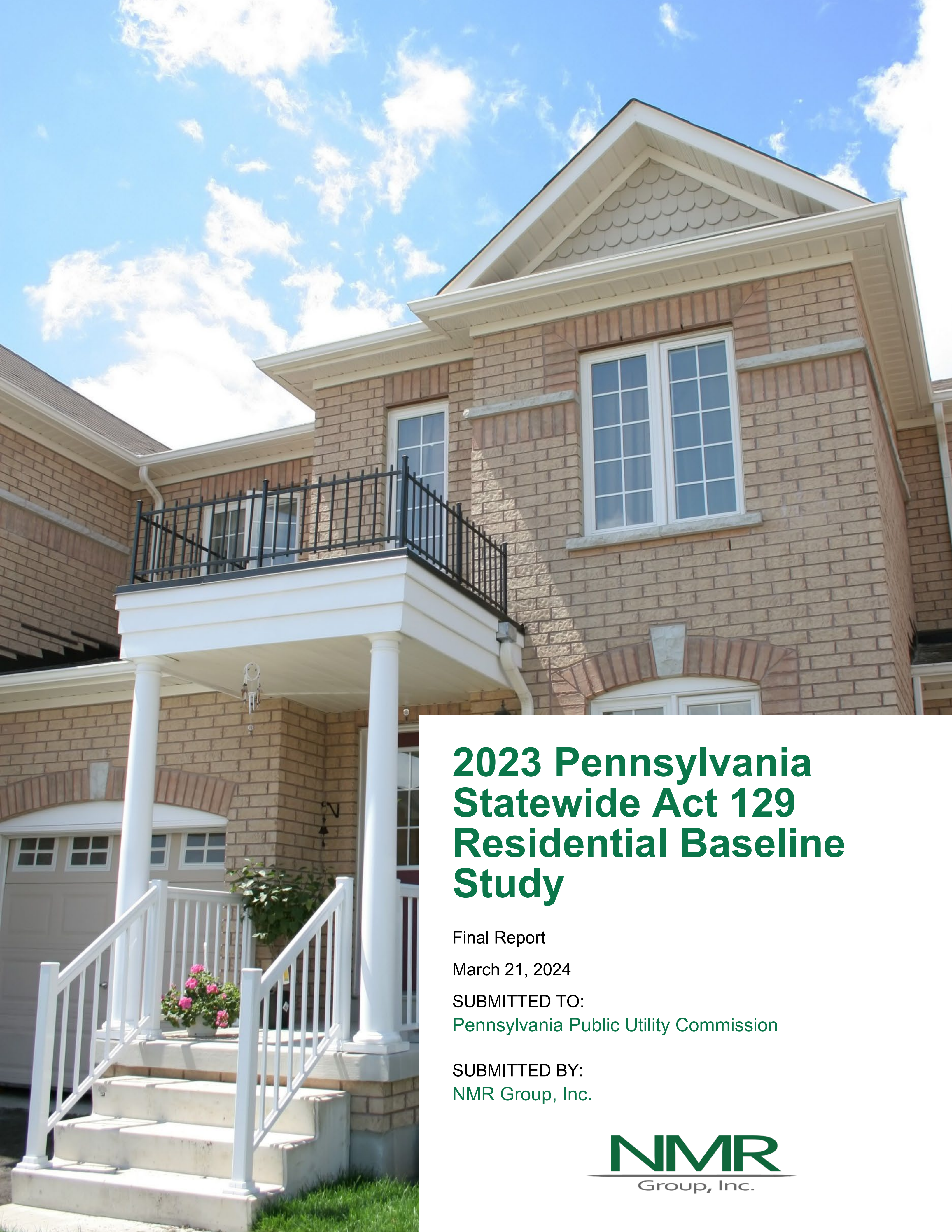


2023 Pennsylvania Statewide Act 129 Residential Baseline Study

Final Report

March 21, 2024

SUBMITTED TO:
Pennsylvania Public Utility Commission

SUBMITTED BY:
NMR Group, Inc.

Pennsylvania Residential Energy Efficiency Study

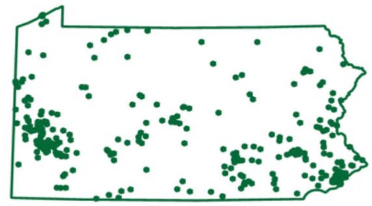
In 2023, the Pennsylvania Statewide Evaluator (SWE), led by NMR Group Inc, conducted a residential energy efficiency study in existing homes as required by the state's energy efficiency and conservation law, Act 129 of 2008. Auditors inspected 286 randomly selected homes across the state to characterize the current baseline energy efficiency level of the housing stock. Auditors collected data on insulation, heating and cooling equipment, appliances, lighting, air leakage, duct leakage, and the willingness to pay for upgrades. The study also includes data from 265 self-audited homes in which participants submitted nameplate photos of key energy consuming mechanical equipment and appliances that were verified by the SWE. This study will be used to update the state's Technical Reference Manual and to support the Phase V energy efficiency market potential study.

189 Detached Single-family

28 Attached Single-family

69 Multifamily homes

265 Self-Audits



All over Pennsylvania

Key Findings

HERS Index Score[1]

Homes, regardless of vintage, are 58% less efficient than a home built to code in 2018.

Air Infiltration[1] (ACH50)

Homes have 280% more (worse) air infiltration than a home built to code in 2018.

Duct Leakage to Outside[1] (LTO CFM25/100 sq.ft.)

Duct systems have 90% more (worse) leakage than those in a home built to code in 2018.

Average Insulation

Walls, ceilings, and floors are between 35% and 77% less efficient than a home built to code in 2018.

[1]Based on a subset of 72 homes that received full energy modeling.

Averages

Age	Heating	Cooling	Water Heating	LED Saturation
56 Years	88.1 AFUE	13.9 SEER2	0.82 UEF	59%

Saturation Over Time

The share of efficient equipment is increasing over time, but the shares of efficient refrigerators and freezers have plateaued.

		2011	2013	2018	2023
	LED and CFL Bulbs	18%	24%*	40%*	67%*
ENERGY STAR	Refrigerators	20%	31%*	31%	48%*
	Freezers	7%	15%*	10%	19%*
	Clothes Washers	24%	26%	40%*	52%*
	Dishwashers	38%	44%	57%*	70%*
	Room ACs	21%	26%	33%	32%

* Significantly different from the previous study at the 95% confidence level.

Lighting Highlights

59% The saturation of LEDs in Pennsylvania is greater than other northeastern states with similar programs such as Maryland, New Hampshire, and Vermont.

LED bulbs occupy 44% of sockets in the average home in Pennsylvania, which is double the amount seen in the 2018 baseline study.

Table of Contents

Acknowledgements

The Act 129 Phase IV Statewide Evaluation (SWE) Team thanks the staff of the seven electric distribution companies highlighted in this report. Their timely provision of data and their support during recruitment efforts proved immensely important for the success of this study. Specifically, the SWE would like to thank Marina Geneles of PECO, Tom McAteer and Mike Stanz of PPL, Dave Defide of Duquesne Light, and Diane Rapp, Stephanie Dalton, and Troy Klink of FirstEnergy. Additionally, the SWE acknowledges the staff of the Pennsylvania Public Utility Commission's (PUC's) Bureau of Technical Utility Services (TUS) for their assistance and support in all aspects of the SWE's work during Phase IV, including providing valuable guidance throughout this study and in the writing of this report.

Acronyms

Acronym	Term
AC	Air Conditioner
ACH50	Air Changes per Hour with a 50 pascal pressure gradient
ACS	American Community Survey
AFUE	Annual Fuel Utilization Efficiency
ASHP	Air-Source Heat Pump
BTU	British Thermal Unit
BTUh	British Thermal Units per Hour
CAC	Central Air Conditioner
CFL	Compact Fluorescent Lamp
CFM25	Cubic Feet per Minute with a 25 pascal pressure gradient
CLG	Cooling
COP	Coefficient of Performance
DHW	Domestic Hot Water
ECM	Electronically Commutated Motor
EDC	Electric Distribution Company
EER	Energy Efficiency Ratio
EF	Energy Factor
EPS	Expanded Polystyrene
ERV	Energy Recovery Ventilation
EUI	Energy Use Intensity
FGB	Fiberglass Batt
GSHP	Ground Source Heat Pump
HERS	Home Energy Rating System
HRV	Heat Recovery Ventilation
HSPF	Heating Season Performance Factor
HTG	Heating
HVAC	Heating Ventilation and Air Conditioning
IECC	International Energy Conservation Code
kWh	Kilowatt Hour
LAP	Lights and Appliances
LED	Light-Emitting Diode
LTO	Leakage to Outside
MWh	Megawatt Hour
PTAC	Packaged Terminal Air Conditioner
PTHP	Packaged Terminal Heat Pump
PUC	Public Utility Commission

PV	Photovoltaic
REM/Rate™	Residential Energy Modeling and Rating software by NORESCO
RESNET	Residential Energy Services Network
R-value	A measure of material's resistance to the flow of heat
SEER	Seasonal Energy Efficiency Ratio
SWE	Statewide Evaluator
TDL	Total Duct Leakage
TE	Thermal Efficiency
TRM	Technical Reference Manual
TUS	Technical Utility Services
UC	Unconditioned
UEF	Uniform Energy Factor
UFFI	Urea-formaldehyde
XPS	Extruded Polystyrene

Executive Summary

This report presents the results of a residential energy-efficiency baseline study conducted in 2023 in the service territories of the seven major Electric Distribution Companies (EDCs) in Pennsylvania. The Pennsylvania Public Utility Commission (PUC) contracted with NMR Group, Inc., Demand Side Analytics, Brightline Group, and Optimal Energy – collectively the SWE team – to conduct this study as one element of the PUC's enforcement responsibilities under Act 129.

Act 129, enacted in 2008, requires each of the seven electric distribution companies (EDCs) with more than 100,000 customers to achieve a specified amount of energy savings over multiyear phases. Phase IV started on June 1, 2021, and will end on May 31, 2026. The PUC is establishing the framework for a potential Phase V, which would begin June 1, 2026.

The study was designed to meet the following objectives:

1. Characterize measure-level efficiencies for Pennsylvania's existing residential building stock statewide and by EDC.
2. Determine the current saturation[1] of energy-using equipment in the residential housing stock statewide and by EDC.
3. Determine the percent of energy-using equipment by end-use that is high-efficiency equipment (e.g., ENERGY STAR).
4. Estimate energy consumption by end-use and heating fuel for the residential housing stock statewide and by EDC.
5. Inform the market potential study for a potential Phase V of Act 129.
6. Inform the update of the 2026 TRM for a potential Phase V of Act 129.
7. Compare current residential efficiency levels to the results of previous Act 129 baseline studies.

Auditors audited 286 homes to collect information on insulation, heating and cooling equipment, lighting, appliances, air leakage, and duct leakage. A sub-sample of 72 homes received diagnostic testing (i.e., air leakage and duct leakage to outside testing) and received full energy modeling, including the calculation of Home Energy Rating System (HERS) Index scores.[2] The SWE evenly spread the sample of 286 homes across all seven EDCs and designed it to match statewide mixes of home type and income status as estimated by the US Census American Community Survey

[1] Saturation is defined as the amount of a measure or technology, such as lighting, that is a specific subtype of that measure. For example, the saturation of LEDs refers to the percent of all light bulbs that are LED bulbs. A related term is penetration which is defined as the number of homes that have at least one of the relevant measures. For example, the penetration of LED bulbs is the percentage of homes that have at least one LED bulb.
[2] The Home Energy Rating System (HERS), developed by the Residential Energy Services Network (RESNET) is a widely used system to measure efficiency in homes. See https://www.resnet.us/hers-index-score-card.

(ACS).[3] Additionally, the SWE team sought a sample that was representative of the mix of heating fuel and home vintages statewide. In addition, to boost the sample sizes for key energy consuming measures, the SWE incorporated an optional survey that allowed survey respondents to submit pictures of appliances and mechanical equipment in their homes.

The recruiting process differed between single-family and multifamily homes. For single-family and multifamily homes, the SWE selected a recruiting sample of customers from the full set of residential billing records provided by the EDCs and contacted occupants directly. Multifamily homes were more difficult to recruit because they required the participation of both tenants and owners or property managers. The SWE team employed multiple methods to generate multifamily contacts, including using billing data, internet searches, and EDC-supplied customer contacts.

Statewide Results for Key Measures

Results for key measures are summarized below for each home type and statewide. The statewide values, in the last column, were weighted to estimate values for the entire housing stock of Pennsylvania.[4] The average HERS score of 107.8 indicates that the average single-family home in Pennsylvania, regardless of vintage, is about 58% less efficient than a home built to code in 2021.[5]

---

[3] Statewide shares were estimated using the American Community Survey five-year Estimates for 2016-2021 https://data.census.gov/mdat/#/search?ds=ACSPUMS5Y2020&vv=POVPIP%280%3A150%29&cv=ucgid&rv=BLD&wt=WGTP&g=0400000US42

[4] The *Count* of homes in the sample is not weighted.

[5] The Pennsylvania Uniform Construction Code Review and Advisory Council adopted 2018 IECC standards in spring of 2021, which took effect in October 2021: https:/www.dli.pa.gov/ucc/Documents/ICC-Code-Review-2018-Final-Report.pdf%20; https://www.energycodes.gov/status/states/pennsylvania. Builders will be able to prove compliance by achieving a HERS Index value of 62 (for climate zone 4) or 61 (for climate zones 5 and 6).

	Detached Single-family	Attached Single-family	Multifamily	Statewide
Count	189	28	69	286
Average Age in Years	54	52	64	56
Average HERS Score*	107.1	76.9	NA	107.8
Average ACH50*	11.8	6.0	NA	11.4
Average Duct Leakage*	7.9	4.4	NA	7.6
Exterior Wall R-value	13.5	13.5	10.2	13.0
Flat Ceiling R-value	27.2	28.3	20.9	27.3
Vaulted Ceiling R-value	23.8	16.2	40.3	22.9
Floor Over Basement R-value	6.9	10.0	1.4	6.9
Cond. Bsmnt. Wall R-value	7.9	7.0	0.0	7.4
% of Prgm. Thermostats	77%	72%	43%	70%
Heating System AFUE (systems with AFUE)	89.5	88.1	89.8	88.1
Cooling System SEER2 (systems with SEER/SEER2)	13.7	13.7	13.6	13.9
Water Heating System UEF (systems with UEF)	0.80	0.81	0.97	0.82
% of Sockets with LED	57%	61%	69%	59%

* Based on the 72 homes that received full energy modeling.

Comparison to Previous Studies

Table 1 compares key measures from the on-site sample of this study to the three other most recent studies: the 2018 baseline study,[6] the 2013 baseline study,[7] and the 2011 baseline study.[8] Comparisons were not made for average mechanical equipment efficiency, air leakage, duct leakage, or HERS score because such data was not reported in the 2011 and 2013 studies. Testing for statistical differences was conducted for comparisons with previous studies, by EDC, and by income status at the 95% confidence level. When there is a statistically significant difference between results, this represents that there is 95% probability that the compared results are truly different from each other, and only a 5% probability that observed differences happened by chance. Bold text indicates that the value is statistically significantly different from another value in the table. Superscript letters identify the specific two values that have statistically significant differences. Throughout the report, the terms “significant” and “significantly” always refer to *statistical* significance at the 95% confidence level. Additional details on statistically significant differences are discussed in Section 3.5. Note that this study and the 2018 study

[6] https://www.puc.pa.gov/Electric/pdf/Act129/SWE-Phase3_Res_Baseline_Study_Rpt021219.pdf
[7] http://www.puc.pa.gov/Electric/pdf/Act129/SWE-2014_PA_Statewide_Act129_Residential_Baseline_Study.pdf
[8] http://www.puc.pa.gov/electric/pdf/Act129/PA_Residential_Baseline_Report2012.pdf

improved on shell and lighting methods used in the 2013 and 2011 studies by using methods more consistent with Residential Energy Services Network (RESNET) protocols and recent baseline studies in the Northeast.[9] Therefore, values reported elsewhere in this report are not comparable to the previous study. To facilitate comparisons, the SWE team re-calculated efficiency values for lighting and shell measures in Table 1 to match the methods used in the previous studies, as follows:

Lighting: Previous reports presented lighting data in a variety of ways, including adjusting socket counts by socket type and separating interior and exterior lighting. The SWE team kept the changes to the lighting market in mind for this iteration of the report, including the prevalence of LED[10] retrofits in many socket types and locations. Lighting tables include all socket types – screw based of varying sizes, pin-based, exterior – and include empty sockets in saturation tables as they represent opportunities for retrofits to LED bulbs as well. For comparison to previous reports, 2023 lighting data is separated in Table 1 by interior and exterior sockets to match previous methodology, but each category still includes all lighting technology and socket types.

LEDs' dominance now displaces both CFL and inefficient bulb types.

The saturation (i.e., the percent of bulbs that are a certain type) of efficient lighting has increased over time, however LEDs now dominate compared to other efficient types like CFLs.[11] LED saturation has risen from 2% in 2013, to 20% in 2018, now to 59% of all sockets observed in the statewide sample. LEDs are replacing both efficient and inefficient bulbs. CFL saturation has decreased from 22% to 6% in that same span of time. Incandescent saturation has more than halved, from 59% to 25%, in that same span of time. Figure 1 displays the increase in efficient lighting saturation across all four studies, as well as the displacement of CFLs by LEDs in terms of both saturation and penetration. LED penetration has also increased dramatically from 17% in 2013 to 99% in the current study. LED saturation in Pennsylvania was greater than that of other

---

[9] Recent studies include studies in Massachusetts (https://ma-eeac.org/wp-content/uploads/RLPNC-17-2-Single-Family-New-Construction-Mini-Baseline-Study.pdf), Connecticut (https://energizect.com/sites/default/files/documents/R1602-RNC%20Baseline%20Report-FINAL%2020180503_Revised.pdf), and Rhode Island (http://rieermc.ri.gov/wp-content/uploads/2018/03/ri-rnc-baseline-study_16jan2018_final.pdf)

[10] Light-emitting diodes (LEDs) are an efficient semiconductor lighting technology. See https://en.wikipedia.org/wiki/Light-emitting_diode.

[11] Saturation is defined as the amount of a measure or technology, such as lighting, that is a specific subtype of that measure. For example, the saturation of LEDs refers to the percent of all light bulbs that are LED bulbs. A related term is penetration which is defined as the number of homes that have at least one of the relevant measures. For example, the penetration of LED bulbs is the percentage of homes that have at least one LED bulb.

northeastern states with similar programs such as Maryland (55% single-family; 45% multifamily),[12] Vermont (55%),[13] and New Hampshire (51%).[14]

Appliances: The share of appliances that were ENERGY STAR qualified increased over time. Specifically, the shares of ENERGY STAR qualified refrigerators, freezers, dishwashers, clothes washers, and clothes dryers have increased since 2018. ENERGY STAR qualifications for dryers were only introduced recently and thus there were only ENERGY STAR dryers in the 2018 study. Additionally, the 2011 and 2013 studies did not report on dehumidifier ENERGY STAR status.

Shell Measures: The 2011 and 2013 reports included R-value[15] data in shell analyses only when insulation was present regardless of whether the insulation only comprised a small fraction of the building shell. This fails to properly consider the impact of uninsulated homes when trying to determine the average R-value of a shell measure in the sample. Additionally, the 2011 and 2013 reports assigned a per-home R-value based on the insulation type and thickness installed in the majority of area in each measure for each home. This report follows the RESNET guidelines for calculating an area-weighted average R-value per-home. When comparing between reports, the 2018 and 2023 results are still area-weighted R-values but exclude uninsulated cases to allow for a more direct comparison. Elsewhere in this report, uninsulated cases are included when calculating the average R-value per measure, except where otherwise specified.

Insulation values have generally stayed the same or trended slightly upwards since 2011 but have shown variability over the four baseline studies. There are several factors that could be attributed to the observed insulation values, including differences in data collection practices between studies, random sample variation, larger sample size of newer homes in the current study, and potential weatherization efforts aimed at enhancing energy efficiency.

[12] EmPOWER Maryland Residential Baseline Study. December 31, 2022. Submitted to EmPOWER Maryland by Applied Energy Group and Verdant Associates. https://verdantassoc.com/deep-dives/empower-maryland-residential-baseline-study/

[13] 2020 Vermont Single-Family Residential New Construction Baseline and Code Compliance Study. January 24, 2023. Submitted to the Vermont Department of Public Service by NMR Group, Inc. https://publicservice.vermont.gov/sites/dps/files/documents/VT_2020_SF_RNC_Baseline_Final_Report_Jan242023.pdf

[14] New Hampshire Residential Baseline Study. June 11, 2020. Submitted to the New Hampshire Evaluation, Measurement and Verification Working Group by Dunsky Energy Consulting. https://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/20200826-Electric-MER-NHSaves-Res-Baseline-Report-Final.pdf

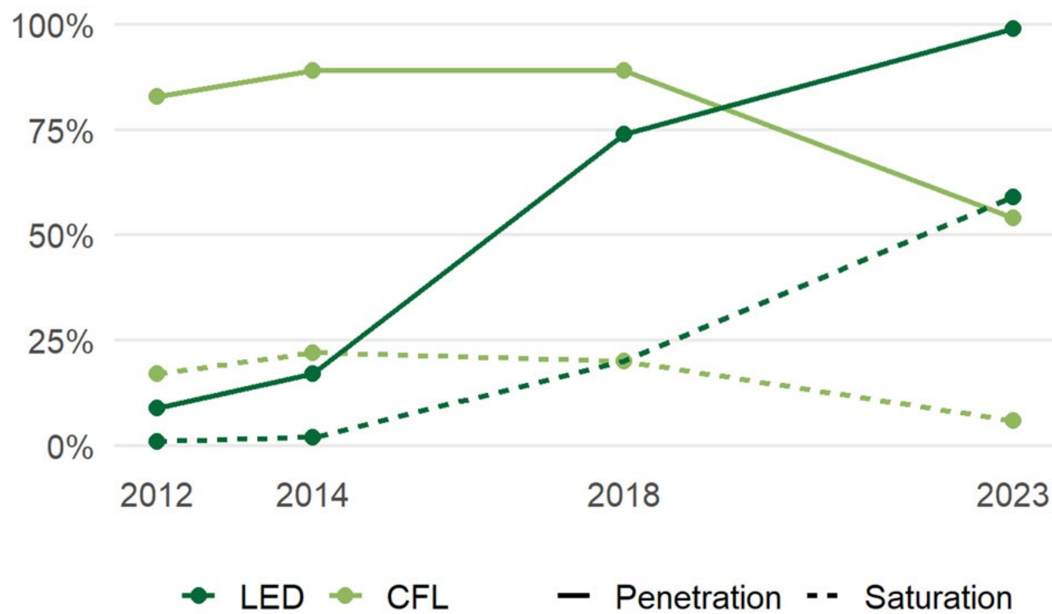
[15] R-value is a measure of the capacity of a material to resist heat flow. A material with a higher R-value is more insulating.

Table 1: Comparison of Efficiency Measures Across Studies

	2011	2013	2018	2023
Lighting				
CFL Saturation (Interior)	**17%**	**22%**[a]	**20%**[a,b]	**7%**[a,b,c]
CFL Saturation (Exterior)	**12%**	**19%**[a]	**21%**[a]	**7%**[a,b,c]
LED Saturation (Interior)	**1%**	**2%**[a]	**20%**[a,b]	**60%**[a,b,c]
LED Saturation (Exterior)	**--**	**2%**[a]	**18%**[a,b]	**58%**[a,b,c]
LED Penetration (Interior)	**9%**	**17%**[a]	**74%**[a,b]	**99%**[a,b,c]
Appliances (Percent ENERGY STAR)				
Refrigerator	**20%**	**31%**[a]	**31%**[a]	**48%**[a,b,c]
Freezer	**7%**	**15%**[a]	**10%**[a]	**19%**[a,c]
Clothes Washer	**24%**	**26%**	**40%**[a,b]	**52%**[a,b,c]
Clothes Dryer	--	--	4%	**27%**[c]
Dishwasher	**38%**	**44%**	**57%**[a,b]	**70%**[a,b,c]
Dehumidifier	--	--	83%	90%
Room AC	**21%**	26%	**33%**[a]	**32%**[a]
Shell (Average R-value)[1]				
Flat Ceiling	R-24	R-25	R-23	R-29
Cathedral Ceiling	R-24	R-25	R-21	R-26
Ambient Walls	R-15	R-13	R-11	R-15
Frame Floor to UC Bsmt/ECS	R-16	R-19	R-12	R-23
Conditioned Foundation Wall	R-14	R-13	R-10	R-13

[a] Significantly different from the 2011 sample at the 95% confidence level.
[b] Significantly different from the 2013 sample at the 95% confidence level.
[c] Significantly different from the 2018 sample at the 95% confidence level.
[1] There is no recorded information on standard deviations among insulated-only subsamples for prior years, so significance testing cannot be performed for these measures.

Figure 1: Efficient Lighting Across Studies



Comparisons by EDC

Table 2 compares key measures across all EDCs. Results are unweighted. Again, bold text indicates that the value is significantly different from the value of another EDC. Superscript letters identify the specific two EDCs that are statistically different.

Throughout the rest of the report, results are primarily reported by home type since in some instances the sample sizes by EDC are small. For detailed results by EDC see Appendix D, Appendix F, Appendix G, and Appendix H.

LED bulb saturation in Met-Ed homes was significantly higher than all other EDCs at 71%. Duquesne had significantly lower LED saturation than the other EDCs at 48%. All EDCs showed LED penetration rates of 98% or above, and with rates of 100% in four EDCs (Duquesne, Met-Ed, Penelec, and Penn Power).

