
Ductless Mini Split Air Conditioner	7	3	0	10
Ductless Mini Split Heat Pump	14	16	8	38
Electric Water Heater	14	38	12	64
Ground Source Heat Pumps	21	89	25	135
Heat Pump Water Heater	4	12	7	23
HVAC Tune Ups	35	46	4	85
Room Air Conditioners	9	6	0	15
Whole House Fan	1	0	0	1
Total Rebated Products, HVAC	279	427	158	864
Energy Efficiency Measures: Consumer Electronics				
Desktops	93	91	48	232
Monitors	380	265	118	763
Smart Strips	50	41	1	92
Television <40	3471	2968	1084	7,523
Television >40	6315	4711	1690	12,716
Total Rebated Products, Consumer Elec.	10,309	8,076	2,941	21,326
Energy Efficiency Measures: Lighting				
CFLs	84,584	90,350	25,962	200,896
LEDs	23,852	4,182	2,354	30,388
Ceiling Fans	14	10	0	24
Total Rebated Products, Lighting	108,450	94,542	28,316	231,308
Program Level				
Total Rebated Products	120,350	104,905	31,822	257,077

Table 5-3. Annual kWh Savings for Qualified Energy Efficient Products by Type of Measure - 2015 Participants

Measure Type	*Ex Ante kWh*	*Ex Post kWh*	*Realization Rate*
Energy Efficiency Measures: Appliances			
Dehumidifiers (>25 to 35)	4,170	3,473	83%
Dehumidifiers (>35 to 45)	16,517	16,514	100%
Dehumidifiers (>45 to 54)	22,341	39,043	175%
Dehumidifiers (>54 to 75)	22,127	36,413	165%
Freezers	140,244	126,893	90%
Refrigerators, bottom freezer	922,783	922,783	100%
Refrigerators, side by side	247,908	247,908	100%
Refrigerators, top freezer	303,966	303,966	100%
Clothes Washers	366,024	366,024	100%
Total kWh Savings, Appliances	2,046,080	2,063,016	101%
Energy Efficiency Measures: HVAC			
Air Source Heat Pumps	256,682	221,618	86%
Central Air Conditioning	200,582	172,718	86%
Ductless Mini Split Air Conditioner	3,061	2,871	94%
Ductless Mini Split Heat Pump	49,586	38,546	78%
Electric Water Heater	3,008	3,008	100%
Ground Source Heat Pumps	546,345	1,140,461	209%
Heat Pump Water Heater	29,831	29,833	100%
HVAC Tune Ups	21,100	22,473	107%
Room Air Conditioners	1,304	1,303	100%
Whole House Fan	206	206	100%
Total kWh Savings, HVAC	1,111,705	1,633,036	147%
Energy Efficiency Measures: Consumer Electronics			
Desktops	30,856	30,856	100%
Monitors	11,445	11,445	100%
Smart Strips	5,198	5,198	100%
Television <40	164,686	164,686	100%
Television >40	392,137	423,411	108%
Total kWh Savings, Consumer Elec.	604,322	635,596	105%
Energy Efficiency Measures: Lighting			
CFLs	9,981,248	9,987,078	100%
LEDs	1,396,354	1,439,258	103%
Ceiling Fans	4,608	4,600	100%
Total kWh Savings, Lighting	11,382,210	11,430,935	100%
Program Level			
Total Program kWh Savings	15,144,317	15,762,584	104%

Table 5-4. Demand (kW) Reductions for Qualified Energy Efficient Products by Type of Measure –2015 Participants

Measure Type	*Ex Ante kW*	*Ex Post kW*	*Realization Rate*
Energy Efficiency Measures: Appliances			
Dehumidifiers (>25 to 35)	1	1	83%
Dehumidifiers (>35 to 45)	4	4	100%
Dehumidifiers (>45 to 54)	5	9	175%
Dehumidifiers (>54 to 75)	5	8	165%
Freezers	22	22	102%
Refrigerators, bottom freezer	161	162	100%
Refrigerators, side by side	43	43	100%
Refrigerators, top freezer	53	53	100%
Clothes Washers	38	38	99%
Total kW Reduction, Appliances	332	340	102%
Energy Efficiency Measures: HVAC			
Air Source Heat Pumps	90	81	90%
Central Air Conditioning	199	170	86%
Ductless Mini Split Air Conditioner	3	2	97%
Ductless Mini Split Heat Pump	14	6	39%
Electric Water Heater	3	0	0%
Ground Source Heat Pumps	108	163	151%
Heat Pump Water Heater	4	4	98%
HVAC Tune Ups	3	3	95%
Room Air Conditioners	2	2	100%
Whole House Fan	-	0	-
Total kW Reduction, HVAC	426	432	101%
Energy Efficiency Measures: Consumer Electronics			
Desktops	4	4	100%
Monitors	2	1	95%
Smart Strips	1	1	100%
Television <40	26	25	100%
Television >40	60	64	107%
Total kW Reduction, Consumer Elec.	92	96	104%
Energy Efficiency Measures: Lighting			
CFLs	1,057	1,195	113%
LEDs	178	172	97%
Ceiling Fans	1	0	78%
Total kW Reduction, Lighting	1,236	1,367	111%
Program Level			
Total Program kW Reduction	2,086	2,234	107%