Table 2: Comparison of Efficiency Measures by EDC

	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn
Lighting							
LED Saturation	**59%[c]**	**59%[c]**	**48%**	**71%[a,b,c]**	**62%[a,b,c,d]**	**53%[a,b,c,d,e]**	**58%[c,d,e,f]**
CFL Saturation	**5%[c]**	**5%[c]**	**10%**	**6%[c]**	**6%[c]**	**11%[a,b,d,e]**	**6%[c,f]**
Total Efficient Bulb Saturation[1]	**67%**	**75%[a,c]**	**66%**	**80%[a,b,c]**	**73%[a,c,d]**	**79%[a,b,c,e]**	**71%[a,b,c,d,f]**
LED Penetration	98%	98%	100%	100%	100%	100%	98%
Appliances (Percent ENERGY STAR)							
Refrigerator	**44%**	**56%**	**45%**	**62%[a]**	51%	51%	**37%[b,c,d]**
Freezer	**6%**	**30%[a]**	27%	23%	**28%[a]**	**29%[a]**	25%
Clothes Washer	58%	53%	46%	55%	61%	56%	47%
Clothes Dryer	**36%[c]**	28%	**17%**	27%	31%	36%	31%
Dishwasher	**67%**	**67%**	74%	**84%[a,b]**	80%	**86%[a,b]**	**89%[a,b]**
Dehumidifier	87%	93%	80%	90%	92%	91%	80%
Room AC	42%	27%	17%	18%	43%	57%	31%
Shell (Average R-value)							
Flat Ceiling	26.3	28.5	**23.5**	26.2	28.0	**29.8[c]**	25.2
Vaulted Ceiling	18.0	29.0	14.6	23.7	26.0	28.3	22.7
Ambient Walls	**12.6[c]**	**12.9[c]**	**9.2**	**13.5[c]**	**14.6[c]**	**15.6-[a,b,c]**	**11.3[f]**
Frame Floor to UC Bsmt/ECS	**1.1**	**11.3[a,c]**	**0.0[5]**	**17.0[a,c]**	7.5	**5.0[d]**	**2.7[b,d]**
Conditioned Foundation Walls	8.1	**5.4**	**5.2**	**11.7[b,c]**	**4.7[d]**	**11.5[b,c,e]**	**6.4[d]**
Mechanical Equipment Efficiency							
Heating (AFUE)	**86.4[c]**	**86.9[c]**	**90.6**	**91.1[a,b]**	**88.1[d]**	**92.7[a,b,e]**	89.4
Cooling (SEER2)[2]	**13.8[c]**	**15.0[c]**	**13.1**	**14.1[c]**	14.1	**13.0[b,d]**	**13.3[b,4]**
Water Heating (UEF)[3]	**0.84[c]**	**0.90[c]**	**0.69**	**0.90[c]**	**0.85[c]**	0.83	**0.79[b,c]**

[a] Significantly different from the PECO sample at the 95% confidence level.
[b] Significantly different from the PPL sample at the 95% confidence level.
[c] Significantly different from the Duquesne Light sample at the 95% confidence level.
[d] Significantly different from the FE: Met-Ed sample at the 95% confidence level.
[e] Significantly different from the FE: Penelec sample at the 95% confidence level.
[f] Significantly different from the FE: Penn Power sample at the 95% confidence level.
[1] Includes LED, CFL, and fluorescent bulbs.
[2] Includes all systems with SEER2 and SEER ratings converted to SEER2.
[3] Includes all systems with UEF ratings and EF ratings converted to UEF.
[4] The statewide value in SEER is 13.7. SEER to SEER2 conversions can be found in Table 200 in Appendix G.
[5] None of the 13 homes with unconditioned basements in Duquesne Light territory had insulation present. It should be noted that 70% of unconditioned basements were uninsulated, statewide. See Appendix D.3 for additional EDC-specific framed floor details.

Comparison of Findings by Income Status

The SWE team characterized each home as being above or below the low-income threshold based on the criteria of household income being at or below 150% of the federal poverty income guidelines.

Table 3 compares results for key measures observed at audited homes by income status excluding 11 homes for which the occupants declined to divulge income information. Overall, efficient bulb saturation was not significantly different between low-income and non-low-income homes. However, LED saturation was (9%) lower in low-income homes than in non-low-income homes, while CFL saturation was (29%) higher in low-income homes than in non-low-income homes. Both of these differences were statistically significant. Figure 2 shows bulb type saturation by income status in more detail. Non-low-income homes had significantly higher R-values in framed floors over unconditioned basements compared to low-income homes.

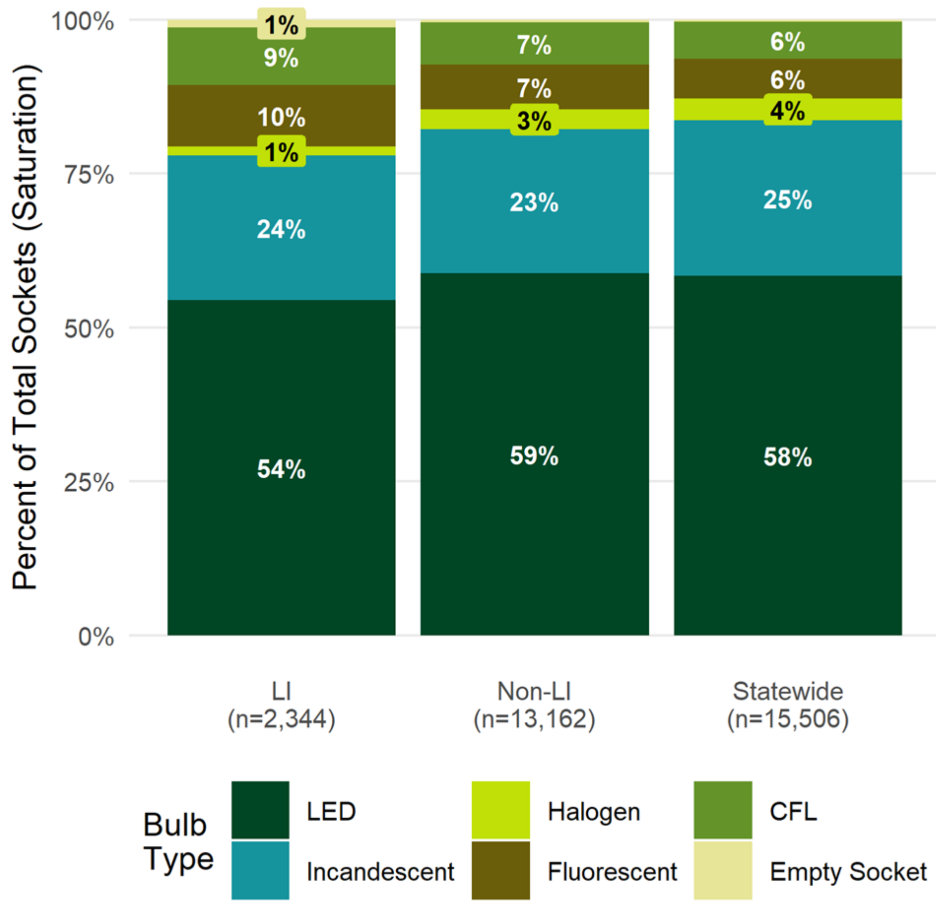
Table 3: Comparison of Efficiency Measures by Income Status

(Base: Site Visits)

	Low-Income *(Sites=65)*	Non-Low-Income *(Sites=210)*
Lighting		
Efficient Lighting Saturation	74%	73%
CFL Saturation	**9%**	**7%**[a]
LED Saturation	**54%**	**59%**[a]
Shell (Average R-value)		
Flat Ceiling	24.3	27.6
Vaulted Ceiling	17.1	24.3
Ambient Walls	11.6	13.2
Frame Floor to UC Bsmt/ECS	**1.2**	**9.0**[a]
Conditioned Foundation Walls	7.9	7.8

[a] Significantly different from the low-income sample at the 95% confidence level.

Figure 2: Bulb Type Saturation by Income Level



Labels omitted for categories accounting for <1% of percent of total sockets.

Table 4 compares results for key measures observed both at audited homes and from the self-audit submissions for mechanical equipment and appliance by income status, excluding 22 homes for which the occupants declined to divulge income information. There were no statistically significant differences observed between the low-income and non-low-income samples for mechanical equipment. Low-income homes had lower rates of ENERGY STAR qualified freezers, clothes washers, and dishwashers, which were statistically significant differences. Low-income homes also had lower rates of ENERGY STAR qualified refrigerators and clothes dryers, but those differences were not statistically significant. Low-income homes did have significantly higher rates of ENERGY STAR qualified dehumidifiers and higher rates of ENERGY STAR qualified room air conditioners, but those differences were not statistically significant.

Table 4: Comparison of Efficiency Measures by Income Status

(Base: Full Sample)

	Low-Income *(Sites=131)*	Non-Low-Income *(Sites=397)*
Appliances (Percent ENERGY STAR)		
Refrigerator	49%	52%
Freezer	**7%**	**24%**[a]
Clothes Washer	**44%**	**58%**[a]
Clothes Dryer	27%	33%
Dishwasher	**60%**	**76%**[a]
Dehumidifier	**100%**	**85%**[a]
Room AC	33%	30%
Mechanical Equipment Efficiency		
Heating Equipment (AFUE)	87.8	89.6
Cooling Equipment (SEER2)[1]	13.3	13.8
Water Heating Equipment (UEF)[2]	0.79	0.84

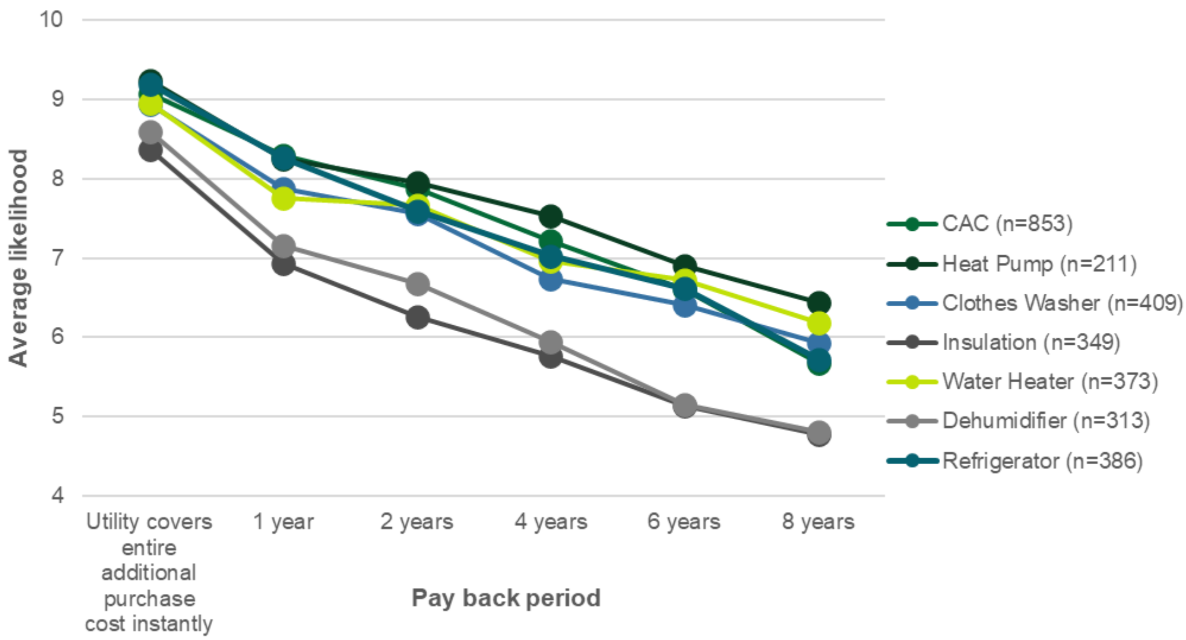
[1] Includes all systems with SEER2 ratings and SEER ratings converted to SEER2.
[2] Includes all systems with UEF ratings and EF ratings converted to UEF.
[a] Significantly different from the low-income sample at the 95% confidence level.

Willingness to Pay Findings

A willingness-to-pay web survey was distributed to a sample of each EDC's customers to provide insight into their likelihood of purchasing higher efficiency options based on specific payback periods.

Respondents were asked a battery of three questions regarding their likelihood to purchase a higher energy efficient equipment option for a variety of payback periods (question one results are displayed in Figure 3). Heat pumps, central air conditioners, refrigerators, and water heaters had the highest purchase likelihoods for all three sets of payback periods. Web survey respondents were more likely to report they would purchase a higher efficiency HVAC option (i.e., heat pump or central air conditioner) when the utility covered the entire incremental cost of the measure. Dehumidifiers were a consistently low-scoring measure regardless of payback period or utility incentive. Insulation measures were consistently ranked the lowest likelihood for respondents to purchase a higher efficiency option, regardless of payback period or utility incentive. The low scores for insulation may be attributed to the more invasive process of adding insulation to a home. This deviates from the 2018 willingness to pay findings, as insulation was ranked among the highest measures respondents were willing to pay for.

Figure 3: Likelihood to Purchase Higher Efficiency Measures by Payback Period and if their Utility Covers the Entire Additional Cost of the Higher Efficiency Option



Section 1 Introduction

This report presents the results of a residential energy-efficiency baseline study conducted in 2023 in the service territories of the seven major Electric Distribution Companies (EDCs) in Pennsylvania. The Pennsylvania Public Utility Commission (PUC) contracted with NMR Group, Inc., Demand Side Analytics, Brightline Group, and Optimal Energy – collectively the SWE team – to conduct this study as one element of the PUC's enforcement responsibilities under Act 129. The study was designed to meet the following objectives:

1. Characterize measure-level efficiencies for Pennsylvania's existing residential building stock statewide and by EDC.
2. Determine the current saturation of energy-using equipment in the residential housing stock statewide and by EDC.
3. Determine the percentage of energy-using equipment by end-use that is high-efficiency equipment (e.g., ENERGY STAR).
4. Estimate energy consumption by end-use and heating fuel for the residential housing stock statewide and by EDC.
5. Inform the market potential study for Phase V of Act 129.
6. Inform the update of the 2026 TRM for Phase V of Act 129.
7. Compare current residential efficiency levels to the results of previous Act 129 baseline studies.

For this study, the SWE conducted onsite energy-efficiency audits at 286 existing single-family and multifamily homes varying in vintage, heating fuel, and income status. The sites were located throughout the service territories of the following EDCs:

- PECO Energy Company (PECO)
- PPL Electric Utilities (PPL)
- Duquesne Light Company (Duquesne Light)
- First Energy: Metropolitan Edison Company (FE: Met-Ed)
- First Energy: Pennsylvania Electric Company (FE: Penelec)
- First Energy: Pennsylvania Power Company (FE: Penn Power)
- First Energy: West Penn Power Company (FE: West Penn)

The SWE designed the onsite data collection with the PUC to ensure comparability with the results of the previous baseline studies, conducted in 2011, 2013, and 2018. To provide a more detailed assessment of the energy features of single-family homes, this study also included energy modeling for a subset of 72 detached, attached, and mobile/manufactured single-family homes. These homes received full diagnostic testing, including the quantification of air leakage and duct leakage where possible. The SWE team generated HERS Index scores for each of these 72 homes. A new component of the 2023 baseline study is the inclusion of a web survey that allowed participants to submit photographs of key energy consuming equipment (e.g., heating and cooling equipment, water heating equipment, and appliances) for an incentive. This additional evaluation activity (referred to throughout the report as “self-audits”) allowed the SWE to boost the sample sizes for these measures without adding additional site visits.

1.1 ACT 129 BACKGROUND

Pennsylvania enacted Act 129 in October of 2008. Act 129 requires each of the seven EDCs to achieve a specified amount of energy savings in their respective service territories over multiyear phases. The Pennsylvania PUC sets the savings targets prior to the start of each phase. Phase IV started on June 1, 2021, and will end on May 31, 2026. The PUC is establishing the framework for a potential Phase V, which would begin June 1, 2026.

The PUC will use an electric efficiency market potential study prepared by the SWE team to inform the savings targets. The residential baseline study is a key input into the market potential study, along with a commercial and industrial baseline study that the SWE team is conducting at the same time as the residential baseline study.

This residential baseline study will also supply several important inputs to the Phase V update of the Act 129 TRM (the 2026 TRM).[16] The TRM serves a variety of purposes for Act 129. In addition to providing measure savings protocols, the TRM ultimately seeks to facilitate the implementation and evaluation of Act 129 programs. The TRM serves as a common reference document for energy-efficiency measures and establishes standardized, statewide protocols to calculate energy and demand savings for measures.

[16] http://www.puc.pa.gov/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx

Section 2 Characterization of Electric Customers and Sales

Data from the U.S. Energy Information Administration (EIA) for 2021 show that sales to residential customers of the seven EDCs subject to Act 129 are 36% of the total sales statewide (Table 5). The average residential customer in the Act 129 EDC service territories uses 11.9 times less electricity per year than the average non-residential customer. However, there are more than seven times as many residential customers. The table is only meant to provide context about Act 129. It cannot be used to assess the effectiveness of Act 129 since multiple factors affect the energy consumption of any customer and those factors are not considered here.

Table 5: 2021 Electricity Sales in Pennsylvania[17]

	Sales (MWh)	Customers	Per Customer (kWh)
Pennsylvania (Total Customers)	143,340,160	6,218,102	23,052
Act 129 EDCs (Total Customers)	137,076,639 (96%)	5,824,758 (94%)	23,533
Act 129 EDCs (Residential Customers)	52,299,503 (36%)	5,126,444 (82%)	10,202

Table 6 shows the trends in residential electricity consumption from 2013-2021, the period including the previous baseline study, for customers of the Act 129 EDCs. While sales have remained relatively flat each year since 2013, the number of customers has increased and thus sales per customer have declined slightly, on average by 0.08% per year.[18, 19] In 2014, PJM predicted average annual growth rates of 1.4% through 2021 for the Act 129 EDCs.[20] The actual average annual growth rate was 0.5%. The actual annual growth rate only exceeded 1.4% twice (2017-2018 and 2019-2020) and growth was negative for three of the seven years. Going forward, the 2023 PJM load forecast predicts annual growth rates of less than 1% in Pennsylvania zones from 2023-2033.[21]

[17] US Energy Information Administration (EIA), https://www.eia.gov/electricity/data.php. Accessed July 6, 2023.
[18] Note that these sales figures are not weather normalized. Weather changes from year to year will affect electricity demand for heating and cooling and other end uses. As shown in the Diagnostic section, nearly half of the electric consumption in the average single-family home goes to space heating or cooling.
[19] The overall average electric consumption for all households in the state of Pennsylvania is 10,402 kWh/year, indicating ACT 129 customers have slightly lower electric consumption than the statewide average. https://www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/PA.pdf
[20] PJM Resource Adequacy Planning Department, PJM Load Forecast Report 2014. Table E-1: Annual Net Energy and Growth Rates for Each PJM Mid-Atlantic Zone and Geographic Region, 2014-2024. https://www.pjm.com/-/media/library/reports-notices/load-forecast/2014-load-forecast-report.ashx. Accessed July 2023.
[21] PJM Resource Adequacy Planning Department, PJM Load Forecast Report 2023. Table E-1: Annual Net Energy and Growth Rates for Each PJM Mid-Atlantic Zone and Geographic Region, 2023-2033. https://www.pjm.com/-/media/library/reports-notices/load-forecast/2023-load-report.ashx. Accessed July 2023.

Table 6: Act 129 EDC Residential Electricity Sales in Pennsylvania (2013-2021)[22]

Year	Sales (MWh)	Customers	Per Residential Customer (kWh)
2013	50,822,507	4,928,276	10,312
2014	50,726,906	4,944,568	10,259
2015	50,942,854	4,958,796	10,273
2016	50,443,722	4,987,885	10,113
2017	48,353,538	5,009,255	9,653
2018	52,269,347	5,042,785	10,365
2019	50,842,795	5,069,686	10,029
2020	51,707,449	5,097,866	10,143
2021	52,299,503	5,126,444	10,202

A primary goal of this report is to characterize how residential customers use electricity in their homes and how electricity consumption varies for different EDC service territories, home types, and heating fuels. These values are a primary input for the market potential study that will help the PUC and EDCs implement effective programs to save energy and meet the requirements of Act 129.

To achieve a reliable, fine-grained view of electricity use by EDC, home type, and heating fuel, the SWE team made use of the Census' Public Use Microdata Sample (PUMS) for the five-year averages of the American Community Survey (ACS) for 2017-2021.[23] This dataset is an anonymized version of the ACS that allows analysis of data that are not pre-tabulated by the Census at the level of the individual household. The PUMS includes a field for the monthly electric bill that, along with data on home type and fuel type, can be translated to consumption estimates for a non-Census geography, such as the EDC service territories. This data source is preferable to the residential billing data, which do not include reliable information about home type or heating fuel. Table 167 in Appendix A includes the full estimates of annual consumption for residential customers by EDC, home type, and heating fuel. The following summary tables show consumption and customer estimates by these categories individually. In Table 7, we see that Duquesne Light, an urban EDC with one of the lowest shares of electrically heated homes, has the lowest consumption per customer.

[22] ibid.

[23] US Census American Community Survey PUMS Data. https://www.census.gov/programs-surveys/acs/microdata/access.html

Table 7: 2021 Electricity Consumption by EDC

EDC	Consumption (MWh)	Customers	Per Customer (kWh)
PECO	14,299,745 (27%)	1,513,921 (30%)	9,446
PPL	14,746,362 (28%)	1,278,614 (25%)	11,533
Duquesne Light	4,220,976 (8%)	544,439 (11%)	7,753
FE: Met-Ed	5,832,423 (11%)	512,214 (10%)	11,387
FE: Penelec	4,330,930 (8%)	498,418 (10%)	8,689
FE: Penn Power	1,662,851 (3%)	148,1389 (3%)	11,225
FE: West Penn	7,206,216 (14%)	630,699 (12%)	11,426

Customers occupying detached single-family homes have the highest annual consumption whereas, customers residing in multifamily dwellings have the lowest, as shown in Table 8. This is likely influenced by the larger size of detached single-family homes compared to other home types.[24] In addition, the average household size for detached single-family homes is also larger than other home types.[25]

Table 8: 2021 Electricity Consumption by Home Type

Home Type	Consumption (MWh)	Customers	Per Customer (kWh)
Detached Single-family	37,799,022 (72%)	3,402,903 (66%)	11,108
Attached Single-family	6,235,012 (12%)	654,163 (13%)	9,531
Multifamily	6,129,853 (12%)	845,350 (16%)	7,251
Manuf./Mobile	2,135,616 (4%)	224,028 (4%)	9,533

Table 9 shows consumption by heating fuel. Customers with electric heat have the highest annual consumption, as expected. While they make up the largest share of customers and total electricity consumption, natural gas customers have the lowest annual electricity use. Natural gas service is commonly available only in more densely populated areas with higher shares of smaller, detached, and multifamily homes. Electric consumption data is further broken out by heating fuel, home type, and EDC in Appendix A.

[24] As shown in Table 25, detached single-family homes have an average conditioned floor area of 2,498 sq. ft, followed by attached single-family homes at 1,1598 sq. ft., and multifamily homes at 878 sq. ft. Manufactured/mobile homes are reported with detached single-family due to low sample sizes (six homes visited), however the average size of these six homes was 1,306 sq. ft.

[25] The average number of occupants observed during the on-site visits was largest for detached single-family homes (2.69), followed by attached single-family homes (2.58) and multifamily homes (1.92). Manufactured homes had an average of 1.67 people per unit, however the on-site study sample size for manufactured homes is low. Additionally, the web survey indicated detached single family with the highest average occupancy (2.76), followed by attached single-family (2.69), manufactured homes (2.43), and multifamily (1.99).

Table 9: Electricity Consumption by Heating Fuel

Heating Fuel	Consumption (MWh)	Customers	Per Customer (kWh)
Utility Gas	18,902,955 (36%)	2,172,835 (42%)	8,700
Electricity	16,391,500 (31%)	1,284,565 (25%)	12,760
Fuel Oil, Kerosene, etc.	9,292,164 (18%)	937,707 (18%)	9,909
Bottled, Tank, or LP Gas	3,824,635 (7%)	371,329 (7%)	10,300
Wood	2,160,475 (4%)	191,567 (4%)	11,278
Coal or Coke	929,425 (2%)	94,893 (2%)	9,794
Other Fuel	511,737 (1%)	45,826 (1%)	11,167
No Fuel Used	243,611 (<1%)	22,776 (<1%)	10,696
Solar Energy	43,001 (<1%)	4,946 (<1%)	8,694

3

Section 3 Methods

The SWE conducted audits of a representative sample of homes to assess the energy efficiency of Pennsylvania's existing housing stock.[26] This is consistent with the approach that has historically been used in Pennsylvania under Act 129, including previous residential baseline studies conducted by the prior SWE teams in 2011, 2013, and 2018. To provide greater detail and insight into the energy efficiency of single-family homes, the SWE performed diagnostic testing and generated energy models for a subset of sites. To increase the sample sizes for key energy consuming equipment, the SWE deployed a web survey that included an option for participants to provide photographs of equipment that exist in their homes.

This chapter describes the methods used throughout the study, including sampling, recruiting, inspecting, and analysis.

3.1 Baseline and Self-Audit Sampling

The study plan called for a sample of 287 energy audits comprised of 217 single-family homes and 70 multifamily housing units and/or buildings spread equally across all seven EDC service territories. The final sample had one less multifamily home than planned, bringing the total sample size to 286.[27] Within the full sample, there are different home types and visit types that warrant specific presentation and analysis in the report. In addition, the study plan boosted the sample sizes for key mechanical equipment and appliances through a web-survey based approach that allowed respondents to submit photos of equipment at their home that the SWE used to verify equipment types and efficiency levels. These web-survey based photo submissions are referred to as the self-audit sample throughout the report. The SWE omitted self-audit sites that also had an on-site visit from analysis and reporting to avoid double counting equipment in homes.

- **Full sample** refers to the entire set of 286 sites visits and 265 self-audits.
- **Total single-family sample** refers to all 217 single-family home inspections. This includes detached, attached, and manufactured or mobile homes.
- **Diagnostic sub-sample** refers to the subset of 72 homes from the total single-family sample that received full energy modeling, including the calculation of HERS Index scores. This sub-sample intentionally included an over representation of electrically heated homes or homes with air conditioning. The energy modeling results are detailed in Section 5 Diagnostic Sub-Sample Results.

[26] Throughout the report *homes* refers to both houses and apartment units.

[27] During the recruitment and inspection process, a number of scheduled sites cancelled before the site visit could be conducted, requiring replacement sites to be recruited, scheduled and inspected. Ultimately the sample size for multifamily inspections fell one unit short of the sample target.

- **Multifamily sample** refers to the 69 multifamily housing units and/or buildings. This includes buildings with as few as two stacked units to as many as 121 units. The largest complex consisted of 11 buildings and 328 units.
- **Total self-audit sample** refers to all 265 completed surveys with photo submissions. This includes detached, attached, manufactured or mobile homes, and multifamily units that did not participate in the on-site inspections.[28]

3.1.1 Full Sample Composition

The full sample is distributed across the seven EDCs with variations mainly driven by the multifamily sample (Table 10). The imbalance is due to the recruiting of more multifamily homes in the EDC service territories in or around large cities, such as Duquesne Light. For a detailed explanation of the multifamily sample and recruitment process, see section 3.2.2 Secondary Multifamily Recruitment. In an effort to reduce sample bias, an incentive of $150 was offered to on-site participants; and up to a $40 incentive was available to self-audit participants.

[28] The total number of self-audit submissions prior to removing homes with on-sites was 410.

Table 10: Sample Composition by EDC

EDC	Total Single-family	Diagnostic Sub-sample	Multifamily Sample	Full Sample
On-Site Results Only				
PECO	33	13	11	44
PPL	31	10	10	41
Duquesne Light	31	10	13	44
FE: Met-Ed	33	10	10	43
FE: Penelec	30	9	11	41
FE: Penn Power	30	9	2	32
FE: West Penn	29	11	12	41
Statewide	**217**	**72**	**69**	**286**
Self-Audit Results Only				
PECO	19		5	24
PPL	40	-	-	40
Duquesne Light	35	-	6	41
FE: Met-Ed	38	-	6	44
FE: Penelec	41	-	2	43
FE: Penn Power	35	-	1	36
FE: West Penn	35	-	2	37
Statewide	**243**	-	**22**	**265**
Total On-site and Self-Audit				
PECO	52	13	16	68
PPL	71	10	10	81
Duquesne Light	66	10	19	85
FE: Met-Ed	71	10	16	87
FE: Penelec	71	9	13	84
FE: Penn Power	65	9	3	68
FE: West Penn	64	11	14	78
Statewide	**460**	**72**	**91**	**551**

Figure 4 maps the distribution of single-family basic audits (i.e., single-family homes that did *not* receive energy modeling), single-family diagnostic audits (i.e., homes that *did* receive energy modeling), and multifamily audits across the seven major EDC service territories. Figure 5 maps the distribution of self-audit only sites.

Figure 4: Map of Sampled Homes with Audits

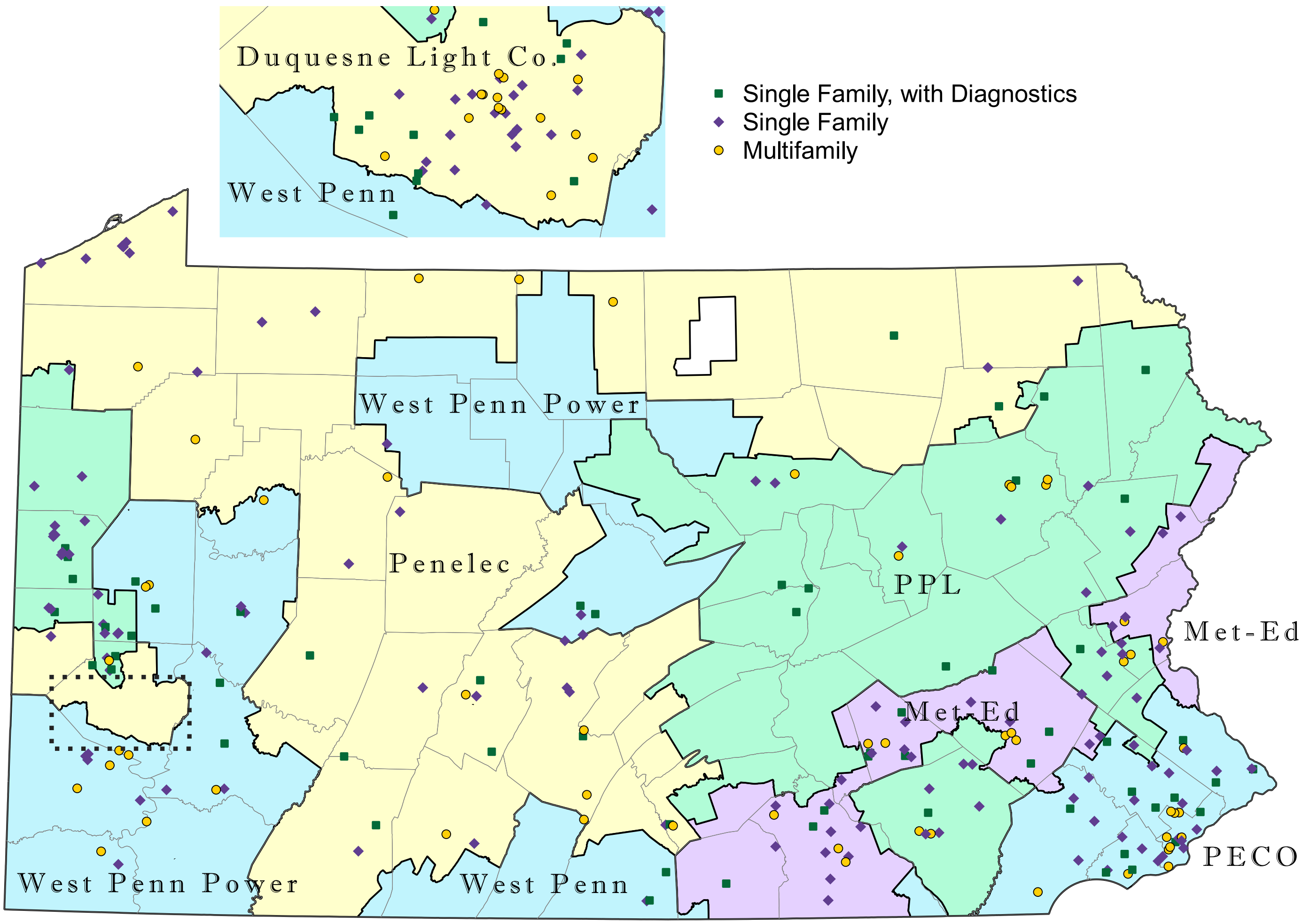
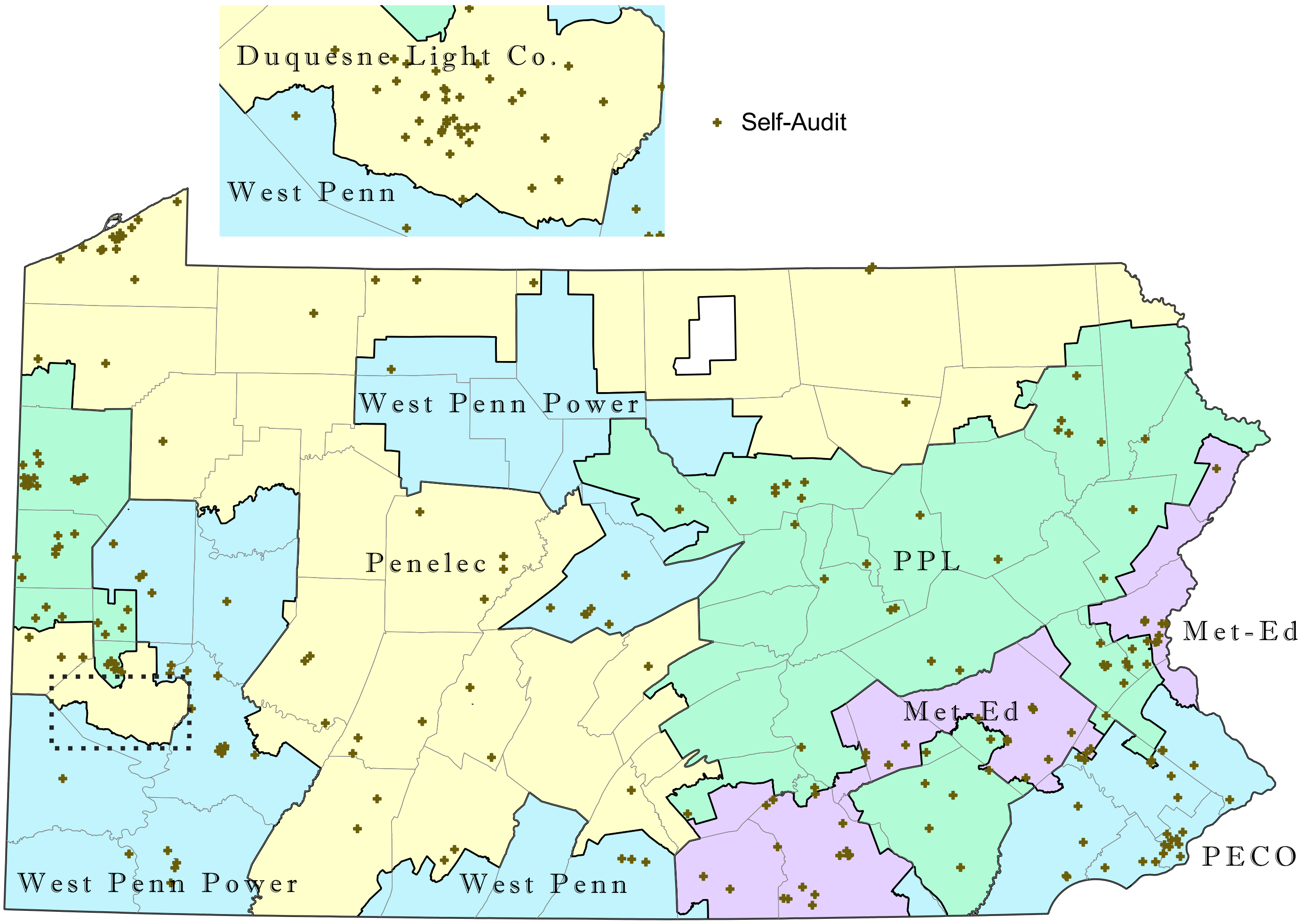


Figure 5: Map of Sampled Self-Audits



To facilitate the comparison of results, the 2023 study utilized the same housing types (single-family detached, single-family attached, mobile/manufactured home, and multifamily) as the prior baseline study. We used data from the American Community Survey (ACS) to estimate the proportion of housing types for all housing units in Pennsylvania and in turn develop targets by home type for our sample.[29] In addition, the SWE team categorized the homes as either above or below the low-income customer threshold based on the 2022 Federal Poverty Guidelines for Pennsylvania.[30] Table 11 compares the full sample's mix of home types and income statuses to the sample plan targets. Overall, the sample ended up with slightly more low-income homes in the study sample compared to the target. In addition, the study sample included fewer manufactured/mobile homes than the sample target. There was a challenge in recruiting

[29] Low-income customers are defined as households at or below 150% of the federal poverty income guidelines. https://aspe.hhs.gov/sites/default/files/documents/4b515876c4674466423975826ac57583/Guidelines-2022.pdf

[30] https://data.census.gov/mdat/#/search?ds=ACSPUMS5Y2020&vv=POVPIP%280%3A150%29&cv=ucgid&rv=BLD&wt=WGTP&g=0400000US42

manufactured homes for on-site inspections, which was largely driven by a low-response rate from the web-survey for respondents that reside in manufactured/mobile homes. The low response rate was compounded by lower rates of willingness to participate in an on-site inspection. This limited our ability to conduct on-site inspections in manufactured homes. Because of the low sample size of the manufactured/mobile homes (six on-site inspections and two self-audits) we combined them with detached single-family homes for weighting, analysis, and reporting. In addition, to account for deviations in the income targets and the achieved sample, income status was accounted for in the weighting scheme. Overall, the final sample closely matched the sample plan. The final sample error at the 90% confidence level was ±5%, for the full sample and on-site only sample, which matches the sample plan. The sample error for the self-audit only sample at the 90% confidence level was ±6%.

Table 11: On-site Sample Composition – Home Type by Income Status

Home Type	Proportion	Non-low-income	Low-income	Don't Know/ Refused	Full Sample*
Detached Single-family	Target	56%	7%	--	63%
	Sample	51%	12%	1%	64%
Attached Single-family	Target	14%	5%	--	19%
	Sample	7%	3%	--	10%
Manufactured / Mobile	Target	2%	1%	--	3%
	Sample	1%	1%	--	2%
Multifamily	Target	9%	5%	--	14%
	Sample	14%	7%	2%	24%
Full Sample	Target	81%	19%	--	100%
	Sample	73%	23%	4%	100%

* Rounding results in some rows not summing to the full sample value.

3.1.2 Total Single-family and Diagnostic Sub-Sample Targets

To account for variation in home efficiency due to vintage, the SWE team attempted to recruit a single-family sample with a vintage mix matching the statewide values for single-family homes. Table 12 and Table 13 summarize the mix of vintages and primary heating fuel for the total single-family sample and the diagnostic sub-sample.

Table 12: Total Single-family Sample Composition – Vintage

Year Built	Total Single-family (*n=217*)	Diagnostic Sub-sample (*n=72*)	ACS (*N*= 4,536,358)
2010 or later	8%	14%	3%
2000-2009	21%	19%	9%
1980-1999	16%	17%	19%
1960-1979	18%	17%	21%
1940-1959	16%	18%	22%
Before 1940	20%	15%	26%

* Rounding results in some rows not summing to the full sample value.

Table 13: Total Single-family Sample Composition – Primary Heating Fuel

Heating Fuel	Total Single-family (*n=217*)	Diagnostic Sub-sample (*n=72*)	ACS (*N*=4,084,005)
Natural Gas	61%	64%	53%
Electricity	23%	22%	18%
Oil or Kerosene	8%	6%	19%
Propane or Other Tank Gas	5%	4%	5%
Wood, Coal, or Coke	1%	1%	4%
Solar	2%	3%	1%

* Rounding results in some rows not summing to the full sample value.

3.1.3 Multifamily Sample Targets

Within the sample of 69 multifamily homes, the SWE attempted to match the mix of building sizes (in units) to the statewide distribution. The final sample somewhat over-represents larger buildings compared to 2-4 unit buildings (Table 14). These smaller properties proved more difficult to recruit than larger sites, as detailed in Section 3.2.2.

Table 14: Multifamily Sample Targets – Number of Units

Number of Units in Building	Multifamily (*n=69*)	ACS (N= 1,175,329)
2 to 4	30%	40%
5 to 19	38%	28%
20 to 49	14%	11%
50 +	17%	21%

* Rounding results in some rows not summing to the full sample value.

3.1.4 Program Participation

Whether a customer or multifamily building had participated in an EDC program was not a factor in selecting the sample. The SWE did, however, assess the prevalence of program participants contained in the initial random sample frame drawn from EDC residential customer lists and in the final sample of study participants to explore whether the sample is representative of program participation in the general population. Overall, the study samples had comparable but slightly higher rates of program participation than the sample frame, as detailed below.

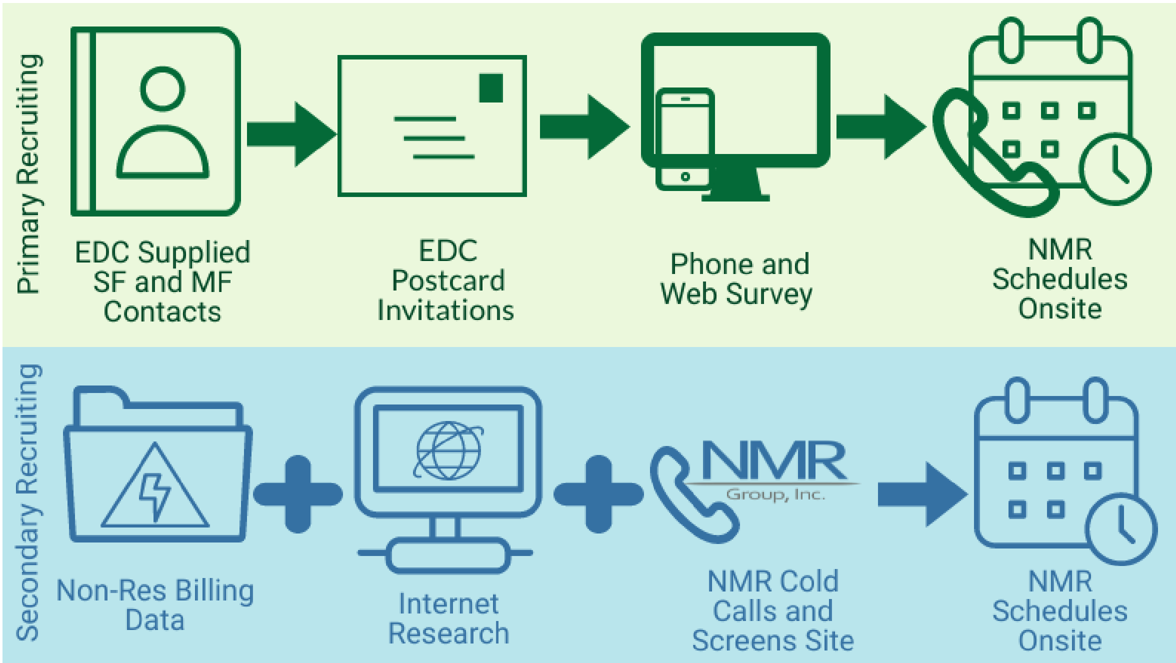
The SWE used historic residential program participant records that covered residential program participants in all EDCs from PY8 to quarter one of PY14 to identify program participants in the sample frame used to recruit the sample of study participants. The SWE matched account numbers and addresses of prior program participants to the EDC residential customer records in the sample frame and sample of study participants. The SWE found that the program participation rate of the sample frame of over 5,000 customers per EDC ranged from 8% to 15%, with a statewide average of 11%. The program participation rates of the sample of study participants (both on-site and self-audit) ranged from 14% to 28%, with a statewide average of 21%. The on-site sample ranged from 12% to 30%, with a statewide average of 21%. The self-audit sample ranged from 16% to 32%, with an average of 23%. The study samples consisted of slightly higher rates of program participation than the sample frame.

3.2 Recruiting

On-site inspections took place between February and August of 2023. The recruitment process initially was the same for single-family and multifamily homes, however over the course of the study, recruitment efforts for multifamily homes expanded. For single-family and multifamily homes, the SWE selected a sample of customers from the full set of residential billing records provided by the EDCs and contacted occupants directly. Because multifamily sites were more difficult to recruit, the SWE employed multiple methods to acquire multifamily participants. Recruitment efforts expanded to target participation from both property managers and tenants to increase the sample pool (see Section 3.2.2 for more details).

There were advantages and disadvantages to both multifamily recruitment methods (i.e., tenant level vs. property manager/owner): tenants were frequently less knowledgeable about the building than property managers when it came to general building characteristics or the presence and type of insulation. Also, without access to all common or central building locations, it was sometimes difficult to identify HVAC or domestic hot water (DHW) equipment when those systems were central rather than in-home. In most cases, auditors were able to record information on key data points. The rest of this section provides greater detail on the recruiting process.

Figure 6: Recruiting Processes for Single-family and Multifamily



3.2.1 Primary Recruitment Methods

The SWE selected a random sample of roughly 5,500 customers per EDC from the full set of residential billing records the EDCs provided. The random sample included both single-family and multifamily homes. The SWE team developed pre-recruitment post cards that were mailed to the entire sample for each EDC. The postcards included the PUC logo, the appropriate EDC logo, and EDC and PUC-specific contact information so that recipients could verify the legitimacy of the study. The postcards were sent in seven waves to accommodate field staff availability and to proceed west to east across the state. After the physical postcards were mailed, the SWE followed up with email invitations and reminders to customers with email contact information that were not included on EDC do not contact lists.

The pre-recruitment postcards and emails notified recipients of the study and invited them to complete an initial screening questionnaire that included general home characteristic and demographic questions, willingness-to-pay questions, and to indicate whether they were interested in participating in an on-site visit for an incentive gift card of $150. These survey questions allowed the SWE to verify name and address, and to gather information relevant to the study recruitment targets, such as home type, income status, home vintage, heating fuel, tenure status, and other occupant demographics. The survey also included an option to complete the self-audit for up to a $40 incentive. For the full screening survey, see Appendix J.

Table 15 shown below represents the number of postcards and emails sent to each EDC.

Table 15: Initial Single-family and Multifamily Recruitment

EDC	Number of Postcards Sent	Number of Participants Emailed	Batches of Reminder Emails Sent
PECO	5,700	3,839	4
PPL	5,702	3,901	5
Duquesne Light	5,365	3,658	4
FE: Met-Ed	5,487	4,183	4
FE: Penelec	5,531	2,637	6
FE: Penn Power	5,498	3,336	4
FE: West Penn Power	5,564	3,177	4

The SWE team contacted survey respondents that were interested in having an on-site audit, and if willing, scheduled a visit for a time and date based on the customers' convenience. On-site audits were scheduled over the phone or via email depending on the customer's preference and availability of valid customer phone numbers and email addresses. Once summer was underway, customers became less responsive to recruitment outreach, this was particularly apparent in June and July. The SWE team suspects that this was due to the peak of the summer vacation season, with fewer people at home. During this time, while many recruits were willing to schedule several weeks in advance to account for vacations, others were not willing to schedule at the time of contact. However, some recruits requested a follow-up contact upon their return from vacation. This made it difficult to schedule sites in target areas, specifically central Pennsylvania, when NMR technicians were in the area for other site visits, leading to a need for technicians to return to the region towards the end of the study and travel longer distances to complete those visits.

Several customers suspected that the study was not legitimate despite being provided with the proper contact information for their EDC and the Pennsylvania Public Utility Commission. Skeptical customers who verified the study's legitimacy through the provided channels were often enthusiastic to participate.

From the pre-recruitment survey, a total of 735 single family and 67 multifamily respondents expressed interest in participating in a site-visit. The SWE made a total of 2,279 phone calls and emails to recruit all 217 single-family home participants and 14 of 69 multifamily participants.[31] Two-thirds (67%) of the customers who agreed to schedule a site visit did so on the first or second contact, but some required up to seven phone calls or emails to schedule the site visit. Section 3.2.2 details additional recruitment efforts to schedule the remaining 55 multifamily site visits.

3.2.2 Secondary Multifamily Recruitment Methods

Recruitment for multifamily participants was far more challenging than for single-family sites. To overcome these challenges, additional recruitment strategies were adapted to involve both

[31] Excludes waitlisted and unreachable customers that did not have valid/correct contact information.

tenants and property managers.[32] As noted in the previous section, the initial sample for multifamily recruitment was based on the pre-recruitment survey. Additional likely multifamily sites were identified in the residential sample frame through either (1) a building details variable (when available in the EDC-provided data) or (2) based on annual electricity usage. In addition, the non-residential baseline study team provided a list of likely master-metered multifamily sites from the EDC billing records provided for the non-residential baseline study.

To confirm the likely multifamily status of these sites, the SWE team employed two strategies: (1) internet research on billing data addresses (e.g., Google searches and Google Street View, where available), (2) internet searches for additional multifamily complexes not included in the billing data. From the list of likely multifamily sites, the SWE team conducted phone and email recruitment efforts.

There were a number of challenges to the outreach to likely multifamily sites. Building owners and property managers were frequently unresponsive to cold calls and emails, making recruitment a challenge. It was difficult to identify and secure contact information for the person onsite that would be the most knowledgeable or appropriate to meet with. In addition, property managers frequently refused when contact was made. The majority of property managers were reluctant to dedicate their or their employees’ time when they saw no immediate benefit, and often, the $150 incentive was not enough to sway them. Other challenges included the following: (1) non-residential sites that were ineligible commercial and industrial customers rather than multifamily sites; (2) a large volume of email bounces because of incorrect email addresses or because the email was associated with accounts payable contacts for a property management company (that only processed invoices).

Despite the difficulty in multifamily recruitment, the additional outreach resulted in successfully recruiting a diverse range of building sizes and ages. One important aspect of the additional outreach was collaborating with property managers who oversee multiple properties throughout a geographic territory, allowing several sites to be scheduled through one recruit.

The following table displays the number of participants emailed for each EDC and the number of reminder emails sent. The count of total emails sent out to participants does not include emails that failed to reach participants due to the wrong email address, bounced emails, and blocked emails. Property managers in more densely populated areas were far more responsive to email outreach, and in those areas the SWE team was occasionally able to recruit multiple buildings or complexes per property manager. This is why no reminder emails were sent to Duquesne Light, PECO, and PPL contacts. Penn Power had the lowest density of multifamily property manager contacts and was the most difficult to recruit.

[32] The 2018 baseline study initially recruited multifamily sites via building owners and property managers. This recruitment strategy alone, did not yield enough visits, and eventually a focus on in-home or tenant-level recruitment was added. This study reversed the approach, emphasizing recruitment of multifamily tenants, but ultimately a mixed method was needed to meet sample targets.

Table 16: Secondary Multifamily Outreach

EDC	Number of Contacts Emailed	Batches of Reminder Emails
PECO	1,280	0
PPL	1,049	0
Duquesne Light	231	0
Met-Ed	998	3
Penelec	873	3
Penn Power	191	4
West Penn Power	695	3

Mid-size multifamily properties (20 to 49 units) were overrepresented relative to smaller and larger sites, likely due to the nature of multifamily sample development, as well as property manager reluctance. Compared to mid-sized and larger buildings, smaller multifamily buildings are more difficult to identify by analyzing billing consumption data or through online research of likely multifamily sites. Finally, property managers at larger multifamily sites were generally more reluctant to participate.

3.2.3 Cancellations

Cancellations had a significant impact on retaining recruits and reaching sample targets (Table 17). Site visits were cancelled by customers 55 times during the onsite audit process. Only about half of the cancellations were able to be rescheduled. More than half of cancellations initiated by customers (35 out of 55) were less than 24 hours before the scheduled site visit—typically after receiving appointment reminder e-mails and phone calls. This includes several instances where recruits were not present at the home at the time of the scheduled site visit and were unreachable for rescheduling, as well as instances where recruits would indicate unwillingness to participate when the technician(s) called on the way to the home or were at the home already— referred to as “No show” in the table below. Most cancellations were due to illness in the household or conflicting obligations.

Table 17: On-site Audit Cancellation Notifications

Number of Hours Before Appointment	Single-Family Basic Visits	Single-Family Full Visits	Multifamily Visits	Total
More than 24 hours	10	10	0	20
1 to 24 hours	16	7	5	28
No show	2	4	1	7
Total	**28**	**21**	**6**	**55**

3.3 Data Collection

Data was collected onsite by trained technicians using a tablet-based digital data collection form developed by NMR Group, Inc. This section describes the inputs in our data collection form and the procedures that were used for onsite data collection and in-office data-cleaning procedures. The study involved three types of onsite audits and one self-audit performed by the participant:

- **Single-family basic audits:** Audits were conducted by one auditor. They collected the basic energy-efficiency information of a home, including shell measures,[33] mechanical equipment, and inventories of lighting and appliances. Audits focused on key measures, such as exterior walls.[34]
- **Single-family diagnostic audits:** Audits were primarily conducted by two technicians. They collected all the same information as with basic audits and any additional information required for energy modeling, such as air leakage and duct leakage testing and data for the entire thermal envelope. Certified HERS Raters led all diagnostic audits.
- **Multifamily audits**: Audits were conducted at multifamily properties. One unit in one building was audited at each property. The in-home information collected at multifamily sites was similar to the information collected at single-family basic sites. In addition, auditors recorded details associated with the common areas for ten multifamily sites, which included additional data such as common area lighting, common laundry facilities, and HVAC or hot water systems serving multiple units.
- **Self-Audits:** Data was collected directly from web survey participants, who were offered incentives to submit photos of key energy consuming mechanical equipment and appliances. The photos included both a picture of an overview of the equipment type and the equipment nameplate. The nameplate allowed auditors to look up product specifications for each equipment type submitted (i.e., efficiency and size).