5.1.1 Appliances

The *ex post* savings are high for dehumidifiers due to a large amount of line items not including the capacity in the data set. The *ex ante* estimates defaulted to using the savings for a 35 to 45 pints-per-day capacity unit when the capacity was not included. ADM used the model numbers to verify the capacity for the units where it wasn't included. This increased the savings for many of the line items due to the capacity for those units being over 45. These variances give subprogram level realization rates of 101% and 102% for kWh and kW respectively.

5.1.2 HVAC

The *ex post* savings vary from the *ex ante* estimates for a number of the HVAC measures. Much of the variation is accounted for by the *ex ante* use of a blended savings value for each unit in a given measure without using the specific inputs that are provided in the participant data. Using a deemed value for each unit does not account for differences in variables such as unit tons or energy efficiency ratings. We see this variation in air source heat pumps, central air conditioners, ductless mini split air conditioners, ductless mini split heat pumps, and ground source heat pumps. The variance created by the different methodologies gives a realization rate of 147% for kWh and 101% for kW.

5.1.3 Consumer Electronics

The *ex ante* estimates for the consumer electronics portion of the program were highly accurate with one exception. For televisions of greater than 40 inches, incorrect savings values were assigned for portion of the units. Correcting these values resulted in increased savings and a 108% kWh realization rate for that category, and a 105% kWh realization rate for the consumer electronics portion of the program. This correction impacted kW reductions similarly resulting in a realization rate of 107%.

5.1.4 Lighting

Ex ante estimates in the lighting portion of the program were highly accurate. The only major discrepancy was in the LED calculation. ADM recommended using an alternative methodology as outlined in the Mid-Atlantic TRM because the delta watts multiplier method in the Ohio TRM is specific to CFLs. The *ex ante* estimates used the Mid-Atlantic method, but used a blended value approach by assigning savings values to certain ranges of wattage instead of calculating each line individually. While this is an acceptable approach, it created a small discrepancy that gave a kWh realization rate of 103% to the LED measure, which did not have a sizeable effect on the entire sub program resulting in a 100% realization rate for the lighting portion of the program. For the kW reductions in the program, rounded values were used in the *ex ante* estimates, but not for the *ex post* calculation. Due to the volume products rebated in the program,

this discrepancy led to a noticeable impact on the kW reductions giving a realization rate of 111%.

6. Conclusions and Recommendations

6.1 Conclusions from the Impact Evaluation

Table 6-1 shows participation by measure category for each of the companies. For the Appliances and HVAC subprograms, the count shown is unique project numbers. For the Consumer Electronics subprogram, the count shown is the number of products rebated. For the Lighting subprogram, the count shown is individual bulbs or fixtures distributed.

Table 6-1. 2015 Participants by Measure Category

Measure Type	*CEI*	*OE*	*TE*	*Total*
Appliances	1,312	1,860	407	3,579
HVAC	279	427	158	864
Consumer Electronics	10,309	8,076	2,941	21,326
Lighting	108,450	94,542	28,316	231,308

The overall evaluation results for estimated gross energy savings and peak demand reductions for the program in the Companies' service territories are summarized in Table 6-2.

Table 6-2. Overall Evaluation Results for Gross kWh and kW Savings

Utility	*Ex Ante Expected Savings*		*Ex Post Verified Savings*		*Realization Rates*	
	kWh	*kW*	*kWh*	*kW*	*kWh*	*kW*
CEI	6,509,844	870	6,645,378	924	102%	106%
OE	6,740,208	932	7,089,500	1,008	105%	108%
TE	1,894,266	284	2,027,706	303	107%	107%
Total	15,144,317	2,086	15,762,584	2,234	104%	107%

The gross kWh savings total, shown in Table 6-2, give a realization rate for kWh savings of approximately 104%. This is determined by the ratio of verified gross kWh savings to expected gross kWh savings. The realization rate for kW reductions was approximately 107%. As discussed in section 5.1 above, the realization rates are slightly greater than 100% because of use of blended *ex ante* values in the HVAC subprogram and LED portion of the lighting subprogram and a conservative assumption of dehumidifier capacity in the appliance subprogram.