[33] Shell measures include insulation and material data for a home’s structural components, such as walls, ceilings, and floors.
[34] Exterior walls are a key component because they often comprise the majority of a home’s thermal envelope (i.e., the boundary between conditioned space and ambient conditions).

3.3.1 Data Collection Inputs

The electronic onsite data collection form contained all the inputs needed to assess the energy efficiency of a home. Auditors collected additional detail at the 72 diagnostic sites to create energy models. At multifamily properties, shell measures, fixtures, appliances, and mechanical equipment were collected at the unit level, while for ten multifamily sites fixtures, shared laundry, and shared mechanical equipment were collected from common areas.

Appendix B details the data collected at each of the three audit types: single-family diagnostic, single-family basic, and multifamily; and details about the data collected from the self-audits.

3.3.2 On-Site Data Collection Procedures

One of the challenges of inspecting completed homes is that several building envelope components are commonly inaccessible. Specifically, exterior wall insulation, window U-factor and solar heat gain coefficient, vaulted ceiling insulation, exterior foundation wall insulation, slab insulation, and garage and cantilevered frame floor insulation can be difficult to visually inspect in an existing home. As part of the onsite data collection procedures, the SWE relied on the following key data sources.

Onsite visual verification of actual component. Actual observations in the field are the first and most important source of data. When direct access to the component was not possible, auditors examined the area around the component to gather whatever information they could. For example, when trying to determine exterior wall insulation, auditors might have removed an electrical outlet cover and probe to determine the presence of insulation.

Onsite visual verification of similar component. Once auditors exhausted opportunities to examine the actual component, they used similar locations to inform their assessment. For example, an auditor might have found visible/accessible above-grade wall insulation in an attic knee wall or a walkout basement that they would then have used to inform their assessment of the enclosed wall cavities.

Plans or other documentation. Home plans, documentation, or blueprints can provide valuable information for inaccessible insulation. When plans were available onsite, auditors first attempted to visually verify data inputs. Auditors would then use the plans to inform their assessment of the home. Typically, plans could be useful in determining insulation R-values and window U-values.

Knowledgeable homeowner recollection. If homeowners could demonstrate reliable knowledge about the building shell with the auditor, auditors could use homeowner recollection to inform their assessment. This would be particularly useful if the homeowner was present during construction or during a major renovation. Additionally, homeowner input could shed light on old appliances and mechanical equipment. For instance, homeowners could estimate the age of old appliances and systems that had missing or illegible name plates.

3.3.3 Self-Audit Data Collection Procedures

Self-audit data collection began with web-survey respondents' submittal of photos of mechanical equipment and/or appliances present in their home. The survey respondent was asked if they were willing to upload additional photos at the end of the recruitment portion of the web survey. Respondents were offered an electronic gift card incentive of up to $40 to submit a photo of their equipment and a photo of the nameplate. Incentives of $10 were offered for each HVAC and water heating equipment submission and incentives of $5 were offered for each refrigerator, freezer, clothes washers, clothes dryers, dishwashers, stoves and ovens, and dehumidifier submission. The SWE processed photo submissions on a weekly basis. Initial reviews confirmed the respondent was located in Pennsylvania, the photos submitted were valid, and calculated the total incentive for each participant. In cases where a submission was missing a key photo (i.e., nameplate), the respondent was notified via email with a request to resubmit the photo in order to confirm the equipment and the incentive amount. After confirming the amount of valid incentive money, an electronic gift card was sent to the participant.

The SWE then looked up key characteristics of valid submissions using the nameplate data (i.e., size, efficiency, and fuel type). The results of self-audit submissions are included in the relevant sections of the report but are distinguished from the on-site results. The report excludes self-audit submissions that also had an on-site inspection, to avoid double counting of mechanical equipment or appliances.

3.4 Weighting

To account for sample bias, this report utilizes multiple weighting schemes: a full sample (combined on-site and self-audits), on-site only, self-audit only, and a diagnostic sub-sample weighting scheme. The full sample weighting scheme deviates from the 2013 and 2018 residential baseline study by expanding the weighting scheme from EDC and home type to also include income status.[35,36] All variations of the full sample weighting scheme: on-sites only, self-audit only, and the full sample (combined) follow this format. The scheme weights the sample by home type, EDC, and income status to give more weight to data from larger EDCs, as well as factor in differences in household income. Since the EDCs were unable to provide data on the counts of each home type and income level in their service areas, the SWE leveraged PUMS data from the US Census Bureau to match home type, EDC, and income-status counts to service territories.[37] The sample was stratified by home type, EDC, and income-status and compared to the count of home types by EDC and income status of the population from the PUMS data. Weights were calculated to account for over and under sampling of home types by EDC in each of the samples relative to the population. As discussed in Section 3.1, the manufactured/mobile home sample size for this study was too low to draw meaningful conclusions compared to other home types. Due to this, manufactured/mobile homes are included in the detached single-family home category. Table 18 shows the final weights for the full sample, on-site sample, and self-audit sample.

[35] http://www.puc.state.pa.us/Electric/pdf/Act129/SWE-2014_PA_Statewide_Act129_Residential_Baseline_Study.pdf
[36] https://www.puc.pa.gov/Electric/pdf/Act129/SWE-Phase3_Res_Baseline_Study_Rpt021219.pdf
[37] American Community Survey 2020 ACS 5-year PUMS: https://data.census.gov/mdat/#/search?ds=ACSPUMS5Y2020&cv=BLD&rv=ucgid,YBL&wt=WGTP&g=0400000US42

Table 18: Statewide weights by Sample Scheme

EDC	Detached Single-family		Attached Single-Family		Multifamily	
	Non-LI	LI	Non-LI	LI	Non-LI	LI
On-site Sample Weights						
PECO	2.54	1.73	1.62	1.73	0.87	1.05
PPL	1.76	2.11	2.33	2.11	1.31	1.31
Duquesne Light	0.73	0.54	0.85	0.54	1.15	0.35
FE: Met-Ed	0.77	0.47	1.07	0.33	0.38	0.72
FE: Penelec	0.95	0.45	0.95	0.45	0.26	0.60
FE: Penn Power	0.25	0.16	0.25	0.16	0.63	0.63
FE: West Penn Power	1.13	0.65	1.13	0.65	0.45	0.56
Self-audit Sample Weights						
PECO	5.19	2.67	1.50	2.67	3.24	0.97
PPL	1.68	1.52	1.73	1.52	--	--
Duquesne Light	0.69	0.30	0.69	0.30	1.77	0.86
FE: Met-Ed	0.58	0.87	0.79	0.23	0.69	0.69
FE: Penelec	0.68	0.27	0.68	0.27	1.80	1.80
FE: Penn Power	0.22	0.09	0.22	0.09	1.17	1.17
FE: West Penn Power	0.89	0.47	0.89	0.47	2.69	2.69
Full Sample Weights (Combined On-site and Self-audit)						
PECO	3.37	2.08	1.56	2.08	1.35	1.01
PPL	1.56	1.36	1.99	1.36	2.52	2.52
Duquesne Light	0.67	0.39	1.23	0.39	1.38	0.49
FE: Met-Ed	0.67	0.60	0.91	0.27	0.42	1.38
FE: Penelec	0.80	0.34	0.80	0.34	0.40	1.15
FE: Penn Power	0.24	0.11	0.24	0.11	0.81	0.81
FE: West Penn Power	1.00	0.54	1.00	0.54	0.76	0.86

The SWE applied a similar weighting scheme to the diagnostic sub-sample as in the 2018 report. In addition, the SWE tested the explanatory power of various combinations of home type, heating fuel, and vintage on overall home consumption. The combination of home type and heating fuel (electrically heated or not) proved to best predict home consumption. Likewise, testing by all heating fuel types did not add accuracy beyond that achieved by using a simple electric heat or non-electric heat indicator. Therefore, the weighting scheme for the diagnostic sub-sample is based on a stratification by home type and electric heat status (Table 19). As noted above, due to small sample sizes for manufactured/mobile homes, these homes were included with detached homes for weighting and reporting purposes.

Table 19: Diagnostic Sub-Sample Statewide Weights

Primary Heating Fuel Type	Detached Single-family	Attached Single-family
Electric	0.90	0.68
Non-electric	1.02	1.18

3.5 Significance Testing and Table Formats

In statistical tables and proportional tables, the mean presented in the “Statewide” column is always a weighted mean unless otherwise noted. The “Statewide” column is the only column that ever displays weighted results. All other columns are unweighted. Significance testing was conducted on key measures. Superscript letters and bolded text indicate that there is 95% probability that the compared results are truly different from each other, and only a 5% probability that observed differences happened by chance. Significance testing was only performed when both tested samples had sample sizes of at least ten. Throughout the report, the terms “significant” and “significantly” always refer to *statistical* significance at the 95% confidence level.

Table 20 shows an example of a statistical table for on-site only results and Table 21 shows an example of a statistical table for measures with results that include on-site only, self-audit only, and full sample data. The “attached single-family” mean and the “multifamily” mean are both significantly different from the “detached single-family” mean as demonstrated by the “a” in superscript. The multifamily mean is significantly different from both of the other groups as demonstrated by the “b” in superscript. The “Statewide” represents the overall distribution for the table and is not tested for significance against any of the sub-groups.

Table 20: Example of Statistical Table Format (On-Sites Only)

	Detached single-family	Attached single-family	Multifamily	Statewide
n-value	*X*	*X*	*X*	*X*
Min	x	x	x	x
Max	x	x	x	x
Mean	**x**	**x**[a]	**x**[a,b]	**x**
Median	x	x	x	x
Sd.	x	x	x	x

[a] Significantly different from the detached single-family sample at the 95% confidence level.

[b] Significantly different from the attached single-family sample at the 95% confidence level.

Table 21: Example of Statistical Table Format (Measures with Self-Audit Data)

Categories	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*n*	*n*	*n*	*n*
Min	x	x	x	x
Max	x	x	x	x
Mean	**x**	**x**[a]	**x**[a,b]	**x**
Median	x	x	x	x
Sd.	x	x	x	x
Self-Audit Results Only				
n-value	*n*	*n*	*n*	*n*
Min	x	x	x	x
Max	x	x	x	x
Mean	**x**	**x**[a]	**x**[a,b]	**x**
Median	x	x	x	x
Sd.	x	x	x	x
Total On-site and Self-Audit				
n-value	*n*	*n*	*n*	*n*
Min	x	x	x	x
Max	x	x	x	x
Mean	**x**	**x**[a]	**x**[a,b]	**x**
Median	x	x	x	x
Sd.	x	x	x	x

[a] Significantly different from the detached single-family sample at the 95% confidence level.
[b] Significantly different from the attached single-family sample at the 95% confidence level.

Table 22 shows an example of significance testing in a proportional table for on-sites only and Table 23 shows an example of significance testing in a proportional table for measures with results that include on-site only, self-audit only, and full sample data. The "total single-family" sample has a significantly different proportion of cases in "Category 3" than the "diagnostic sub-sample." The "diagnostic sub-sample" has a significantly different proportion of cases in "Category 2" than the multifamily sample. There is no significance testing with the "Statewide" column.

In addition to statistical tables and proportional tables, this report frequently presents *penetration* and *saturation* results. *Penetration* is defined as the number of homes that have at least one of the relevant measures. For example, the penetration of LED bulbs shows the percentage of homes that have at least one LED bulb. *Saturation* is defined as the amount of a larger measure that are a specific subtype of that measure. For example, the saturation of LEDs refers to the percent of all light bulbs that are LED bulbs. Since a single home may have, for example, light bulbs of several different types, penetration tables may sum to more than 100%. Saturation and proportion tables sometimes do not sum to exactly 100% due to rounding error.

Table 22: Example of Proportional Table Format (On-sites)

Categories	Total Single-family	Diagnostic Sub-sample	Multifamily	Statewide
n-value	*n*	*n*	*n*	*n*
Category 1	x%	x%	x%	x%
Category 2	x%	**x%**	**x%**[b]	x%
Category 3	**x%**	**x%**[a]	x%	x%
Category 4	x%	x%	x%	x%

[a] Significantly different from the total single-family sample at the 95% confidence level.
[b] Significantly different from the diagnostic sub-sample at the 95% confidence level.

Table 23: Example of Proportional Table Format (Measures with Self-Audit Data)

Categories	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*n*	*n*	*n*	*n*
Category 1	x%	x%	x%	x%
Category 2	x%	**x%**	**x%**[b]	x%
Category 3	**x%**	**x%**[a]	x%	x%
Category 4	x%	x%	x%	x%
Self-Audit Results Only				
n-value	*n*	*n*	*n*	*n*
Category 1	x%	x%	x%	x%
Category 2	x%	**x%**	**x%**[b]	x%
Category 3	**x%**	**x%**[a]	x%	x%
Category 4	x%	x%	x%	x%
Total On-site and Self-Audit				
n-value	*n*	*n*	*n*	*n*
Category 1	x%	x%	x%	x%
Category 2	x%	**x%**	**x%**[b]	x%
Category 3	**x%**	**x%**[a]	x%	x%
Category 4	x%	x%	x%	x%

[a] Significantly different from the total single-family sample at the 95% confidence level.
[b] Significantly different from the diagnostic sub-sample at the 95% confidence level.

Section 4 General Characteristics

This section presents general characteristics of the sample of audited homes included in the residential baseline study, including average conditioned floor area, foundation type, thermostat type, presence of pools and hot tubs, renewable energy systems, and electric vehicles and chargers. The sample included 189 detached single-family homes, 28 attached single-family homes, and 69 multifamily homes (Figure 7), defined below.

- **Detached single-family:** A single-residence structure that is not physically attached to any other structure. [38]
- **Attached single-family:** A single-residence that is separated from the adjacent units by a ground-to-roof wall and has its own heating and cooling systems and utilities.
- **Multifamily:** Any residential structure that has units on top or below other units or attached units with shared heating or cooling systems or utilities.

Figure 7: Examples of Audited Homes

4.1 Home Characteristics

On average, homes were 56 years old (Table 24). The audited homes trended younger than previous studies. The 2018 Pennsylvania baseline study had an average audited home age of 65 years.

Table 24: Average Age of Audited Homes (Years)

	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*189*	*28*	*69*	*286*
Years	54	52	64	56

[38] Detached single-family homes also include six manufactured / mobile homes due to the low sample size. Manufactured / mobile homes are defined as a single-residence structure that is transportable in one or more sections and is built on a permanent chassis with or without a permanent foundation (Based on HUD definitions. See CFR 3280.2.). Detached and attached single-family home and multifamily definitions are based on the U.S. Census: https://www.census.gov/construction/chars/definitions/

Table 25 shows the average conditioned floor area (CFA) by home type.[39] The statewide weighted average CFA was 2,019 square feet. The average CFA was 2,498 square feet for all single-family homes and 878 square feet for multifamily units.

Table 25: Audited Home Conditioned Floor Area (Sq. Ft.)

	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*189*	*28*	*69*	*286*
Min	588	612	390	390
Max	8,871	3,258	3,051	8,871
Mean	**2,498**	**1,598**	**878**	**2,019**
Median	2,347	1,352	784	1,702
Std. Dev.	1,161	727	432	1,212

Table 26 shows the foundation types of the homes in the sample.[40] Unconditioned basements were the most common (33%), followed by conditioned basements (32%), and then on-grade slab (12%).

Table 26: Foundation Type

Foundation Types	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*189*	*28*	*69*	*286*
Unconditioned Basement	34%	43%	22%	33%
Conditioned Basement	43%	18%	6%	32%
Cond./Uncond. Mix	5%	4%	--	4%
On-grade Slab	5%	29%	28%	12%
Apt. over Enclosed Space	--	--	43%	9%
Other[1]	13%	7%	2%	10%

[1] Includes 2% that were a mix of unconditioned basement and on-grade slab, 2% that were a mix of conditioned basement and on-grade slab, and one attached single-family home that was over a garage.

4.2 Thermostats

Auditors recorded the types of thermostats at each home.[41] Table 27 shows the *penetration* of each thermostat type. Manual thermostats were present at 33% of homes, a decrease from the

[39] Auditors used RESNET protocols to define conditioned floor area in accordance with the method used for HERS ratings.
[40] Enclosed crawl spaces were grouped with unconditioned basements. Conditioned crawl spaces were grouped with conditioned basements. "Apt over Enclosed Space" refers to apartments that were entirely above either a garage or commercial property.
[41] Thermostats serving only common space in multifamily buildings were ignored since consistent collection was not feasible. Auditors were unable to acquire thermostat details at 15 homes.

previous baseline where manual thermostats were present at 50% of homes. Programmable thermostats or more advanced thermostat technologies (e.g., *wi-fi* or *smart*)[42] were present in 70% of homes. There were no thermostats in 1% of homes. These homes had heating systems with built-in controls or on-off switches, such as stoves, electric baseboards, or through-the-wall heat pumps—the previous study reported 5% of homes had no thermostat.

Table 27: Thermostat Penetration

Type	Detached Single-family	Attached Single-family	Multifamily	Statewide[1]
n-value	*180*	*25*	*54*	*259*
Programmable	59%	56%	39%	55%
Manual	28%	28%	54%	33%
Smart	11%	12%	--	9%
Wi-fi	7%	4%	4%	6%
None	--	--	3%	1%

[1] Since some homes have more than one thermostat, column totals can sum to more than 100%.

Table 28 shows the *saturation* of thermostat type across all thermostats observed during audits. Most thermostats (53%) were programmable, an increase from previous studies where most thermostats were manual (53% in 2018). Homes with electric baseboards were more likely to have manual thermostats than homes without electric baseboards: 69% of thermostats in homes with electric baseboards were manual compared to 24% in the rest of homes. Seventy-four percent of central cooling systems had programmable thermostats. This represents a 16% increase from 2018, which found that 58% of central cooling systems had programmable thermostats.

Table 28: Thermostat Saturation

Type	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*210*	*26*	*72*	*308*
Programmable	56%	58%	32%	53%
Manual	27%	27%	63%	32%
Smart	10%	12%	--	8%
Wi-Fi	7%	4%	3%	7%

4.3 Pools and Hot Tubs

Only 16 homes (6%) had either a pool or a hot tub. There were ten pools and six hot tubs in the sample. Seven of the pools were heated. Table 29 shows the penetration of pools and hot tubs by home type.

[42] Wi-fi enabled thermostats allow for users to control settings via an online application. Smart thermostats, in addition to being connected to wi-fi, can learn and optimize temperature controls based on occupant behavior.

Table 29: Pool and Hot Tub Penetration

Type	Detached Single-family	Attached Single-family	Multifamily	Statewide
n	*189*	*28*	*69*	*286*
Pool	5%	--	--	4%
Hot Tub	3%	--	--	2%
None	92%	100%	100%	94%

4.4 Renewables

Sixteen homes had solar photovoltaic (PV) systems for onsite power generation, for a weighted penetration rate of 5.8%. In comparison, the 2018 residential baseline study recorded only three homes with PV systems, for a weighted penetration rate of 1%. Key details for the PV systems are provided in Table 30 (sites with multiple PV configurations have multiple entries). Fifteen of the homes were detached single-family homes, and one was a multifamily home. Only one home had a battery storage system present on-site. None of the sampled sites had solar thermal hot water systems or wind power generation systems.

Table 30: Solar Photovoltaic Systems
(Base: Solar Photovoltaic Systems by Orientation)

Array Area (sq. ft.)	Power Production (kW)	Inverter Efficiency[1]	Orientation	EDC
180	3	0.97	East	Penn Power
216	3.6	0.97	West	Penn Power
810	14	0.99	South	Penn Power
342	5.7	0.98	Southwest	Penelec
175	3	0.99	Northwest	Penelec
375	4.5	0.99	Southeast	Penelec
1008	16.8	0.92	South	Penn Power
700	12	0.97	Southwest	Penelec
400	6	0.96	South	Met-Ed
432	8	0.99	West	PPL
864	9.6	0.96	South	Met-Ed
378	6.3	NA	South	Met-Ed
306	5.1	NA	North	Met-Ed
297	8.9	0.99	Southeast	Met-Ed
180	3	0.99	Southeast	Met-Ed
216	3.6	NA	West	PPL
210	6.3	0.99	Northwest	PECO
192	5.7	0.99	Southwest	PECO
300	6.86	0.96	South	PECO

[1] The SWE determined inverter efficiency using specification derived from the inverter nameplate and manufacturing specifications.

4.5 Electric Vehicles and Chargers

Ten electric vehicles were found at seven homes. Four of these vehicles were plug-in hybrid style vehicles, and six of these were purely electric vehicles. Three of the homes used a Level-1 charger, which uses a standard 120-volt AC outlet. Five of the homes used a Level 2 charger, which offers higher rate charging through 240V electrical service. (One home used both a Level-1 and a Level-2 charger.) None of the homes with electric vehicles had an electric storage system. Table 31 below shows the make and model of the surveyed electric vehicles.

Table 31: Electric Vehicles and Chargers

Type	Charger Configuration	Make	Model
Plug-in hybrid	L1 - Standard Outlet	Chrysler	Pacifica
Plug-in hybrid	L2 - Installed Charger	Chevrolet	Volt
Plug-in hybrid	L2 - Installed Charger	Chevrolet	Volt
Plug-in hybrid	L2 - Installed Charger	Chevrolet	Volt
Purely electric	L1 - Standard Outlet	Lectric	(Unknown bicycle)
Purely electric	L1 - Standard Outlet	Tesla	MODEL 3
Purely electric	L2 - Installed Charger	Tesla	(Unknown)
Purely electric	L2 - Installed Charger	Nissan	Leaf
Purely electric	L2 - Installed Charger	Chevrolet	Bolt
Purely electric	L2 - Installed Charger	Ford	Mustang Mach-E

5

Section 5 Diagnostic Sub-Sample Results

The SWE team generated energy models for each of the 72 diagnostic sub-sample homes using REM/Rate™ version 16.3.2.[43] The homes received full diagnostic testing, including air infiltration and duct leakage tests. Energy models were used to calculate HERS Index scores and energy use intensities (EUI) for various end uses including heating (HTG), cooling (CLG), domestic hot water (DHW), and lights and appliance (LAP). This chapter presents the results of the modeling and diagnostic testing.

For context, results of the diagnostic sub-sample are compared to the 2018 International Energy Conservation Code® (IECC). This is not to imply that homes in the sample *should* be built to the standards of 2018 IECC. Pennsylvania adopted 2018 IECC in October 2021, and enforcement began in February of 2022. The 2018 IECC code would not have been enforced on any of the homes in the diagnostic sub-sample, as all homes were constructed in 2021 or before.[44] Still, the 2018 IECC provides a useful benchmark to compare the energy efficiency of the sampled homes to the performance of a new home built to the current code.

As discussed in the methods section above, the study used a different weighting scheme from the rest of the report when looking only at the diagnostic sub-sample. The only weighted results presented in this section are statewide results. The weights used in this section are based on home type and whether homes used electricity as their primary heating fuel.

Figure 8: Diagnostic Results Highlights

Key Findings:

- The average weighted HERS Index score of 107.8 indicates that, statewide, the entire existing housing stock is 58% less efficient than homes built to 2018 IECC.[45]

---

[43] Version 16.3.2 was the most recent version of REM/rate at the time of the study.
[44] The Pennsylvania Uniform Construction Code Review and Advisory Council adopted 2018 IECC standards in spring of 2021, which took effect in October 2021: https:/www.dli.pa.gov/ucc/Documents/ICC-Code-Review-2018-Final-Report.pdf%20; https://www.energycodes.gov/status/states/pennsylvania. Builders will be able to prove compliance by achieving a HERS Index value of 62 (for climate zone 4) or 61 (for climate zones 5 and 6).
[45] See Section 5.1 for a description of the HERS Index. A home built to 2018 IECC minimum standards would receive a HERS Index score of 62.

- The average energy use intensity (EUI) of 59.25 kBTU/sq.ft./yr is used mostly for space heating (37.10 kBTU/sq.ft./yr or 63%) and combined lights and appliances (11.51 kBTU/sq.ft./yr or 19%).[46]
- The average electric EUI was 13.0 kWh/sq.ft./yr for primarily electrically heated homes and 7.7 kWh/sq.ft./yr for primarily non-electrically heated homes.[47]
- The average weighted ACH50[48], a measurement of air leakage in the home, of 11.4 is above the 2018 IECC requirement of 3.0 but not unreasonable considering the statewide average age of homes sampled was 56 years old.
- The average weighted duct leakage to the outside (LTO) of 7.6 is higher than the 2018 IECC requirement of 4.0 but not unreasonable considering the age of the duct systems.

5.1 HERS Index Scores

This section summarizes the diagnostic sub-sample HERS Index scores. The HERS Index is based on the 2006 IECC, where a score of 100 equals a home built to 2006 prescriptive standards and a score of 0 represents a net-zero-energy home (i.e., a home that uses no more energy than it generates onsite). The SWE performed significance testing on subsamples where each group had a sample size of ten or greater.

The overall mean HERS Index score of 107.8 signifies that the average home in the sample is 58% less efficient than a home built to the 2018 IECC.[49] The majority of homes (93%) have HERS Index scores that are higher (i.e., less efficient) than the 2018 IECC performance benchmark of 62.[50] This is not unreasonable given that the sample had homes dating back to 1900. Not surprisingly, older homes on average have higher HERS Index values (indicating lower energy efficiency) than newer homes. However, the HERS score has improved across the state, moving closer to the 2006 IECC prescriptive requirements and the HERS index score baseline rating of 100 since the previous baseline study (Table 32).[51]

---

[46] EUI is a measure of annual energy consumption per year normalized by area of a home.
[47] To convert to BTU, kWh values were multiplied by 3.412.
[48] ACH50 refers to air changes per hour at a pressure differential of 50 Pascals between the inside and outside of a home. It is a standard measure of air leakage in homes. RESNET protocols for measuring air leakage in homes: https://www.resnet.us/wp-content/uploads/ANSIRESNETICC-380-%E2%80%93-2016-Standard-for-Testing-Airtightness-of-Building-Enclosures-Airtightness-of-Heating-and-Cooling-Air-Distribution-Systems-and-Airflow-of-Mechanical-Ventilation-Systems-.pdf.
[49] The HERS Index is benchmarked to the 2006 IECC. https://www.resnet.us/energy-rating
[50] Note that the 2018 IECC does not require homes to meet a certain HERS Index score of 62, rather a score of 62 has been found equivalent to 2018 IECC in climate zones 4 and 5. See https://www.resnet.us/about/code-officials/adoption-of-hers-index-and-eri/
[51] The home with a HERS Index of 488 had no insulation in the walls, a small amount of insulation in the ceiling, a coal furnace manufactured before 1950, high infiltration, and high duct leakage. Another home, which had a HERS Index of 230, had high infiltration, leaky ducts with *panning*, and natural gas furnace. *Panning* refers to the use of open wall or floor cavities as ducts, typically with sheet metal attached to the studs.