The *ex ante* and *ex post* kWh savings and realization rates for each measure category are presented in Table 6-3.

Table 6-3. Overall Evaluation Results by Measure Type

Measure Type	*Ex Ante Expected Savings*		*Ex Post Verified Savings*		*kWh RR*	*kW RR*
	kWh	*kW*	*kWh*	*kW*		
Appliances	2,046,080	332	2,063,016	340	101%	102%
HVAC	1,111,705	426	1,633,036	432	147%	101%
Consumer Electronics	604,322	91.997	635,596	96	105%	104%
Lighting	11,382,210	1,236	11,430,935	1,367	100%	111%
Total	15,144,317	2,086	15,762,584	2,234	104%	107%

7. Appendix A: Required Savings Tables

Tables showing measure-level participation counts and savings for the EEP Program's 2015 participants were provided in various locations throughout this report. This appendix provides additional tables summarizing savings results.

- Table 7-1 reports the annual ex post kWh savings by utility and measure reported in 2015
- Table 7-2 reports the average annual ex post on-peak kW reductions by utility and measure reported in 2015
- Table 7-3 reports the lifetime ex post kWh savings by utility and measure reported in 2015

Table 7-1. Ex Post Annual kWh Savings by Measure and Operating Company 2015 Participants

Measure Type	*CEI*	*OE*	*TE*	*Total*
Energy Efficiency Measures: Appliances				
Dehumidifiers (>25 to 35)	599	2,515	359	3,473
Dehumidifiers (>35 to 45)	5,802	9,670	1,041	16,514
Dehumidifiers (>45 to 54)	15,670	20,717	2,656	39,043
Dehumidifiers (>54 to 75)	14,216	19,453	2,743	36,413
Freezers	33,770	75,726	17,397	126,893
Refrigerators, bottom freezer	326,692	490,038	106,053	922,783
Refrigerators, side by side	93,956	129,048	24,904	247,908
Refrigerators, top freezer	137,694	129,900	36,372	303,966
Clothes Washers	133,724	187,456	44,844	366,024
Total kWh Savings (Appliances)	762,123	1,064,524	236,370	2,063,016
Energy Efficiency Measures: HVAC				
Air to Air Heat Pump	64,702	121,911	35,006	221,618
Central Air Conditioner	66,650	65,192	40,875	172,718
Ductless Minisplit AC	2,014	857	0	2,871
Ductless Minisplit HP	14,274	15,436	8,836	38,546
Electric Water Heater	658	1,786	564	3,008
Geothermal Heat Pump	176,767	744,177	219,516	1,140,461
Heat Pump Water Heater	5,188	15,565	9,080	29,833
Tune-up	9,471	11,986	1,016	22,473
Room AC	782	521	0	1,303
Whole House Fan	206	0	0	206
Total kWh Savings (HVAC)	340,712	977,432	314,892	1,633,036
Energy Efficiency Measures: Consumer Electronics				
Desktops	12,369	12,103	6,384	30,856
Monitors	5,700	3,975	1,770	11,445
Smart Strips	2,825	2,317	57	5,198
Television <40	76,098	64,940	23,648	164,686
Television >40	210,143	156,658	56,610	423,411
Total kWh Savings (Consumer Electronics)	307,135	239,993	88,469	635,596
Energy Efficiency Measures: Lighting				
CFLs	4,073,333	4,637,176	1,276,569	9,987,078
LEDs	1,159,392	168,459	111,406	1,439,258
Ceiling Fans	2,683	1,917	-	4,600
Total kWh Savings (Lighting)	5,235,408	4,807,552	1,387,975	11,430,935
Program Level				
Total kWh Savings	6,645,378	7,089,500	2,027,706	15,762,584

Table 7-2. Annual Ex Post On-Peak Demand Reductions (kW) by Measure and Operating Company 2015 Participants