Table 32: HERS Index Scores by Vintage

	Before 1940	1940-1959	1960-1979	1980-1999	2000-2009	2010 or later	Statewide
n-value	*11*	*13*	*12*	*12*	*14*	*10*	*72*
Min	72.0	86.0	58.0	59.0	59.0	63.0	58.0
Max	488.0	199.0	196.0	176.0	176.0	76.0	488.0
Mean	**148.1**	**116.8**	**114.3**	**82.5**	**82.5**	**70.1**	**107.8**
Median	94.0	107.0	104.5	79.0	77.5	70.0	86.0
Std. Dev.	122.3	31.8	41.8	31.7	28.7	3.9	59.4

Attached single-family homes had lower HERS Index values than detached homes (Table 33). This is an expected result since heat loss is lower in attached homes due to the common walls. Note that the statewide average HERS score is higher than both detached and attached single-family home average scores due to weighting.

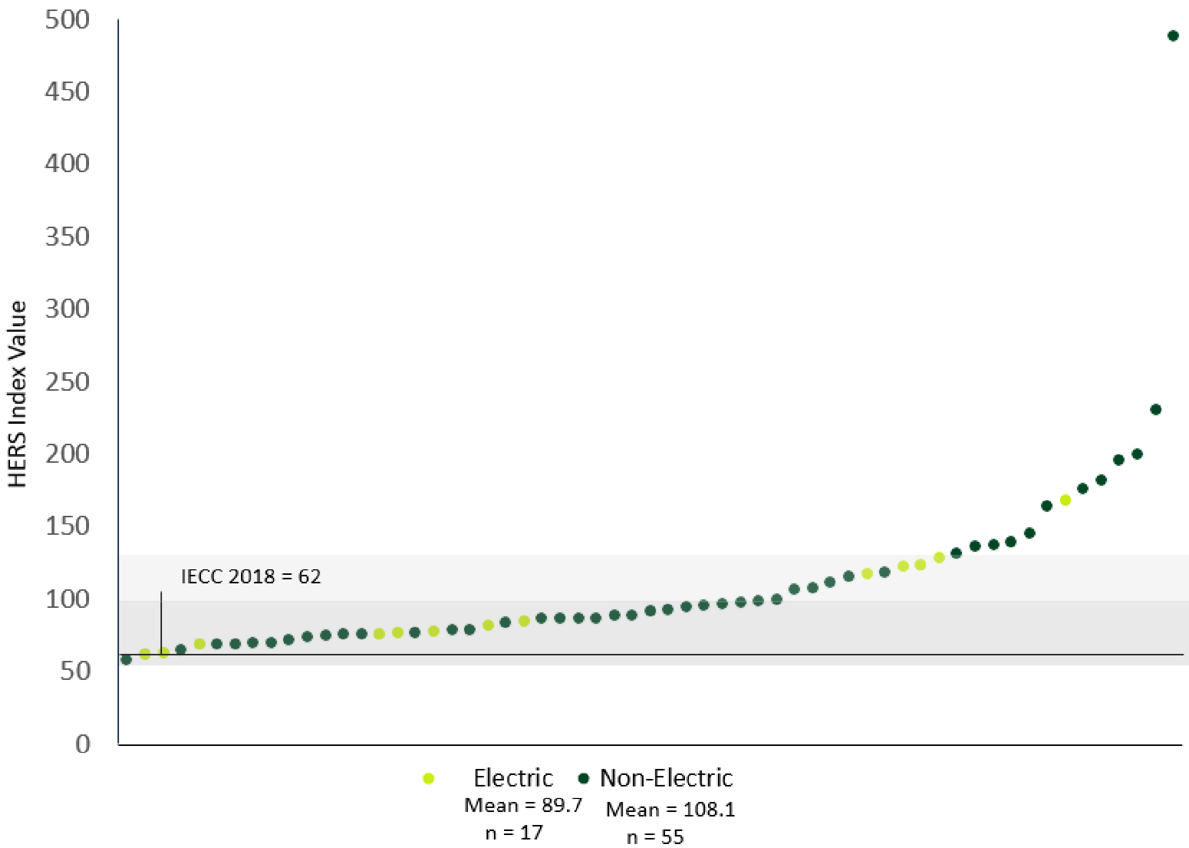
Table 33: HERS Index Scores by Home Type

	Detached Single-family	Attached Single-family	Statewide[1]
n-value	*61*	*11*	*72*
Min	58.0	58.0	58.0
Max	488.0	115.0	488.0
Mean	**107.1**	**76.9**	**107.8**
Median	88.0	71.0	86.0
Std. Dev.	63.1	17.5	59.4

[1] The average statewide HERS Index Score is higher than the detached and attached single-family HERS Index Score due to weighting.

Figure 9 displays HERS Index scores of homes with and without electric primary heat. The plot displays the values in increasing order and shows the interquartile range for the entire sample as a dark grey and light grey bar. The border between them represents the median. As noted above, the majority of homes (67) have HERS Index scores that are higher (i.e., less efficient) than the 2018 IECC performance benchmark of 62. There was no statistically significant difference between electrically heated and non-electrically heated homes.

Figure 9: HERS Index Value with and Without Electric Primary Heat



There were some significant differences in HERS Index scores by low-income status. See Appendix C Detailed Diagnostic Results for detailed HERS Index score results by primary heating fuel, income status, and EDC.

5.2 Energy Consumption and Loads

The REM/Rate energy models produced detailed information on modeled energy consumption for each home. To facilitate comparisons within the sample, results are binned by home efficiency relative to a home built to 2018 IECC standards (Table 34). To comply with this standard, a home built under the 2018 IECC performance path must achieve a HERS Index score of 62 or less.[52] Homes that had HERS Index scores below 62 are more efficient than the 2018 IECC, and homes with HERS Index scores above 62 are less efficient. The efficiency categories in Table 34 are used for the rest of the energy consumption analysis.

[52] See 2018 IECC performance path requirements for climate zones 4 and 5: https://www.resnet.us/about/code-officials/adoption-of-hers-index-and-eri/

Table 34: HERS Index Value Comparison to 2018 IECC

Efficiency Category	Number of Homes	Average HERS
Better than 2018 IECC	5	59.5
Up to 25% Less Efficient	20	70.6
Between 25% and 100% Less Efficient	32	95.8
More than 100% Less Efficient	15	187.0
Statewide (Weighted)	72	107.8

Figure 10 shows the average EUI by end use (i.e., heating, cooling, water heating, lighting, and appliances) for each efficiency category. EUI is a measure of energy consumption per year normalized by the area of the home. As expected for Pennsylvania, the largest share of the EUI for each efficiency category comes from heating, followed by appliances and water heating. Lighting and appliances combined account for 11.51 kBTU/sq.ft./year. Statewide, the weighted average total EUI is 59.25 kBTU/sq.ft./year.

Figure 10: Energy Use Intensity by End Use (kBTU/sq.ft./year)

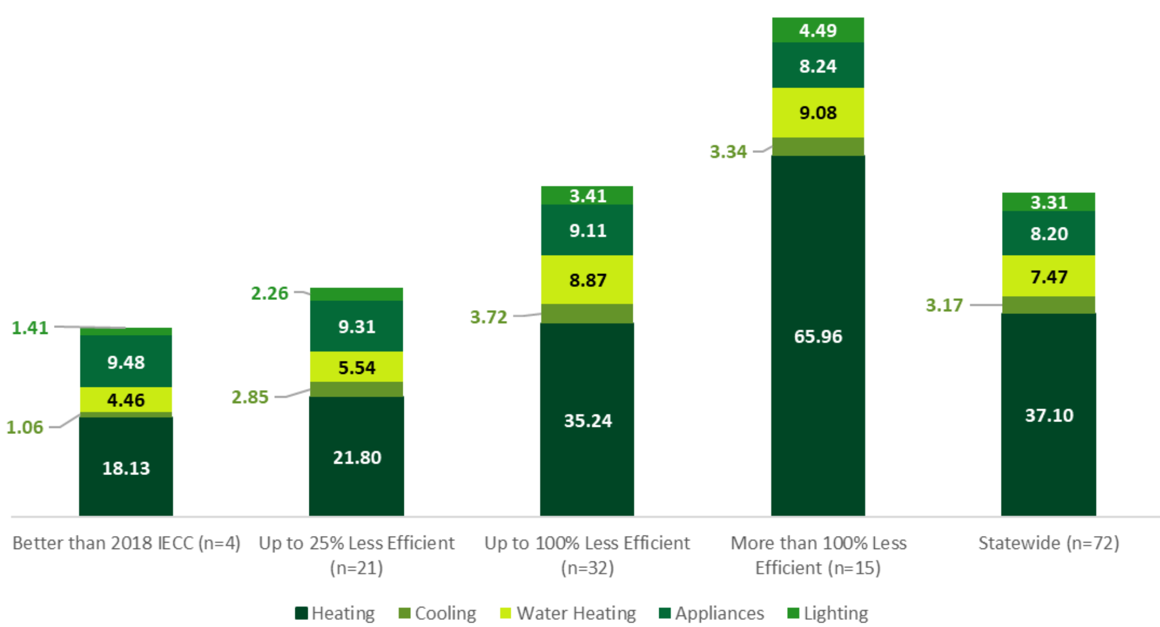


Figure 11 shows the unweighted electric EUI by end use for homes with primarily electric heat and homes with primarily non-electric heat. Note that the primarily non-electrically heated homes could still use supplemental electric heat. Primarily electrically heated homes had an average electric EUI of 13.0 while primarily non-electrically heated homes had an average electric EUI of 7.7. Primarily electrically heated homes had an EUI of 6.8 for heating while primarily non-electrically heated homes had an EUI of only 2.5 for heating.

Figure 11: Average Electric EUI by End Use by Heating Fuel (kWh/sq.ft./year)

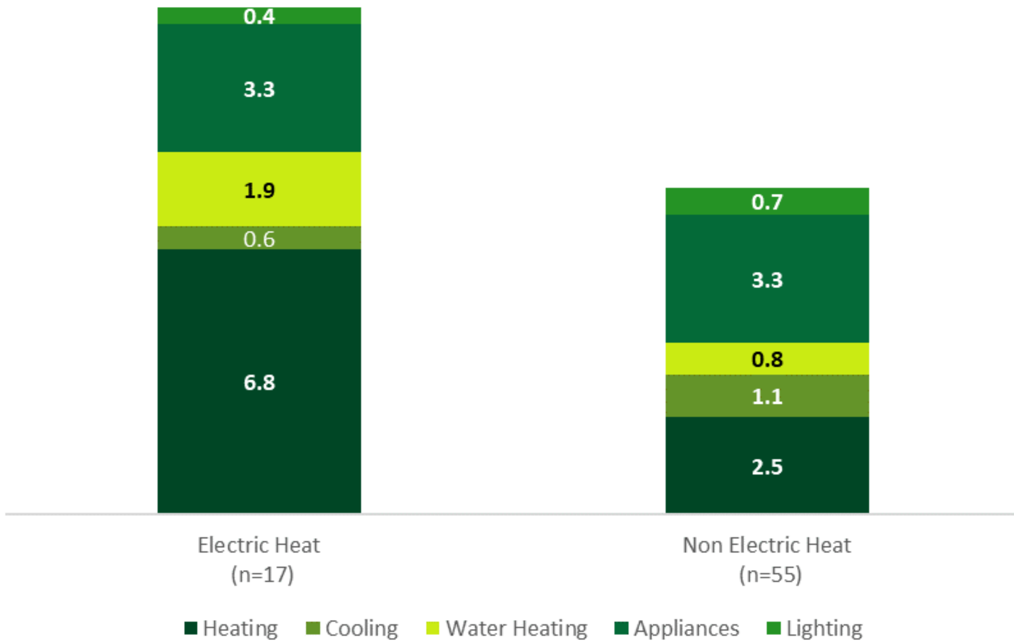


Figure 12 and Figure 13 specifically look at the electric consumption for all 72 homes, regardless of whether the home is electrically heated. Onsite consumption of electricity is split by end use. Note that the statewide results are weighted and the weighting scheme accounts for electric heat status (electric heated homes in the sample were slightly over-represented compared to the statewide population).

The average modeled electric consumption of the 72 homes in the diagnostic sample was 16,139 kWh/year. Appliances make up the largest share, followed closely by heating (Figure 12). In efficient homes, appliances make up over half of the annual electric consumption.[53] In inefficient homes, heating makes up the biggest share of electric consumption.

Figure 13 shows the average electric EUI by end use. Statewide, the average electric EUI is 8.2 kWh/sq.ft./year. Heating comprises the largest share followed by appliances.

---

[53] A majority of the homes that performed better than the 2018 IECC contained multiple appliances such as fridges, coolers and freezers which contributed to the higher average electric consumption for lighting and appliances compared to homes in other categories.

Figure 12: Average Electric Consumption by End Use (kWh/year)

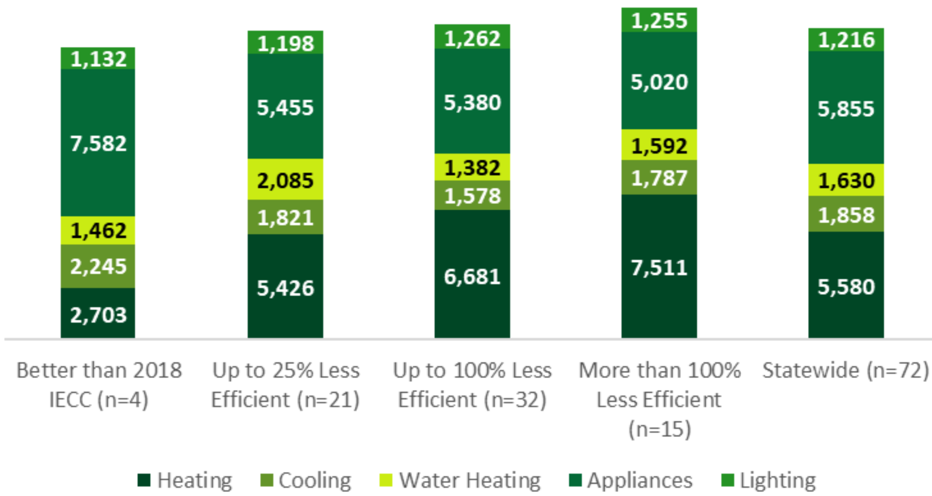
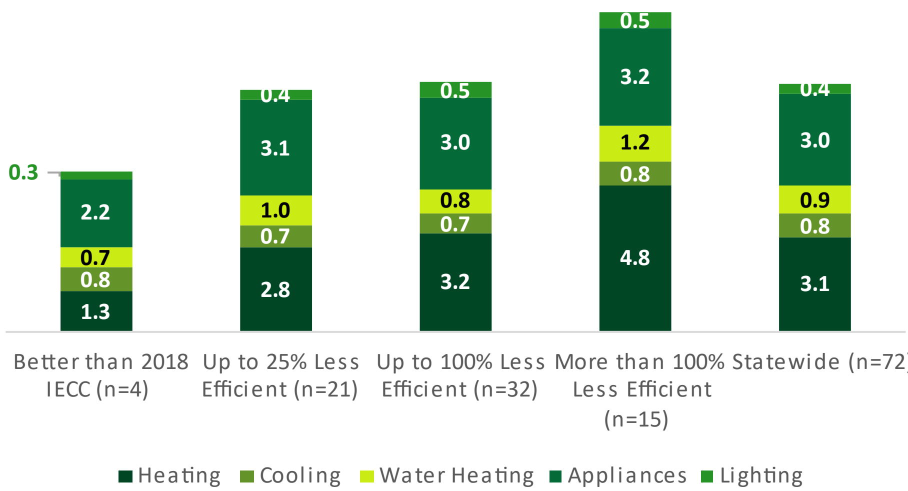


Figure 13: Average Electric EUI by End Use (kWh/sq.ft./year)



5.3 Air Infiltration

Field technicians conducted blower door tests at 71 diagnostic visits. Table 35 through Table 37 summarize the ACH50 results split by vintage, home type, and low-income status.[54] The average ACH50 for the entire sample was 11.4. This is less efficient than the 2018 IECC requirement of 3.0, but as mentioned above, all homes, when built, were not subject to this requirement at the

[54] Technicians were unable to run the blower door in one site visit due to the appearance of asbestos in the basement. The homeowner was informed and due to RESNET/IECC guidelines the blower door was not performed. The average ACH50 from the sample of 71 homes was applied to that site.

time they were constructed. As expected, newer homes had lower (i.e., more efficient) ACH50 values than older homes (Table 35).

Table 35: ACH50 by Vintage

	Before 1940	1940-1959	1960-1979	1980-1999	2000-2009	2010 or later	Statewide
n-value	*11*	*13*	*12*	*12*	*14*	*10*	*72*
Min	5.6	8.6	5.8	3.3	1.6	3.4	1.6
Max	52.9	29.9	25.5	18.3	24.7	6.7	52.9
Mean	**19.2**	**16.6**	**11.3**	**9.2**	**6.1**	**4.2**	**11.4**
Median	13.1	15.3	8.6	8.9	5.1	3.9	8.6
Std. Dev.	14.5	6.6	6.3	4.5	5.6	1.0	9.0

There were no statistically significant differences in ACH50 between different home types, though detached homes had the highest mean and maximum ACH50 values (Table 36).

Table 36: ACH50 by Home Type

	Detached Single-family	Attached Single-family	Statewide
n-value	*61*	*11*	*72*
Min	2.5	1.6	1.6
Max	52.9	11.3	52.9
Mean	**11.8**	**6.0**	**11.4**
Median	9.1	5.0	8.6
Std. Dev.	9.3	2.9	79.0

Low-income homes had significantly higher (i.e., less efficient) ACH50 values than non-low-income homes (16.5 compared to 9.8; Table 37).

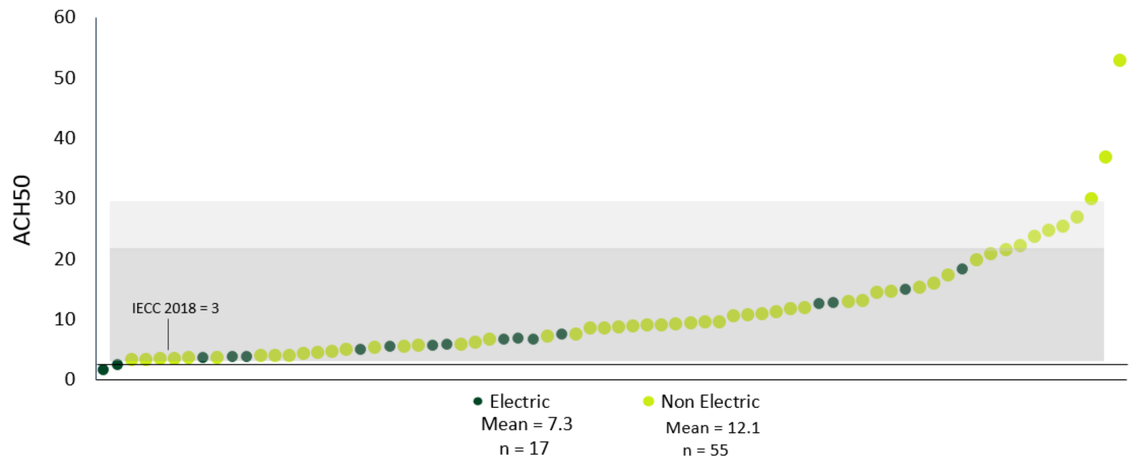
Table 37: ACH50 by Low-income Status

	No	Yes	Refused	Statewide
n-value	*58*	*12*	*2*	*72*
Min	2.5	1.6	5.7	1.6
Max	27.0	52.9	14.4	52.9
Mean	**9.8**	**16.5**[a]	**10.1**	**11.4**
Median	8.1	10.1	10.1	8.6
Std. Dev.	6.5	15.8	6.1	79.0

[a] Significantly different from the “Yes” column at the 95% confidence level.

Figure 14 shows that 22 (31%) homes meet the 2018 IECC requirement. There was no statistically significant difference between homes with and without primary electric heat.[55]

Figure 14: ACH50 by Electric vs. Non-Electric Primary Heat



Homes that were built before 2000 were qualitatively assessed to determine whether the home still exhibited original conditions. This analysis further explores how air leakage in older homes can differ between homes that have had improvements and those that have not. The results from this qualitative assessment and detailed ACH50 results by primary heating fuel and EDC, are found in Appendix C Detailed Diagnostic Results.

5.4 Duct Leakage To Outside

Ducts were present at 66 diagnostic sites, and there were 68 duct systems in total. Technicians attempted to test the duct leakage of every system, but at times were unable to get a reliable measurement. This was due to systems being too leaky to reach test pressure or the home having inaccessible duct registers.[56] Table 38 summarizes the completion rates of total duct leakage (TDL) and leakage to outside (LTO) tests by vintage. Overall, LTO tests were completed for 41 systems in 38 homes. This report focuses on LTO tests instead of TDL tests because LTO reflects a loss of energy.

[55] The two homes with the largest ACH50 values are detached single family homes constructed before the 1930's. Both homes contained no insulation within the above-grade walls, foundation walls and very minimal insulation within the ceilings.
[56] Extremely leaky duct systems often had *panning* (i.e., a metal sheet nailed to an open wall or floor cavity to turn the cavity into a *duct*) or large holes in unconditioned space. Additionally, some had inaccessible registers that could not be sealed during testing.

Table 38: Duct Leakage Tests by Vintage

(Base = Systems)

Result	Before 1940	1940-1959	1960-1979	1980-1999	2000-2009	2010 or later	Statewide
LTO and TDL Completed	6	8	4	5	9	8	41
Unsuccessful LTO/TDL Tests	4	5	5	8	4	2	27
Inaccessible Registers	1	0	1	3	1	0	6

For the 27 systems that were too leaky to test, the SWE team estimated LTO using an algorithm for duct leakage in unsealed duct systems from the Manual J protocols.[57] The estimate is based on duct system supply and return surface areas. The average system-level LTO is 7.6 CFM25/100 sq. ft when considering both estimated and tested (i.e., actual) values (Table 39).[58] The average estimated LTO of the systems that were too leaky to test (11.1) is higher (i.e., more leaky) than the average of tested systems (4.8).[59] This result is unsurprising since results were only obtainable for systems that were tight enough to test.

To assess the accuracy of the Manual J estimation method, the SWE team also compared the estimated leakage values against the actual values for the 27 tested systems. On average, the calculated estimates were 38% higher than the actual values. This is reasonable given that the estimation method assumes a leaky, unsealed duct system, whereas the sample includes sealed duct systems.

Table 39: Duct Leakage to Outside (CFM25/100 sq.ft.)

(Base = Systems)

	Estimated	Tested	Statewide
n-value	*27*	*41*	*68*
Min	0.0	0.0	0.0
Max	29.9	27.1	29.9
Mean	**11.1**	**4.8**	**7.6**
Median	12.6	2.3	4.7
Std. Dev.	8.9	6.6	8.1

[57] Manual J is the standard set by the Air Conditioning Contractors of America for sizing residential heating and cooling equipment. Manual J sets default leakage rates for unsealed systems in units of CFM25/Sq. Ft duct surface area as 0.35 times supply surface area for supply-side leakage and 0.7 times return surface area for return leakage. See Manual J Residential Load Calculation, 8th Edition, page 19, Figure 3-6.

[58] CFM25/100 sq. ft stands for cubic feet per minute at a pressure difference of 25 pascals between the inside and outside of the home per 100 square feet of conditioned floor area. The 2018 IECC standard specifies a maximum leakage to outside value of 4 CFM25/100 sq. ft.

[59] Duct systems located entirely within the thermal boundary have an LTO value of zero. When excluding duct systems located entirely within the thermal boundary, the average statewide LTO raises to 10.7 (estimated LTO of 15.2 and tested LTO of 7.5).

As expected, newer homes tend to have less duct leakage than older homes (Table 40). Newer homes have an average duct leakage to outside of 2.7 (CFM25) while homes built between 1960-79 had an average of 12.9. This could be the result of older homes having more ducts exposed to unconditioned or ambient conditions in crawl spaces. (Table 40, Figure 15).

Table 40: Duct Leakage to Outside by Vintage (CFM25/100 sq. ft.)

(Base = Systems)

	Before 1940	1940-1959	1960-1979	1980-1999	2000-2009	2010 or later	Statewide
n-value	*11*	*13*	*9*	*11*	*14*	*10*	*68*
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Max	26.6	17.6	27.1	29.9	20.2	8.3	29.9
Mean	**10.5**	**6.9**	**12.9**	**7.1**	**5.1**	**2.7**	**7.6**
Median	7.9	9.1	15.0	4.6	1.7	0.8	4.7
Std. Dev.	10.5	6.7	9.6	8.8	6.6	3.3	8.1

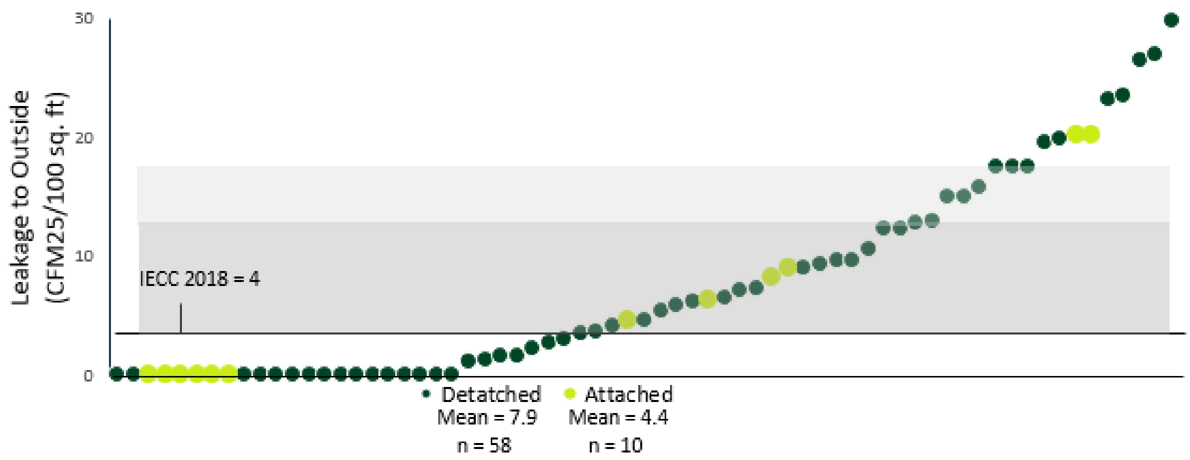
Detached homes have higher duct leakage to outside (8.2 CFM25) than attached single-family homes (4.4 CFM25). (Table 41, Figure 15).

Table 41: Duct Leakage to Outside by Home Type (CFM25/100 sq.ft.)

(Base = Systems)

	Detached Single-family	Attached Single-family	Statewide
n-value	*58*	*10*	*68*
Min	0.0	0.0	0.0
Max	29.9	20.2	29.9
Mean	**7.9**	**4.4**	**7.6**
Median	5.4	4.6	4.7
Std. Dev.	8.4	6.4	8.1

Figure 15: Duct Leakage to Outside by Home Type

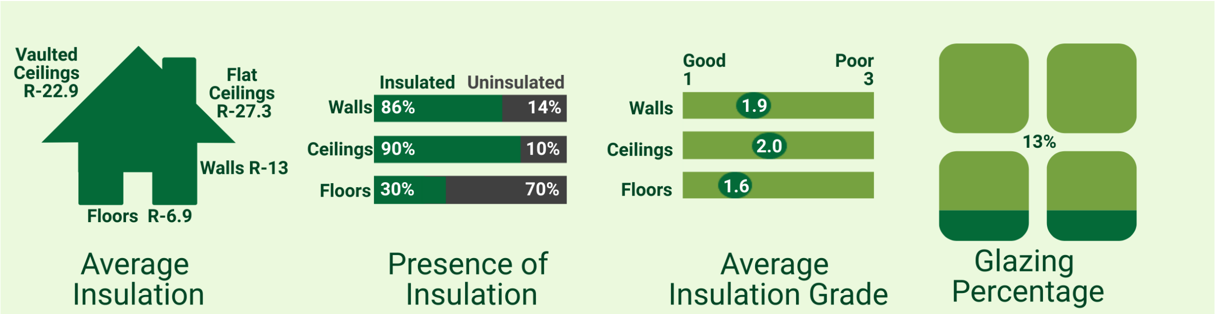


For detailed results split by heating fuel, income status, and EDC, see Appendix C Detailed Diagnostic Results.

Section 6 Building Envelope

This section describes efficiency features of the building shell (i.e., building envelope) of all homes in the sample. These features included above grade walls, ceilings, foundation walls, slab floors, and windows.

Figure 16: Building Envelope Results Highlights



Key Findings:

- Homes in the sample demonstrate significant potential for efficiency improvements through upgrading insulation in the building shell. Exterior walls are primarily uninsulated in 14% of homes, ceilings are primarily uninsulated in 10% of homes, and frame floors over unconditioned basements are primarily uninsulated in 70% of homes.
- The average R-value of exterior walls is R-13. The average R-value of walls in single-family homes (13.5) is significantly higher than in multifamily homes (10.2).
- Flat ceilings in the sample have an average R-value of 27.3, while vaulted ceilings average 22.9.
- 41% of foundation walls enclosing conditioned space are uninsulated, and the average R-value is 7.4.
- Windows comprise 13% of external wall area. Over ninety percent of window area is made up of plain double pane glazing, and 56% of window area had confirmed low-emissivity coatings.

6.1 Shell Measure Data Collection

A building's thermal envelope is formed by the walls, floors, ceilings, and fenestration (i.e., windows and doors) that separate conditioned space from unconditioned or ambient space.[60] For this study, auditors gathered data on thermal resistance (e.g., R-values and U-factors) and insulation type for envelope measures, such as walls, ceilings, and frame floors. Data were also

[60] Because doors are such a small portion of the building shell, information on doors was collected and included in the REM/Rate models for diagnostic visits, but not included in reporting.

collected on the level of insulation for foundation walls and slab floors in conditioned spaces, and the area, framing, and glazing material of windows.

This section focuses on key components of the thermal envelope. The above grade walls section details walls between conditioned and ambient space, the ceiling section details flat and vaulted ceilings, and the frame floor section details floors over unconditioned basements. The foundation wall, slab floor, and window sections focus on measures found in conditioned space. For additional EDC-specific analysis, see Appendix D.

For each data point, information is reported to the extent it could be determined onsite.[61] For example, when assessing insulation type and thickness, auditors were constrained by what they could see and feel in homes with sealed cavities. *Primary insulation type* is defined as the insulation type (or combination of types, denoted with a "+" in the tables below) found in the majority of the home for each measure. As such, there are some cases where multiple insulation types (or lack thereof) were present in significant proportions of total shell-measure area, but for reporting at the site level, only the most common combination of framed, continuous, and exterior insulation is reported. Average R-value is calculated as an area-weighted average, following RESNET protocols, that accounts for scenarios where a home has walls insulated to varying degrees.[62] These calculations include *all* types of insulation (or lack thereof) found across the relevant shell component, throughout the entire residence. For example, one home was primarily insulated with fiberglass batts, but it included a small addition that was insulated with closed-cell spray foam. For this home, the batts represented the sole observation of a primary insulation type, but the foam insulation in the addition was factored into the area-weighted R-value calculation for all exterior walls in the home. Additionally, if the majority of wall area in a home was uninsulated, the home was considered to have primarily uninsulated walls, but the R-values of any present insulation was included in the average R-value calculations.

Each section below also includes a table detailing insulation grade for a given measure. Insulation grade is a rating of how well the insulation was installed in the building cavity – Grade I is the highest (best) rating and Grade III is the lowest. Poor insulation grade lowers the thermal performance of the shell assembly. For more detail on insulation grade, including examples, see Appendix E. Tables showing insulation grade only include observations of a measure found in the diagnostic sample of homes, as these were the only homes where insulation grade was assessed. Grade is a necessary REM/Rate input for modeling wall building envelope assemblies when generating HERS Index scores, which was only done for the diagnostic sample.

6.2 Conditioned to Ambient Walls

This section details the primary insulation type and average R-value for conditioned to ambient (exterior) walls in sampled homes.

[61] Data was not collected on the building envelope for homes that participated in the self-audit and were not included in the on-site sample.

[62] RESNET is a recognized national standards-making body for building energy-efficiency rating and certification systems in the United States, including the HERS Index. http://www.resnet.us/

6.2.1 Primary Insulation Type

Statewide, 71% of exterior walls were primarily insulated with fiberglass batts or a combination including fiberglass batts, while 14% were primarily uninsulated (Table 42). The proportion of uninsulated walls confirmed in this study is lower compared to the previous baseline study (34%). However, it highlights the opportunity for energy savings that exists by upgrading wall insulation. Multifamily homes are the most likely to have uninsulated wall area, with nearly one-third (33%) found to be without exterior wall insulation, compared to 13% among detached single-family homes and 11% among attached single-family homes.

Table 42: Ambient Wall Primary Insulation

Insulation Type	Detached single-family	Attached single-family	Multifamily	Statewide
n-value	*189*	*28*	*69*	*286*
Fiberglass Batt (FGB)	67%	79%	49%	71%
No Insulation	13%	11%	33%	14%
Blown-in Cellulose	7%	--	6%	5%
FGB + Rigid Foam[1]	7%	4%	4%	4%
Rigid Foam	3%	--	7%	2%
Blown-in Fiberglass	2%	--	--	1%
Closed-cell Spray Foam + Rigid Foam	1%	--	--	1%
Open-cell Spray Foam + Rigid Foam	1%	7%	--	1%

[1] Rigid foam includes expanded polystyrene (EPS), extruded polystyrene (XPS), and polyisocyanurate.* Totals may not equal sum of column or row due to rounding.

Table 43 shows ambient wall primary insulation organized by home vintage. Not surprisingly, many uninsulated walls in the sample are clustered among homes built before 1960, and over 40% of ambient walls in homes built before 1940 were uninsulated.

Table 43: Ambient Primary Wall Insulation by Home Vintage

Insulation Type	Before 1940	1940-1959	1960-1979	1980-1999	2000-2009	2010 or later	Statewide[1]
n-value	*70*	*40*	*51*	*50*	*50*	*25*	*286*
Fiberglass Batt (FGB)	40%	57%	73%	78%	82%	56%	71%
No Insulation	44%	22%	14%	4%	2%	0%	14%
Blown-in Cellulose	11%	10%	4%	4%	4%	0%	5%
FGB + Rigid Foam[1]	1%	--	4%	10%	10%	16[e]%	4%
Rigid Foam	--	5%	4%	4%	--	16%	2%
Blown-in Fiberglass	1%	5%	--	--	--	--	1%
Closed-cell Spray Foam + Rigid Foam	1%	--	--	--	--	4%	1%
Open-cell Spray Foam + Rigid Foam	--	--	2%	--	2%	8%	1%

[1] Rigid foam includes expanded polystyrene (EPS), extruded polystyrene (XPS), and polyisocyanurate.
* Totals may not equal sum of column or row due to rounding.

6.2.2 Ambient Wall Insulation Grade

Within the diagnostic sample, over two-thirds of the homes had Grade II (58%) or Grade III (12%) insulation in their walls, as depicted in Table 44. This is not surprising since Grade I installations are rare even in new construction and generally require high quality spray or dense pack insulation and an assessment by an auditor before the wall cavity is enclosed. As Table 42 shows, most homes had walls with fiberglass batt insulation, which is less likely to earn a Grade I rating even in ideal conditions. Auditors following RESNET rating guidelines are particularly reluctant to give fiberglass insulation a Grade I in a closed cavity that cannot be fully inspected.

Table 44: Exterior Wall Insulation Grades

Grade	Detached single-family	Attached single-family	Statewide
n-value	*61*	*11*	*72*
I	18%	18%	17%
II	54%	73%	58%
III	15%	--	12%
No Cavity Insulation	13%	9%	12%

* Totals may not equal sum of column or row due to rounding.

6.2.3 Average R-value

The average per-home R-value for conditioned to ambient walls statewide was R-13 (Table 45). Out of the 286 sites examined, 49 sites had uninsulated exterior walls. Excluding these uninsulated sites increases the average R-value for the remaining 237 homes to R-15.1. For comparison, the 2018 IECC R-value requirement for exterior walls is R-20.0.

Out of the 50 uninsulated sites included in the sample, three in ten (15) were in Duquesne Light territory. Duquesne Light homes had the lowest average ambient wall R-value among the EDCs at R-9.2. This value was lower than all other EDCs, which ranged from 11.3 (West Penn Power) to 15.6 (Penn Power). For more detailed information regarding the R-value split by EDC, see Table 184 in Appendix D.

Table 45: Average Conditioned to Ambient Wall R-value

	Detached single-family	Attached single-family	Multifamily	Statewide
n-value	*189*	*28*	*69*	*286*
Minimum	0.0	0.0	0.0	0.0
Maximum	38.7	21.0	26.3	38.7
Mean	**13.5**	**13.5**	**10.2**	**13.0**
Median	13.0	13.0	11.9	13.0
Std. Dev.	6.8	5.9	8.3	7.2

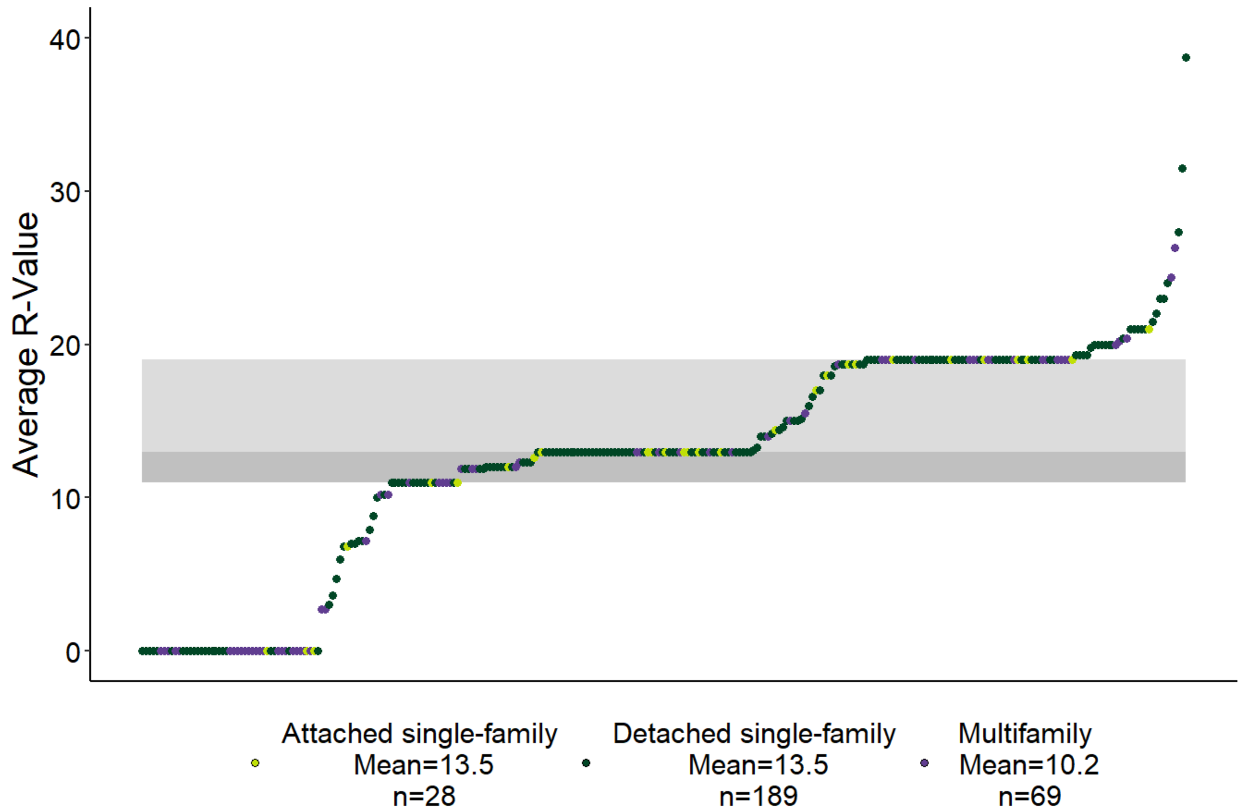
Table 46 further breaks down wall R-values by home vintage. Predictably, average R-values rise through each period. These values highlight the opportunity for efficiency gains through targeting older, less insulated or uninsulated homes with insulation upgrades.

Table 46: Above Grade Wall R-value by Vintage

	Before 1940	1940-1959	1960-1979	1980-1999	2000-2009	2010 or later	Statewide
n-value	*70*	*40*	*51*	*50*	*50*	*25*	*286*
Minimum	0.0	0.0	0.0	0.0	0.0	4.7	0.0
Maximum	26.3	27.4	38.7	22.0	24.0	31.5	38.7
Mean	**8.5**	**9.2**	**11.9**	**15.6**	**17.0**	**17.4**	**13.0**
Median	11.0	11.0	13.0	17.0	19.0	18.7	13.0
Std. Dev	8.3	6.4	6.6	4.7	4.2	5.3	7.2

Figure 17 displays per-home R-values for all sites in the sample. Aside from the grouping of uninsulated homes on the left side of the graph, there is a large cluster of homes at the statewide median of R-11. Additionally, there are secondary groupings at R-13 and R-19. These groupings align with the nominal R-values of standard fiberglass batts, which are the most commonly used insulation type in the sample. Specifically, R-11 and R-13 fiberglass batts are typically utilized for walls framed with 2x4 dimensions, which is the most common framing dimension found in the sample. On the other hand, R-19 batts are commonly used to fill 2x6 cavities, representing the next most common framing type.

Figure 17: Per-home Ambient Wall R-values



6.3 CEILINGS

The following section describes onsite data collected on two main types of ceilings:

- Flat ceilings, where there is attic space above the ceiling and can also be thought of as unconditioned attic floors.
- Vaulted ceilings, which refer to a ceiling assembly that has no attic space above it and is insulated at the roof deck/rafters.

Auditors also collected data on attic hatches. However, they are excluded here because attic hatches comprise such a small percent of ceiling area.

6.3.1 Flat Ceiling Primary Insulation Type

In flat ceiling assemblies, fiberglass batts were found to be the most prevalent insulation type used in flat ceiling assemblies statewide. They were present in over half of the homes either as a standalone insulation (51%) or in combination with another type (4%) (Table 47). Fiberglass batts were the most common primary insulation type regardless of home type.

Across the state, 4% of flat ceilings statewide were primarily uninsulated, indicating that the majority of ceiling area had no insulation. However, flat ceilings above attached single-family homes (10%) and multifamily homes (12%) were more likely to be uninsulated than those above detached single-family homes (3%). Blown-in insulation, either fiberglass (19%) or cellulose

(20%), was also widely used. This has increased from 15% and 14%, respectively, in the prior study. In the previous study, 17% of flat ceilings were uninsulated. While flat ceilings were more consistently insulated than walls, they represent an opportunity for energy savings via R-value upgrades.

Table 48 shows the prevalence of primary insulation types by home vintage. Flat ceilings found in homes dating from before 1940 are more likely to be uninsulated. Four percent of homes built between 1940 and 1999 remain uninsulated, and no homes built since the year 2000 had uninsulated ceilings.

Table 47: Flat Ceiling Primary Insulation

Insulation Type	Detached single-family	Attached single-family	Multifamily	Statewide
n-value	*164*	*21*	*16*	*201*
Fiberglass Batt (FGB)	49%	48%	62%	51%
Blown-in Cellulose	24%	10%	12%	20%
Blown-in Fiberglass	17%	29%	6%	19%
No insulation	3%	10%	12%	4%
Blown-in Cellulose + FGB	3%	5%	--	3%
Blown-in Fiberglass + FGB	2%	--	--	1%
Blown-in Rock Wool	1%	--	6%	1%
Open-cell Spray Foam + Rigid Foam[1]	1%	--	--	<1%
Rock Wool Batt	1%	--	--	<1%

[1] Rigid foam includes expanded polystyrene (EPS), extruded polystyrene (XPS), and polyisocyanurate.
* Totals may not equal sum of column or row due to rounding.

Table 48: Primary Flat Ceiling Insulation by Home Vintage

Insulation Type	Before 1940	1940-1959	1960-1979	1980-1999	2000-2009	2010 or later	Statewide
n	*40*	*32*	*34*	*36*	*42*	*17*	*201*
Fiberglass Batt (FGB)	55%	56%	62%	42%	45%	29%	51%
Blown-in Cellulose	20%	28%	15%	22%	26%	18%	20%
Blown-in Fiberglass	10%	9%	12%	22%	19%	47%	19%
No insulation	12%	3%	6%	3%	--	--	4%
Blown-in Cellulose + FGB	--	3%	6%	3%	2%	6%	3%
Blown-in Fiberglass + FGB	--	--	--	6%	2%	--	1%
Blown-in Rock Wool	2%	--	--	3%	--	--	1%
Open-cell Spray Foam + Rigid Foam[1]	--	--	--	--	2%	-	<1%
Rock Wool Batt	--	--	--	--	2%	--	<1%

[1] Rigid foam includes expanded polystyrene (EPS), extruded polystyrene (XPS), and polyisocyanurate.
* Totals may not equal sum of column or row due to rounding.

6.3.2 Flat Ceiling Insulation Grade

About a third of the diagnostic sample had Grade II insulation (34%), while another third (33%) had Grade I insulation (Table 49). Just 7% of the 64 diagnostic homes with flat attic space were uninsulated.

Table 49: Flat Ceiling Insulation Grade

Grade	Detached single-family	Attached single-family	Statewide
n	*57*	*7*	*64*
I	35%	14%	33%
II	32%	57%	34%
III	28%	14%	26%
No Cavity Insulation	5%	14%	7%

* Totals may not equal sum of column or row due to rounding.

6.3.3 Flat Ceiling R-value

The average statewide flat ceiling R-value was R-27.3 (Table 50), with some variation in the average by home type. Multifamily homes have the lowest average (R-20.9), while attached single-family homes had the highest average (R-28.3). Nine sites had flat ceilings that were completely uninsulated. Narrowing the sample to the 192 homes with some type of insulation present in flat ceilings, the average statewide R-value rises to R-28.1. For comparison, the 2018 IECC R-value requirement for flat ceilings is R-49.0, a value that should be attainable in most homes with flat ceilings.

Table 50: Average Flat Ceiling R-value

	Detached single-family	Attached single-family	Multifamily	Statewide
n-value	*164*	*21*	*16*	*201*
Minimum	0.0	0.0	0.0	0.0
Maximum	66.7	59.6	44.4	66.7
Mean	**27.2**	**28.3**	**20.9**	**27.3**
Median	30.0	30.0	19.0	30.0
Std. Dev.	10.8	12.7	12.4	11.2

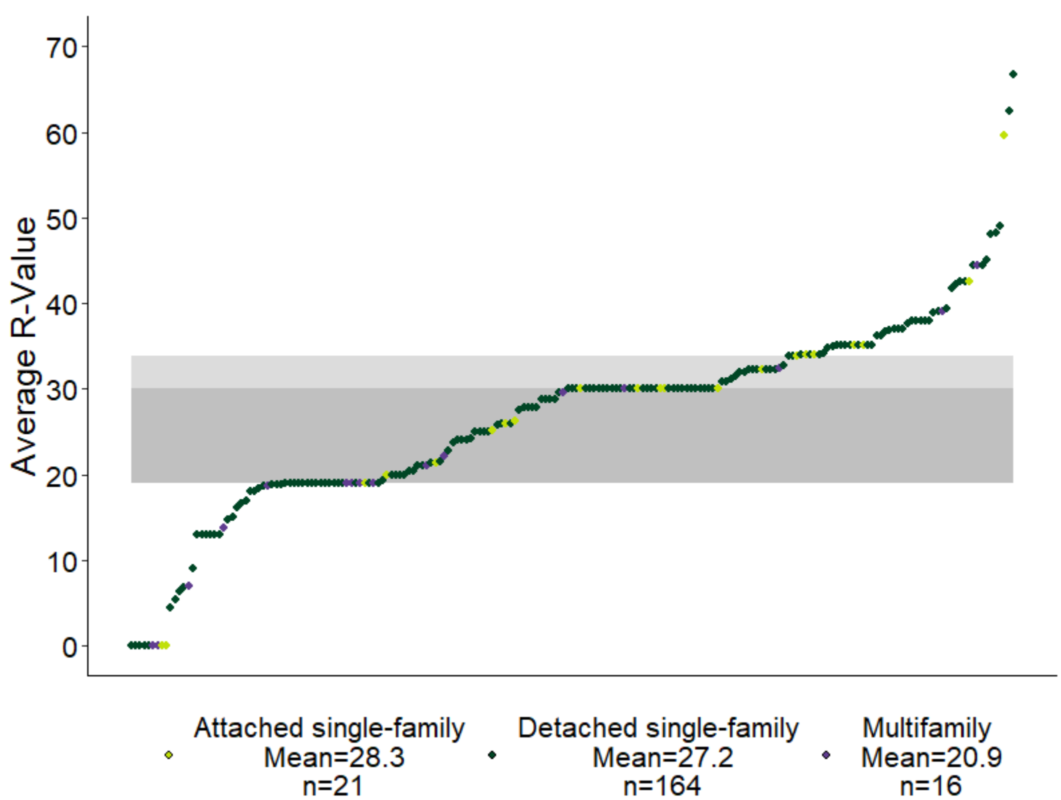
Table 51 displays average flat ceiling R-value by home vintage. Average R-value increases over each period, peaking among the newest sub-sample of homes (built in or after 2010). Flat ceilings with attic space typically allow for easier application of new insulation, and the table highlights the potential for efficiency gains through adding insulation to older homes that pull the statewide average R-value down. This can be seen through comparison with the results of the 2018 study, as there is only a sampling-related difference in flat ceiling R-value for homes built since 2010, which rose from 33.2 to 33.6, but the statewide average has risen from 19.5 to 27.3. The most marked improvement has been in homes built before 1940, for which the mean flat ceiling R-value has risen from R-14.7 by 47% to R-21.6.

Table 51: Flat Ceiling R-value by Home Vintage

R-Values	Before 1940	1940-1959	1960-1979	1980-1999	2000-2009	2010 or later	Statewide
n-value	*40*	*32*	*34*	*36*	*42*	*17*	*201*
Min	0.0	0.0	0.0	0.0	18.8	14.8	0.0
Max	44.4	49.0	66.7	59.6	62.4	42.6	66.7
Mean	**21.6**	**23.8**	**25.4**	**28.4**	**31.0**	**33.6**	**27.3**
Median	19.7	19.7	27.8	30.0	30.4	34.0	30.0
Std. Dev.	12.2	10.7	12.1	11.2	8.5	6.5	11.2

Figure 18 displays the distribution of per-home average R-values for flat ceilings in the sample. Groupings are visible around R-19 and again at the statewide median of R-30. These clusters fit with the data shown in Table 47, as they are two common R-value options for fiberglass batts, the most prevalent insulation type in the sample.

Figure 18: Per-home Flat Ceiling R-values



6.3.4 Vaulted Ceiling Primary Insulation Type

Vaulted ceilings were found to be less common in the sample compared to ceilings with attic space. Due to their design, verifying the presence and type of insulation in vaulted ceilings can be more challenging. Where data could be collected on vaulted ceilings, the cavities were primarily insulated with fiberglass batts (75%) or uninsulated (16%), similar to other shell measures in the sample (Table 52). There was only one example of a vaulted ceiling above conditioned space in a multifamily home where insulation could be verified. While the sample size for attached single-family was also small, the higher rate of uninsulated ceilings is identical (33%) to that found in the previous study, which had a larger sample.

Table 53 shows primary insulation types organized by the age of the home. All but one of the homes with uninsulated vaulted ceilings are found in homes built before 1960, and none are found in homes built after 1980.