Measure Type	*CEI*	*OE*	*TE*	*Total*
Energy Efficiency Measures: Appliances				
Dehumidifiers (>25 to 35)	0	1	0	1
Dehumidifiers (>35 to 45)	1	2	0	4
Dehumidifiers (>45 to 54)	4	5	1	9
Dehumidifiers (>54 to 75)	3	4	1	8
Freezers	6	13	3	22
Refrigerators, bottom freezer	57	86	19	162
Refrigerators, side by side	16	23	4	43
Refrigerators, top freezer	24	23	6	53
Clothes Washers	14	19	5	38
Total kW Savings (Appliances)	126	176	39	340
Energy Efficiency Measures: HVAC				
Air to Air Heat Pump	24	45	12	81
Central Air Conditioner	70	60	40	170
Ductless Minisplit AC	2	1	0	2
Ductless Minisplit HP	2	2	1	6
Electric Water Heater	0	0	0	0
Geothermal Heat Pump	25	108	30	163
Heat Pump Water Heater	1	2	1	4
Tune-up	2	2	0	3
Room AC	1	1	0	2
Whole House Fan	0	0	0	0
Total kW Savings (HVAC)	126	221	85	432
Energy Efficiency Measures: Consumer Electronics				
Desktops	2	2	1	4
Monitors	1	1	0	1
Smart Strips	0	0	0	1
Television <40	12	10	4	25
Television >40	32	24	9	64
Total kW Savings (Consumer Electronics)	46	36	13	96
Energy Efficiency Measures: Lighting				
CFLs	487	555	153	1,195
LEDs	139	20	13	172
Ceiling Fans	0	0	0	0
Total kW Savings (Lighting)	626	575	166	1,367
Program Level				
Total kW Savings	924	1,008	303	2,234

Table 7-3. Lifetime Ex Post Energy Savings (kWh) 2015 Participants

Measure Type	*EUL*	*CEI*	*OE*	*TE*	*Total*
Energy Efficiency Measures: Appliances					
Dehumidifiers (>25 to 35)	12	7,186	30,179	4,311	41,676
Dehumidifiers (>35 to 45)	12	69,626	116,043	12,497	198,165
Dehumidifiers (>45 to 54)	12	188,044	248,601	31,872	468,517
Dehumidifiers (>54 to 75)	12	170,592	233,441	32,921	436,954
Freezers	17	574,087	1,287,347	295,742	2,157,175
Refrigerators, bottom freezer	17	5,553,764	8,330,646	1,802,901	15,687,311
Refrigerators, side by side	17	1,597,252	2,193,816	423,368	4,214,436
Refrigerators, top freezer	17	2,340,798	2,208,300	618,324	5,167,422
Clothes Washers	11	1,470,964	2,062,016	493,284	4,026,264
Total kWh Savings (Appliances)		11,972,312	16,710,388	3,715,220	32,397,920
Energy Efficiency Measures: HVAC					
Air to Air Heat Pump	18	1,164,634	2,194,392	630,105	3,989,130
Central Air Conditioner	18	1,199,706	1,173,460	735,750	3,108,915
Ductless Minisplit AC	15	30,211	12,857	0	43,068
Ductless Minisplit HP	15	214,103	231,542	132,538	578,184
Electric Water Heater	14	9,212	25,004	7,896	42,112
Geothermal Heat Pump	18	3,181,815	13,395,188	3,951,292	20,528,295
Heat Pump Water Heater	10	51,883	155,650	90,796	298,328
Tune-up	5	47,355	59,932	5,079	112,366
Room AC	12	9,381	6,254	0	15,634
Whole House Fan	20	4,120	0	0	4,120
Total kWh Savings (HVAC)		5,912,419	17,254,278	5,553,456	28,720,153
Energy Efficiency Measures: Consumer Electronics					
Desktops	4	49,476	48,412	25,536	123,424
Monitors	15	85,500	59,625	26,550	171,675
Smart Strips	4	11,300	9,266	226	20,792
Television <40	15	1,141,470	974,100	354,720	2,470,290
Television >40	15	3,152,145	2,349,870	849,150	6,351,165
Total kWh Savings (Consumer Electronics)		4,439,891	3,441,273	1,256,182	9,137,346
Energy Efficiency Measures: Lighting					
CFLs	6.8	27,698,661	31,532,795	8,680,671	67,912,128
LEDs	15	17,390,883	2,526,889	1,671,094	21,588,866
Ceiling Fans	6.8	18,246	13,033	0	31,279
Total kWh Savings (Lighting)		45,107,791	34,072,717	10,351,765	89,532,272
Program Level					
Total kWh Savings		67,432,413	71,478,657	20,876,622	159,787,692