Table 52: Primary Vaulted Ceiling Insulation

Insulation Type	Detached single-family	Attached single-family	Multifamily	Statewide
n-value	*34*	*6*	*1*	*41*
Fiberglass Batt (FGB)	79%	50%	--	75%
No insulation	12%	33%	--	16%
Rigid Foam[1]	--	17%	0%	5%
Blown-in Cellulose	6%	--	100%	3%
Closed-cell Spray Foam + Rigid Foam	3%	--	--	1%

[1] Rigid foam includes expanded polystyrene (EPS), extruded polystyrene (XPS), and polyisocyanurate.
* Totals may not equal sum of column or row due to rounding.

Table 53: Primary Vaulted Ceiling Insulation by Home Vintage

Insulation Type	Before 1940	1940-1959	1960-1979	1980-1999	2000-2009	2010 or later	Statewide
n-value	*10*	*8*	*5*	*7*	*10*	*1*	*41*
Fiberglass Batt (FGB)	40%	63%	80%	100%	90%	100%	75%
No insulation	30%	25%	20%	--	--	--	16%
Rigid Foam[1]	10%	--	--	--	--	--	5%
Blown-in Cellulose	20%	--	--	--	10%	--	3%
Closed-cell Spray Foam + Rigid Foam	--	13%	--	--	--	--	1%

[1] Rigid foam includes expanded polystyrene (EPS), extruded polystyrene (XPS), and polyisocyanurate.
* Totals may not equal sum of column or row due to rounding.

6.3.5 Vaulted Ceiling Insulation Grade

Twenty-one percent of homes in the diagnostic sample with vaulted ceilings had Grade II insulation, while another 36% had Grade III (Table 54).

Table 54: Vaulted Ceiling Insulation Grade

Grade	Detached single-family	Attached single-family	Statewide
n-value	*14*	*2*	*16*
I	29%	--	31%
II	36%	--	21%
III	21%	100%	36%
No Cavity Insulation	14%	--	12%

* Totals may not equal sum of column or row due to rounding.

6.3.6 Vaulted Ceiling R-value

The average vaulted ceiling R-value statewide was R-22.9 (Table 55). Attached single-family sites were more likely to have uninsulated vaulted ceilings, which is reflected in the lower average R-values for this group (R-16.2). Six homes in the sample had uninsulated vaulted ceilings (Figure 19). The average R-value for the vaulted ceilings among the 35 sampled homes with insulation present was R-26.3. When looking at average vaulted ceiling R-values by home vintage, the average is higher for homes post-1960, but otherwise does not show a clear pattern, which is to be expected with the limited quantity of verified data.

Table 55: Average Vaulted Ceiling R-value

	Detached single-family	Attached single-family	Multifamily	Statewide
n-value	*34*	*6*	*1*	*41*
Minimum	0.0	0.0	40.3	0.0
Maximum	65.9	30.0	40.3	65.9
Mean	**23.8**	**16.2**	**40.3**	**22.9**
Median	23.7	18.5	40.3	26.3
Std. Dev.	12.9	15.4	--	13.5

Table 56: Vaulted Ceiling R-value by Home Vintage

	Before 1940	1940-1959	1960-1979	1980-1999	2000-2009	2010 or later	Statewide
n-value	10	8	5	7	10	1	41
Minimum	0.0	0.0	12.0	28.0	13.0	30.0	0.0
Maximum	40.3	32.3	65.9	38.0	38.0	30.0	65.9
Mean	**17.5**	**16**	**31.5**	**30.9**	**24.1**	**30.0**	**22.9**
Median	19.0	18.8	26.3	30.0	24.6	30.0	26.3
Std. Dev.	15.4	12.5	20.9	3.2	8.5	--	13.5

Figure 19: Per-home Vaulted Ceiling R-values

6.4 Frame Floors

In homes with unconditioned basements,[63] the frame floor separating the basement from conditioned space above it serves as the lower thermal boundary of the building envelope. Typically, the cavities between the floor joists are open, allowing auditors to easily verify the presence, type, and R-value of insulation.

6.4.1 Primary Frame Floor Insulation Type

Seven out of ten sampled homes with unconditioned basements had uninsulated frame floors between basements and conditioned space (Table 57). This represents a major opportunity for insulation upgrades, especially since these cavities are usually open and allow for easy application of insulation materials.

Examining frame floor insulation by home vintage shows that while uninsulated floors are more common among the larger samples of older homes built before 1960, newer homes also have uninsulated floors over unconditioned basements (Table 58). Three out of four homes built after 2010 had fiberglass batt insulation, but almost half (44%) of homes with floors over unconditioned basements built between 1980 and 2009 did not have insulation present.

Table 57: Primary Frame Floor Insulation

Insulation Type	Detached single-family	Attached single-family	Multifamily	Statewide
n-value	*80*	*13*	*8*	*101*
No Insulation	72%	54%	88%	70%
Fiberglass Batt (FGB)	28%	38%	12%	28%
Rigid Foam[1]	--	8%	--	2%

[1] Rigid foam includes expanded polystyrene (EPS), extruded polystyrene (XPS), and polyisocyanurate.
* Totals may not equal sum of column or row due to rounding.

[63] Unconditioned basements here are defined as spaces that lack a heating source adequate to fully heat the room year-round and are not finished spaces (i.e., do not have walls and ceiling cavities closed and drywall or other finishing materials installed). This classification method follows RESNET protocols. Enclosed crawl spaces are grouped with unconditioned basements in this analysis.

Table 58: Primary Frame Floor Insulation by Home Vintage

Insulation Type	Before 1940	1940-1959	1960-1979	1980-1999	2000-2009	2010 or later	Statewide
n-value	*35*	*18*	*16*	*9*	*19*	*4*	*101*
No Insulation	94%	88%	56%	67%	37%	25%	70%
Fiberglass Batt (FGB)	3%	11%	44%	33%	63%	75%	28%
Rigid Foam[1]	3%	--	--	--	--	--	2%

[1] Rigid foam includes expanded polystyrene (EPS), extruded polystyrene (XPS), and polyisocyanurate.
* Totals may not equal sum of column or row due to rounding.

6.4.2 Frame Floor Insulation Grade

Two thirds of homes in the diagnostic sample had uninsulated frame floors. Half of the insulation that was installed was of Grade II or III quality, while the other half of the installed insulation was of Grade I quality.

Table 59: Frame Floor Insulation Grade

Grade	Detached single-family	Attached single-family	Multifamily	Statewide
n-value	*24*	*4*	*0*	*28*
I	12%	50%	–	17%
II	8%	--	–	7%
III	4%	25%	–	8%
No Cavity Insulation	75%	25%	–	68%

6.4.3 Frame Floor R-value

Due to the prevalence of uninsulated frame floors over unconditioned basements, the average R-value was only R-6.9 (Table 60). Multifamily homes stood out from the other home types with an average of R-1.4, due to seven of eight verified examples lacking any insulation. When only looking at the 29 sites, of all types, with insulation present, the average R-value rose to R-24.4. This demonstrates the potential impact of insulation in improving the energy efficiency of homes with unconditioned basements. Table 61 shows how frame-floor insulation practices have changed over time. The average frame-floor R-value of homes built since 2000 is over R-10 higher than those built in the 1900s. As shown in Table 58, the largest group of homes with unconditioned basements were built before the 1940s, and 94% of them are uninsulated. Most homes built since 2000, by comparison, have at least R-19 (achieved with a standard fiberglass batt).

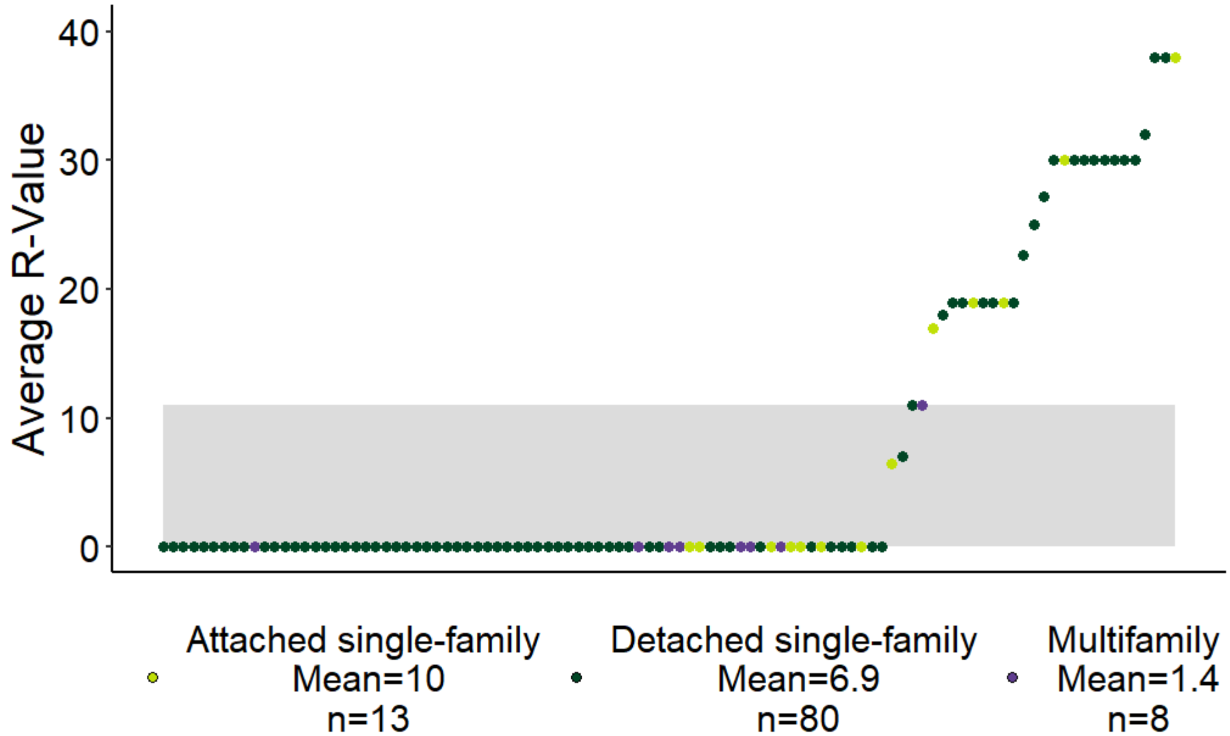
Table 60: Average per-home Frame Floor R-value

	Detached single-family	Attached single-family	Multifamily	Statewide
n-value	*80*	*13*	*8*	*101*
Minimum	0.0	0.0	0.0	0.0
Maximum	38.0	38.0	11.0	38.0
Mean	**6.9**	**10.0**	**1.4**	**6.9**
Median	0.0	0.0	0.0	0.0
Std. Dev.	12.0	13.3	3.9	11.8

Table 61: Frame Floor R-value by Home Vintage

R-Values	Before 1940	1940-1959	1960-1979	1980-1999	2000-2009	2010 or later	Statewide
n-value	*35*	*18*	*16*	*9*	*19*	*4*	*101*
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	30.0	19.0	30.0	30.0	38.0	38.0	38.0
Mean	**1.0**	**2.1**	**9.1**	**7.1**	**16.7**	**23.2**	**6.9**
Median	0.0	0.0	0.0	0.0	19.0	27.5	0.0
Std. Dev	5.2	6.1	12.2	11.6	14.4	16.4	11.8

Figure 20: Per-home Frame Floor R-values



6.5 Foundation Walls

Conditioned basements were present in 39% of homes. In conditioned basements, auditors checked for insulation along the interior and exterior of the foundation walls. Interior insulation was found in 64 homes, but the presence of exterior insulation was only confirmed in three homes. Exterior insulation can be difficult to verify without building plans or construction photos as it is often covered by a protective layer and cut off below grade. So, while exterior continuous insulation is uncommon on foundation walls in older homes, it is possible its prevalence is underrepresented in the sample.

6.5.1 Primary Foundation Wall Insulation Type

About four in ten homes (41%) in the sample with conditioned basement space had foundation walls that were primarily uninsulated (Table 62). Beyond that, fiberglass batts were the most common insulation type, present in 38% of the homes, followed by rigid foam insulation at 16%.

Table 62: Primary Foundation Wall Insulation

Insulation Type	Detached single-family	Attached single-family	Multifamily	Statewide
n-value	*101*	*7*	*2*	*110*
No insulation	41%	43%	100%	41%
Fiberglass Batt (FGB)	37%	14%	--	38%
Rigid Foam[1]	17%	29%	--	16%
Blown-in Cellulose	1%	--	--	2%
FGB + Rigid Foam	5%	--	--	2%
Open-cell Spray Foam + Rigid Foam	--	14%	--	<1%

[1] Rigid foam includes expanded polystyrene (EPS), extruded polystyrene (XPS), and polyisocyanurate.
* Totals may not equal sum of column or row due to rounding.

Table 63: Primary Foundation Wall Insulation by Home Vintage

Insulation Type	Before 1940	1940-1959	1960-1979	1980-1999	2000-2009	2010 or later	Statewide
n-value	*10*	*18*	*26*	*16*	*30*	*10*	*110*
No insulation	50%	56%	54%	44%	27%	20%	41%
Fiberglass Batt (FGB)	40%	39%	27%	38%	40%	20%	38%
Rigid Foam[1]	10%	6%	8%	19%	23%	50%	16%
Blown-in Cellulose	--	--	4%	--	--	--	2%
FGB + Rigid Foam	--	--	8%	--	10%	--	2%
Open-cell Spray Foam + Rigid Foam	--	--	--	--	--	10%	<1%

[1] Rigid foam includes expanded polystyrene (EPS), extruded polystyrene (XPS), and polyisocyanurate.
* Totals may not equal sum of column or row due to rounding.

6.5.2 Foundation Wall Insulation Grade

All but four diagnostic sites with conditioned-basement foundation wall insulation present were detached single-family homes (Table 64). Over half (58%) of homes in the diagnostic sample had uninsulated foundation walls in conditioned space. Foundation wall insulation is more likely to be exposed rather than plastered over, and thus raters are more often able to visually confirm the presence of Grade I insulation.

Table 64: Foundation Wall Insulation Grade

Grade	Detached single-family	Attached single-family	Statewide
n-value	*31*	*4*	*35*
I	23%	25%	22%
II	13%	--	11%
III	6%	25%	9%
No Cavity Insulation	58%	50%	58%

6.5.3 Foundation Wall R-value

The statewide average R-value for foundation walls in conditioned space was R-7.4 (Table 65). This was reduced substantially by the 41% of homes in the sample with conditioned basement space enclosed by primarily uninsulated foundation walls. Removing the uninsulated walls from the sample, the R-value of insulated walls rises to R-13.0. Curiously, the average R-value for foundation walls does not rise with more recent home construction, as it does for other elements of the building shell (Table 66). One potential reason for this is the popularity of basement renovations that expand the livable area of the home, which can include insulating foundation walls in the scope of the renovation. Figure 21 shows per-home foundation wall R-values.

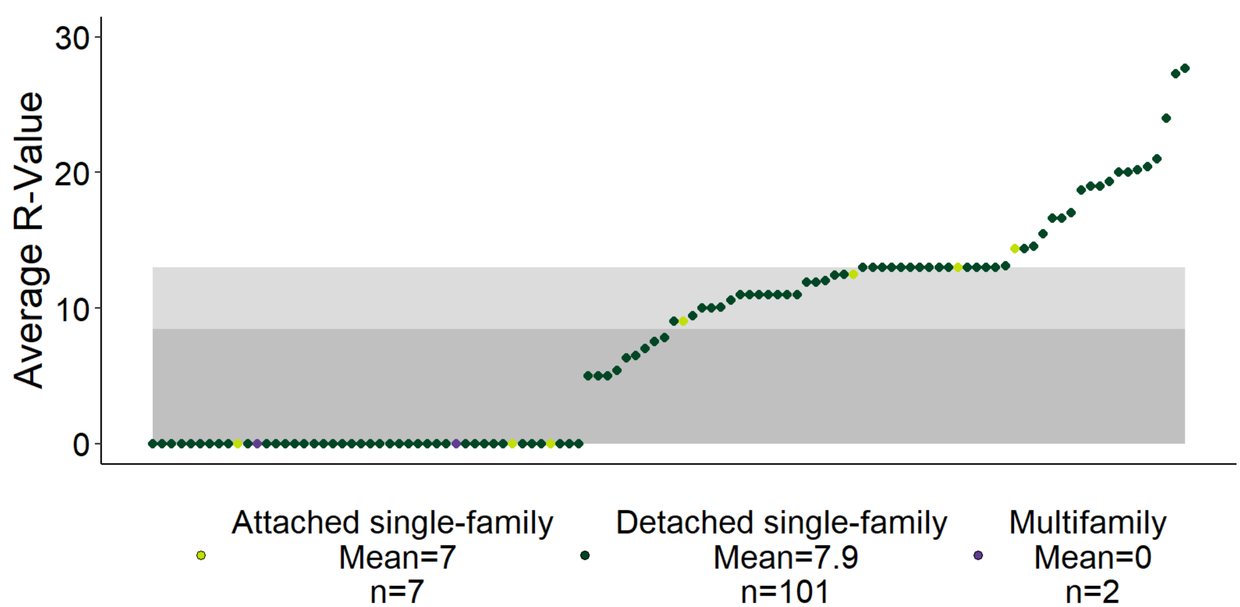
Table 65: Average Foundation Wall R-value

	Detached single-family	Attached single-family	Multifamily	Statewide
n	*101*	*7*	*2*	*110*
Minimum	0.0	0.0	0.0	0.0
Maximum	27.7	14.4	0.0	27.7
Mean	**7.9**	**7.0**	**0.0**	**7.4**
Median	9.0	9.0	0.0	8.4
Std. Dev.	7.6	6.7	0.0	7.6

Table 66: Average Foundation Wall R-value by Home Vintage

	Before 1940	1940-1959	1960-1979	1980-1999	2000-2009	2010 or later	Statewide
n	*10*	*18*	*26*	*16*	*30*	*10*	*110*
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	20.0	21.0	20.2	27.7	27.3	14.4	27.7
Mean	**8.9**	**6.1**	**5.9**	**7.9**	**9.8**	**7.2**	**7.4**
Median	11.0	2.5	0.0	9.0	10.0	10.0	8.4
Std. Dev.	8.3	7.2	7.1	8.4	7.8	6.4	7.6

Figure 21: Per-home Foundation Wall R-values



6.6 Slab Floors

Slab floors form the lower boundary of the thermal envelope in homes with conditioned basement space or with on-grade floors that have no basement underneath. It is best practice to insulate slabs that serve as part of the thermal boundary, though the presence of insulation is usually not possible to verify post-construction without building plans or other documentation. Auditors were able to verify the presence of slab insulation at just one site out of the 147 that had slab floor bordering conditioned space – in a detached single-family that had one-inch-thick perimeter foamboard insulation visible to the auditor.

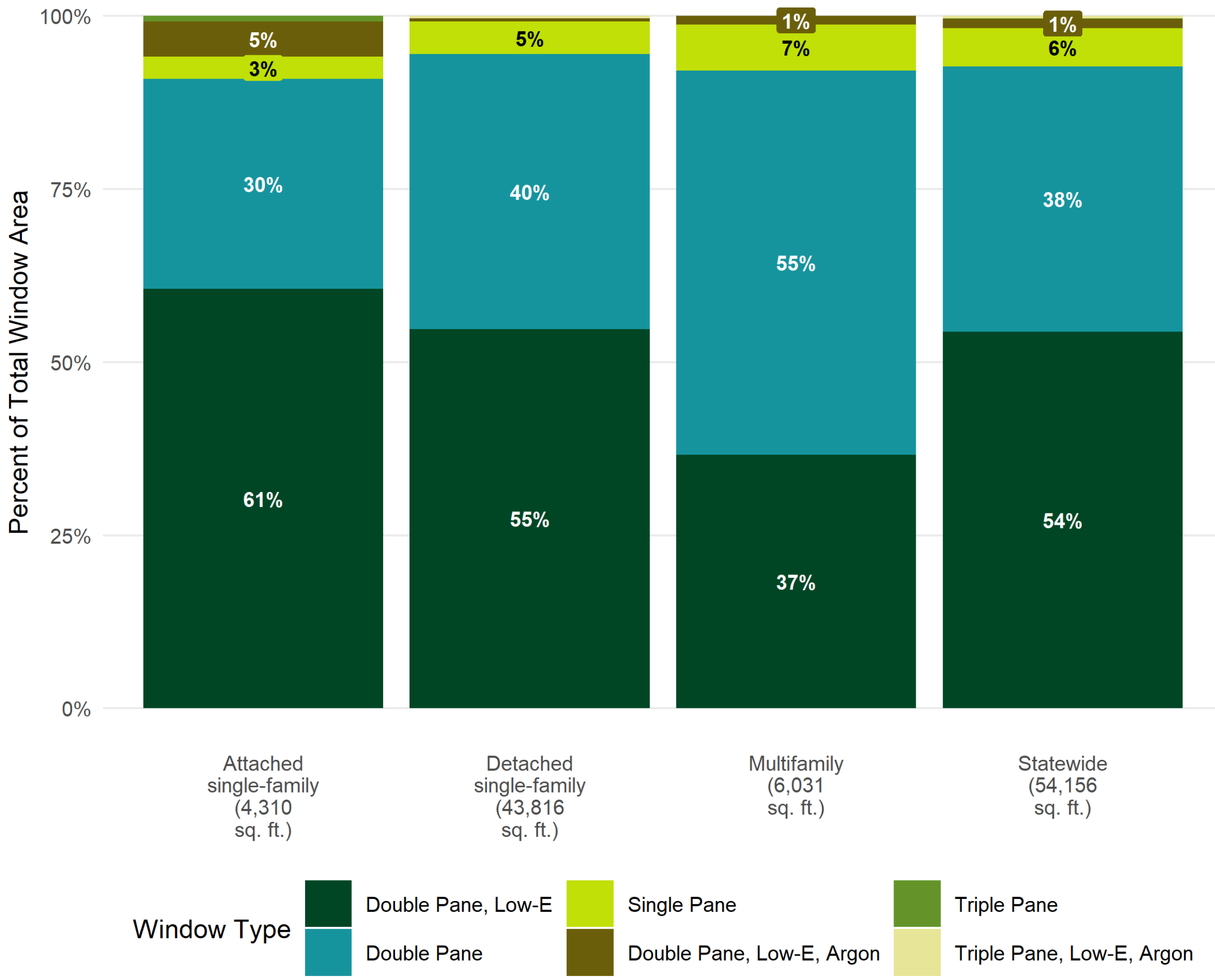
6.7 WINDOW

During onsite visits, auditors recorded the framing and material of glazing (i.e., windows), as well as the size of each window in the home. This section looks at the prevalence of glazing types *as a percentage of total window area*, rather than using counts of windows. Average glazing area per site is calculated as the percent of exterior wall area composed of glazing for each home. All window data is limited to windows located in conditioned space.

6.7.1 Glazing Types

Statewide, double-pane windows with Low-E coating emerged as the most prevalent glazing type, constituting 54% of the total glazing area. Regular double-pane windows accounted for 38% of the total area, while double-pane windows with both Low-E coating and Argon gas comprised 1% of the total area. Verifying the presence of argon gas is difficult to assess without documentation and thus this may be an underestimate. Single pane glazing represented about 6% of the sample, concentrated in older homes, which was unsurprising. Triple pane glazing made up less than half of 1% of window area in the sample and was only found in detached single-family homes. This is not surprising given that this type of glazing is rare even in new construction. It is, however, a common component in very high-performance homes, and may become more prevalent in the future as the demand for net-zero construction expands.

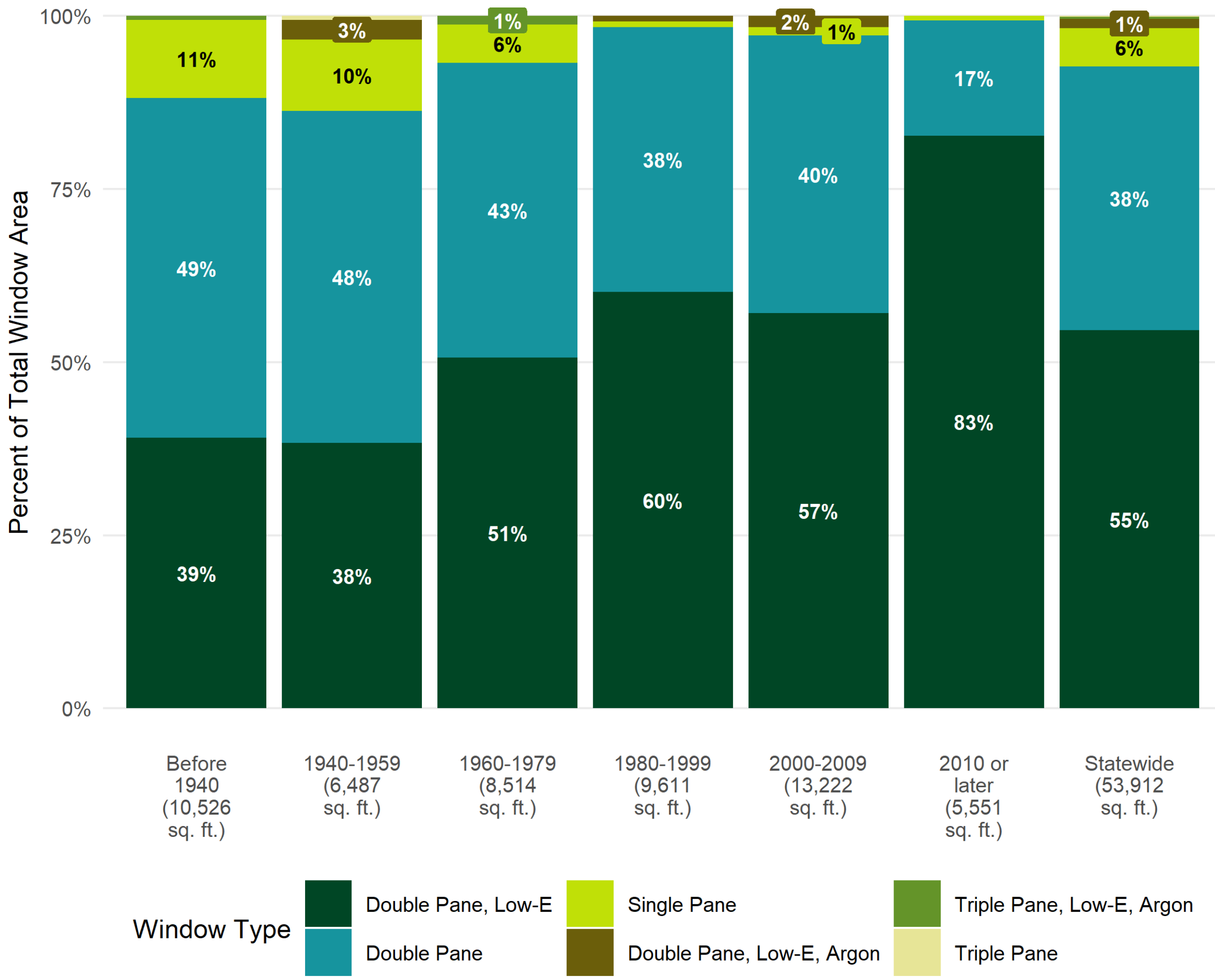
Figure 22: Glazing Types by Window Square Footage (Home Types)



Double pane glazing – either plain or with added efficiency features – was the most common type across all home types and EDCs, making up over 90% of glazing in all subgroups.

Figure 23 further breaks down the distribution of glazing types by the vintage of the home or building. Homes built before 1960 have the highest percentage of single-pane glazing (10%), whereas homes built in the 1960s and 70s have a smaller proportion (6%) and homes built after 1980 have rates of single-pane glazing under 1%. The proportion of Low-E coating ranges between around 40 and 60%, except for homes built in 2010 or later, where the prevalence of low-E coating is much higher (83%).

Figure 23: Glazing Percentages by Home Vintage



6.7.2 Exterior Glazing Percentages

Statewide, glazing comprises about 13% of a home's exterior wall area on average (Table 67). These values were derived from comparing the measured square footage of ambient (exterior) walls to the square footage of glazing located in those same walls at each site. When splitting the data by home type or EDC, there was little variation from the statewide average (Table 193).

Table 67: Glazing as a Percentage of Exterior Wall Area (Home Types)

	Detached single-family	Attached single-family	Multifamily	Statewide
n-value	*189*	*28*	*69*	*286*
Minimum	3%	6%	2%	2%
Maximum	69%	32%	48%	69%
Mean	**13%**	**14%**	**15%**	**13%**
Median	11%	12%	14%	12%
Std. Dev.	7%	6%	8%	7%

* Totals may not equal sum of column or row due to rounding.

Section 7 Ducts

This section focuses on the location and insulation of supply and return ducts in audited homes. No self-audit data was collected on duct systems. For quantified analysis on duct leakage, see Section 5 Diagnostic Sub-Sample Results. The 2018 IECC was adopted by Pennsylvania and has insulation requirements for supply ducts and return ducts.[64] Homes built in Pennsylvania prior to October 2021 are not subject to 2018 IECC but provide a point of reference for the homes in the study sample.

7.1 Duct Location

Approximately 77% of the full sample had duct systems. Table 68 and Table 69 show that 34% of homes had the majority of supply ductwork located in unconditioned spaces, while 37% of homes had the majority of return ductwork located in unconditioned spaces (attics, basements, crawlspaces, and/or garages). More than one-third (35% supply and 37% return) of homes had more than 90% ductwork located in conditioned space.

About 16% of homes had all ducts in unconditioned spaces, while 30% of homes had all ducts in conditioned spaces. Detached single-family homes were more likely to have ducts in unconditioned spaces, whereas the multifamily homes were more likely to have ducts in conditioned spaces.

Table 68: Supply Duct Location

(Base: Homes)

	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*189*	*28*	*69*	*286*
No Ducts	17%	11%	51%	23%
<50% Conditioned	40%	32%	13%	34%
50%-90% Conditioned	8%	11%	--	8%
>90% Conditioned	35%	46%	36%	35%

* Totals may not equal sum of column or row due to rounding.

[64] The 2018 IECC, Section 403.3.1 Prescriptive Duct Insulation states: Supply and return ducts in attics shall be insulated to an R-value of not less than R-8 for ducts 3 inches in diameter and larger and not less than R-6 for ducts smaller than 3 inches in diameter. Supply and return ducts in other portions of the building shall be insulated to not less than R-6 for ducts 3 inches in diameter and not less than R-4.2 for ducts smaller than 3 inches in diameter. https://codes.iccsafe.org/content/iecc2018/chapter-4-re-residential-energy-efficiency

Table 69: Return Duct Location

(Base: Homes)

	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*189*	*28*	*69*	*286*
No Ducts	17%	11%	51%	23%
<50% Conditioned	41%	39%	14%	37%
50%-90% Conditioned	6%	NA	1%	3%
>90% Conditioned	37%	50%	33%	37%

* Totals may not equal sum of column or row due to rounding.

Table 70 and Table 71 show ductwork location based on the year the home was built. Forty-three percent of the homes built before 1940 had no ductwork, while 16% of homes built in 2000 or later had no ductwork. Of the homes built before 1940, 19% had the majority of their ductwork located in conditioned space. Almost three-quarters (72%) of the homes built after 2010 had more than 90% of the return ductwork in conditioned space, while 68% of the homes built after 2010 had more than 90% of the supply ductwork in conditioned space.

Table 70: Supply Duct Location by Home Vintage

(Base: Homes)

	Before 1940	1940-1959	1960-1979	1980-1999	2000-2009	2010 or later	Statewide
n-value	*70*	*40*	*51*	*50*	*50*	*25*	*286*
No Ducts	43%	18%	25%	28%	8%	8%	23%
<50% Conditioned	36%	40%	35%	30%	32%	12%	34%
50%-90% Conditioned	3%	0%	8%	8%	12%	12%	8%
> 90% Conditioned	19%	42%	31%	34%	48%	68%	35%

* Totals may not equal sum of column or row due to rounding.

Table 71: Return Duct Location by Home Vintage

(Base: Homes)

	Before 1940	1940-1959	1960-1979	1980-1999	2000-2009	2010 or later	Statewide[1]
n-value	*70*	*40*	*51*	*50*	*50*	*25*	*286*
No Ducts	43%	18%	25%	28%	8%	8%	23%
<50% Conditioned	39%	42%	37%	32%	30%	16%	37%
50%-90% Conditioned	0%	0%	2%	6%	14%	4%	3%
> 90% Conditioned	19%	40%	35%	34%	48%	72%	37%

* Totals may not equal sum of column or row due to rounding.

As noted earlier, of all the homes that had ducts, 60% had ducts in unconditioned areas. Table 72 and Table 73 show the percent of duct area in each location in an average home by home type and statewide. More than half of these ducts were located in unconditioned basements (54% supply and 58% return) and approximately one third of these ducts were in attics (32% supply and 33% return).

Table 72: Unconditioned Supply Duct Location

(Base: Homes with ducts in unconditioned spaces)

	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*123*	*21*	*11*	*155*
Unconditioned basement	55%	83%	40%	54%
Attic, Exposed	27%	6%	40%	32%
Crawl Space	7%	6%	10%	6%
Garage	8%	6%	10%	5%
Exterior wall	3%	0%	0%	2%
Attic, Under Insulation	1%	0%	0%	<1%

* Totals may not equal sum of column or row due to rounding.

Table 73: Unconditioned Return Duct Location
(Base: Homes with ducts in unconditioned spaces)

	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*123*	*21*	*11*	*155*
Unconditioned basement	59%	88%	36%	58%
Attic, Exposed	29%	6%	36%	33%
Crawl Space	6%	0%	18%	4%
Garage	4%	6%	9%	2%
Exterior wall	2%	0%	0%	2%
Attic, Under Insulation	1%	0%	0%	1%

* Totals may not equal sum of column or row due to rounding.

7.2 Duct Insulation

Where ductwork was located outside of conditioned spaces, auditors recorded the level of duct insulation present in the home. Table 74 and Table 75 show that the average R-value of ducts per home by home type and statewide. The average was R-2.6 for supply ducts and R-2.4 for return ducts. More than half of the observed ducts (53%) had no insulation. Note that these observations are limited to homes with ductwork in unconditioned spaces and where the auditor was able to confirm the level of insulation.

Table 74: Unconditioned Supply Duct R-values
(Base: Homes with ducts in unconditioned spaces)

	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*120*	*21*	*10*	*151*
Min	0.0	0.0	0.0	0.0
Max	8.0	6.0	8.0	8.0
Mean	**2.5**	**1.3**	**2.4**	**2.6**
Median	0.0	0.0	0.0	0.0
Std. Dev.	2.7	2.2	3.2	2.7

Table 75: Unconditioned Space Return Duct R-values

(Base: Homes with ducts in unconditioned spaces)

	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*118*	*21*	*11*	*150*
Min	0.0	0.0	0.0	0.0
Max	8.0	6.0	8.0	8.0
Mean	**2.3**	**1.0**	**2.7**	**2.4**
Median	0.0	0.0	0.0	0.0
Std. Dev.	2.6	2.0	3.3	2.6

* Totals may not equal sum of column or row due to rounding.

Section 8 Mechanical Equipment

This section describes the heating, cooling, and water heating equipment that was observed during onsite audits. Analysis covered types, fuels, capacities, efficiency, and ENERGY STAR status.

Figure 24: Mechanical Equipment Results Highlights

Key Findings: Heating

- Natural gas was the primary heating fuel in 50% of housing units statewide for the full sample followed by electricity (36%) and fuel oil (12%).
- Furnaces were the most common primary heating system type in 44% of housing units statewide for the full sample, followed by boilers (21%) and air-source heat pumps (19%).
- The average Annual Fuel Utilization Efficiency (AFUE) for residential furnaces was 89.1 AFUE, average efficiency for residential boilers was 85.4 AFUE, and average efficiency of heat pumps was 7.5 HSPF2.[65]
- Forty-two percent of all heating systems were ENERGY STAR qualified (excludes heating equipment not covered by the ENERGY STAR program), which is an increase from the 2018 baseline.

Key Findings: Cooling

- Central air-conditioners were present at 44% of audited homes, air-source heat pumps at 21%, and ductless mini-splits at 2%.
- The average SEER2[66] of cooling systems for the full sample was 13.9.
- Twenty three percent of audited homes had at least one room air conditioner.
- Just over half (51%) of permanent cooling systems for the full sample were ENERGY STAR qualified.

---

[65] Heating Season Performance Factor 2 (HSPF2) is the updated standard measure of heating efficiency for air source heat pumps. It is the ratio of the heat output during the heating season to the electricity input.
[66] Seasonal Energy Efficiency Ratio (SEER2) is the updated standard measure of cooling efficiency. It is the ratio of the cooling output during the cooling season to the electricity input.

Key Findings: Domestic Hot Water

- The vast majority of water heaters for the full sample were conventional standalone, storage tanks (87%); fueled primarily by electricity (50%) and natural gas (48%).
- Heat pump water heaters (HPWH), highly efficient water heating systems, had an average efficiency of 3.20 UEF, but only comprised 3% of water heater systems in audited homes.
- Fossil fueled standalone water heaters made up the largest share of water heaters found in audited homes at 40%.
- Both instantaneous and tankless water heaters each made up 3% of water heaters found in audited homes.
- Instantaneous water heaters had an average efficiency of 0.93 UEF, while tankless water heaters had an average efficiency of 0.48 EF.
- Fossil fuel standalone water heaters had an average of 0.62 UEF, while electric water heaters had an average efficiency of 0.92 UEF.
- Only 13% of water heaters for the full sample were ENERGY STAR qualified (excluding systems that do not fit in ENERGY STAR criteria).

8.1 HEATING EQUIPMENT

This section focuses on residential equipment serving only a single unit in homes or multifamily buildings. Heating equipment was designated as primary or supplemental. Primary heating equipment is that with the largest capacity or that which serves the largest portion of the home's conditioned floor area. For example, a home with two natural gas furnaces will have one primary system type (*furnace*) and one primary fuel type (*natural gas*). Supplemental heating refers to any equipment type that did not supply the majority of a home's heating load. For self-audit data, the SWE team assigned primacy based on equipment type. Furnaces, boilers, air-source heat pumps, mini-splits and electric baseboards were classified primary, and the rest of the heating equipment types were classified as secondary. Since the self-audit data is self-reported and may not include all heating systems in a home, there is some uncertainty with the primacy status of the self-audit heating equipment.

Multifamily sites had heating equipment that served only one residential unit or heating equipment that served multiple units. In some cases, supplemental heating systems served common areas. Shared heating equipment was found in 12 of the 69 (22%) multifamily buildings audited. Heating systems that served only common areas were observed in four multifamily buildings. In these cases, the tenant space was heated by equipment that served individual units. Shared heating equipment is excluded from analysis unless otherwise noted. There were also seven multifamily sites for which a primary heating system was not identified due to lack of access.

Similar to the occurrence of shared heating equipment in multifamily buildings, some buildings had commercial-sized heating equipment.[67] Statewide, five commercial heating systems were

[67] Commercial heating equipment consisted of boilers, furnaces, and packaged rooftop-units. Boilers with capacities over 300,000 BTUh. and furnaces with capacities over 275,000 BTUh. are considered commercial sized equipment.

identified during the multifamily onsite audits. Of the five commercial systems, two were commercial boilers that served multiple units. Statewide, the average capacity for commercial grade heating equipment was 439,500 BTUh (British thermal units per hour). The remaining three commercial heating systems were variable refrigerant flow heat pumps located on the rooftops of two multifamily buildings and a water-source heat pump that served multiple units. However, lack of rooftop access and faded nameplates made identifying output capacities and efficiencies impossible. Commercial heating equipment is excluded from analysis unless otherwise noted.

8.1.1 Primary Heating Systems

Table 76 displays the primary heating fuel distribution. Primary heating systems were fueled with natural gas most frequently (50%), followed by electricity (36%) and fuel oil (12%). Electric systems were most common in multifamily homes (56%).

Table 76: Primary Heating Fuel by Home Type

(Base = Homes)

Fuel	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-Site Results Only				
n-value	*189*	*28*	*62*	*279[1]*
Natural Gas	61%	71%	40%	55%
Electric	23%	25%	60%	31%
Oil	10%	4%	--	12%
Propane	5%	--	--	3%
Wood - logs	1%	--	--	<1%
Self-Audit Results Only				
n-value	*112*	*19*	*4*	*135*
Electric	41%	42%	25%	47%
Natural Gas	46%	53%	75%	39%
Oil	12%	5%	--	13%
Propane	1%	--	--	<1%
Wood - logs	1%	--	--	<1%
Total On-site and Self-Audit				
n-value	*301*	*47*	*66*	*414*
Natural Gas	55%	64%	44%	50%
Electric	30%	32%	56%	36%
Oil	10%	4%	--	12%
Propane	4%	--	--	2%
Wood - logs	1%	--	--	<1%

[1] The total on-site sample does not equal 286 due to seven homes with heating equipment that was not accessible.

* Totals may not equal sum of column or row due to rounding.

Statewide, furnaces were the most common primary heating system (39%, Table 77). Boilers and ASHPs were the second and third most common primary heating systems statewide at 21% and 19%. The previous study found ASHPs in only 10% of homes. Electric baseboards were more common in multifamily homes than detached and attached single-family homes.

Table 77: Primary Heating Equipment by Home Type

(Base = Homes)

Type	Detached single-family	Attached single-family	Multifamily	Statewide[1]
On-Site Results Only				
n-value	*189*	*28*	*62*	*279*
Furnace	**60%**	**64%**	**27%**	**49%**
Natural Gas	86%	100%	94%	86%
Oil	6%	--	--	9%
Propane	6%	--	--	4%
Electric	1%	--	6%	1%
Wood - logs	1%	--	--	<1%
Boiler	**17%**	**11%**	**15%**	**22%**
Natural Gas	59%	67%	100%	61%
Oil	32%	33%	--	35%
Propane	9%	--	--	4%
ASHP (Electric)	**15%**	**25%**	**18%**	**18%**
Electric baseboard	**5%**	--	**27%**	**8%**
Mini-split (Electric)	**2%**	--	**5%**	**2%**
GSHP (Electric)	**2%**	--	--	**1%**
PTHP (Electric)	--	--	**3%**	**<1%**
VRF Heat Pump (Electric)	--	--	**2%**	**<1%**
Wall Furnace/Space Heater	--	--	**2%**	**<1%**
Natural Gas	–	–	1(100%)	100%
WSHP (Electric)	--	--	**2%**	**<1%**
Self-Audit Results Only				
n-value	*112*	*19*	*4*	*135*
Furnace	**46%**	**47%**	**100%**	**39%**
Natural Gas	79%	89%	75%	78%
Oil	13%	--	--	12%
Electric	6%	11%	25%	9%
Wood - logs	2%	--	--	<1%
ASHP (Electric)	**20%**	**16%**	--	**22%**
Boiler	**16%**	**16%**	--	**17%**
Natural Gas	56%	67%	–	49%
Oil	39%	33%	–	49%
Propane	6%	--	–	3%
Electric baseboard	**10%**	**16%**	--	**13%**
GSHP (Electric)	**5%**	**5%**	--	**7%**

Mini-split (Electric)	**4%**	**--**	**--**	**3%**
Total On-site and Self-Audit				
n-value	*301*	*47*	*66*	*414*
Furnace	**54%**	**57%**	**32%**	**44%**
Natural Gas	84%	96%	90%	83%
Oil	8%	--	--	11%
Electric	2%	4%	10%	3%
Propane	4%	--	--	3%
Wood - logs	1%	--	--	<1%
Boiler	**17%**	**13%**	**14%**	**21%**
Natural Gas	58%	67%	100%	61%
Oil	35%	33%	--	36%
Propane	8%	--	--	3%
ASHP (Electric)	**17%**	**21%**	**17%**	**19%**
Electric baseboard	**7%**	**6%**	**26%**	**10%**
GSHP (Electric)	**3%**	**2%**	**--**	**3%**
Mini-split (Electric)	**2%**	**--**	**5%**	**2%**
PTHP (Electric)	**--**	**--**	**3%**	**<1%**
VRF Heat Pump (Electric)	**--**	**--**	**2%**	**<1%**
Wall Furnace/Space Heater	**--**	**--**	**2%**	**<1%**
Natural Gas	–	–	1(100%)	100%
WSHP	**--**	**--**	**2%**	**<1%**

[1] The total on-site sample does not equal 286 due to seven homes where heating equipment was not accessible.
* Totals may not equal sum of column or row due to rounding.

Close to two thirds (64%) of primary heating systems were in conditioned space (Table 78). For multifamily homes, almost all (97%) of their primary heating systems were found in conditioned space. This could be due to the exclusion of shared equipment, which are most commonly found in unconditioned basements or rooftops. Unlike multifamily, in detached and attached single-family homes it was common for their primary heating systems to be found in unconditioned space.

Table 78: Primary System Location by Home Type

(Base = Systems)

Location	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-Site Results Only				
n-value	*229*	*29*	*76*	*334*
Conditioned Area/Conditioned Crawl Space	63%	55%	97%	68%
Unconditioned Basement/Enclosed Crawl Space	33%	41%	3%	28%
Attic	3%	--	--	3%
Garage or Open Crawl Space	1%	3%	--	2%
Self-Audit Results Only				
n-value	*139*	*24*	*3*	*166*
Unconditioned Basement/Enclosed Crawl Space	58%	47%	--	53%
Conditioned Area/Conditioned Crawl Space	39%	53%	100%	45%
Garage or Open Crawl Space	3%	--	--	3%
Total On-sites and Self Audit				
n-value	*368*	*53*	*79*	*500*
Conditioned Area/Conditioned Crawl Space	56%	54%	97%	64%
Unconditioned Basement/Enclosed Crawl Space	41%	43%	2%	32%
Attic	2%	--	--	2%
Garage or Open Crawl Space	1%	2%	--	2%

* Totals may not equal sum of column or row due to rounding.

8.1.2 Age of Heating Equipment

Table 79 presents the vintage distribution of heating equipment, with available data, found during onsite audits. Equipment age information was obtained from nameplates, serial numbers, and contacting manufacturers.[68] The average age across all system types was 13 years. This analysis

[68] The date of manufacture was not available using the methods described above for 201 heating systems. The heating equipment with unidentified ages consisted mostly of electric baseboards, wall furnaces, space heaters, fireplaces, and stoves.

only includes heating equipment where age was obtainable, in order not to bias the results towards newer systems. Heating equipment manufactured in the last five years was the most common (24%). Statewide, 38% of boiler systems and 15% of furnaces were manufactured prior to 2001.

Note that the vintage bins used throughout the report for mechanical systems and appliances differ from those used for homes since mechanical systems and appliances have shorter lifespans than homes, are replaced more frequently, and have more rapid technological improvements.

Table 79: Heating Equipment Vintages by Equipment Type

(Base = Systems)

Vintage	Furnace	ASHP	Boiler	Ductless Mini Split	Other[1]	Statewide
On-Site Results Only						
n-value	*150*	*56*	*32*	*18*	*19*	*275*
2019 to 2023	18%	21%	12%	50%	37%	22%
2016 to 2018	18%	14%	6%	6%	5%	16%
2011 to 2015	17%	25%	12%	22%	26%	16%
2006 to 2010	19%	25%	16%	--	11%	19%
2001 to 2005	13%	7%	22%	17%	5%	13%
1991 to 2000	13%	5%	28%	6%	11%	11%
1981 to 1990	2%	2%	--	--	--	1%
1980 or earlier	1%	--	3%	--	5%	1%
Self-Audit Results Only						
n-value	*40*	*25*	*15*	*6*	*3*	*89*
2019 to 2023	18%	36%	7%	50%	0%	28%
2016 to 2018	15%	16%	7%	33%	33%	12%
2011 to 2015	20%	24%	7%	--	--	16%
2006 to 2010	15%	8%	0%	17%	67%	9%
2001 to 2005	20%	12%	27%	--	--	21%
1991 to 2000	5%	4%	47%	--	--	11%
1981 to 1990	8%	--	7%	--	--	3%
1980 or earlier	--	--	--	--	--	--
Total On-sites and Self Audit						
n-value	190	81	47	24	22	364
2019 to 2023	18%	26%	11%	50%	32%	24%
2016 to 2018	17%	15%	6%	12%	9%	16%
2011 to 2015	18%	25%	11%	17%	23%	16%
2006 to 2010	18%	20%	11%	4%	18%	17%
2001 to 2005	14%	9%	23%	12%	5%	14%
1991 to 2000	11%	5%	34%	4%	9%	10%
1981 to 1990	3%	1%	2%	--	--	2%
1980 or earlier	1%	--	2%	--	5%	1%

[1] The other category includes wall furnaces/space heaters, GSHPs, PTHPs, portable space heaters, fireplaces and stoves.

* Totals may not equal sum of column or row due to rounding.

8.1.3 Heating Equipment ENERGY STAR Status

Heating equipment was verified to be ENERGY STAR qualified through physical observation of the ENERGY STAR logo on the equipment, supplemental research on the ENERGY STAR website, manufacturer websites, and prior ENERGY STAR version equipment lists.[69] Table 80 presents the ENERGY STAR status of all heating equipment observed through self-audit data or on-sites, excluding equipment that does not fall into current ENERGY STAR heating system classifications (e.g., stoves, fireplaces). Forty-two percent of heating equipment was ENERGY STAR qualified. Saturation of ENERGY STAR equipment within EDCs varied widely. In FE: Penn Power territory and FE: Met-Ed territory, more than half (57%) of heating equipment was ENERGY STAR qualified.

Table 80: Heating Equipment ENERGY STAR Status by Home Type

(Base = Systems)

ENERGY STAR	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-Site Results Only				
n-value	*355*	*32*	*91*	*478*
Yes	44%	44%	21%	40%
No	56%	56%	79%	60%
Self-Audit Results Only				
n-value	*92*	*15*	*3*	*110*
Yes	55%	40%	33%	56%
No	45%	60%	67%	44%
Total On-site and Self-Audit				
n-value	*447*	*47*	*94*	*588*
Yes	46%	43%	21%	42%
No	54%	57%	79%	58%

* Totals may not equal sum of column or row due to rounding.

8.1.4 Heating System Efficiencies

This section only includes residential heating equipment. Commercial heating equipment is summarized above. The statewide average efficiency for all fossil-fuel fired furnace and boiler equipment with known efficiency values was 88.1 AFUE (Table 81).

It is often difficult to determine efficiency values for older equipment. Excluding older equipment could potentially bias efficiency results towards newer systems. To examine this, the SWE applied age-based default efficiency values to equipment with no obtainable efficiency information but a known date of manufacture.[70] The statewide average efficiency including age-based default values for all heating systems was 87.9 AFUE. Given this small bias, the tables in this report are based only on confirmed efficiencies.

---

[69] Equipment that was designated ENERGY STAR at the time of its manufacture was deemed ENERGY STAR qualified even if standards had increased past the equipment's individual efficiency.

[70] REM/Rate energy modeling software provides default efficiency values based on vintage, equipment type, and fuel.

Table 81: Residential Grade Heating System Efficiency by Home Type

(Base = Systems)

AFUE	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-Site Results Only				
n-value	*149*	*21*	*11*	*181*
Min	68.0	80.0	79.0	68.0
Max	98.0	97.0	95.0	98.0
Mean	**90.0**	**87.4**	**89.6**	**88.6**
Median	92.0	85.0	92.0	92.0
Std. Dev.	6.3	7.5	6.5	6.5
Self-Audit Results Only				
n-value	*42*	*10*	*1*	*53*
Min	64.0	80.0	92.0	64.0
Max	97.0	96.8	92.0	97.0
Mean	**87.9**	**89.4**	**92.0**	**87.0**
Median	92.0	92.0	92.0	92.0
Std. Dev.	7.7	6.8	NA	7.5
Total On-site and Self-Audit				
n-value	*191*	*31*	*12*	*234*
Min	64.0	80.0	79.0	64.0
Max	98.0	97.0	95.0	98.0
Mean	**89.5**	**88.1**	**89.8**	**88.1**
Median	92.0	91.0	92.0	92.0
Std. Dev.	6.7	7.2	6.2	6.7

The statewide average efficiency for all residential fossil-fuel fired furnaces with known efficiency values was 89.1 AFUE (Table 82).[71] Across all home types, the average furnace efficiency was consistent. There were no significant differences in average furnace efficiency among the EDCs. If age-based defaults are included, the average AFUE goes down to 89.0.

[71] Fossil fuel fired furnaces include natural gas, propane, and fuel oil. Electric furnaces were excluded from the analysis as they are 100% efficient.

Table 82: Residential Grade Furnaces (Fossil Fueled) by Home Type

(Base = Systems)

AFUE	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-site Results Only				
n-value	*118*	*19*	*10*	*147*
Min	68.0	80.0	80.0	68.0
Max	98.0	97.0	95.0	98.0
Mean	**91.2**	**87.8**	**90.6**	**89.6**
Median	93.0	91.0	92.0	92.1
Std. Dev.	6.1	7.8	5.7	6.4
Self-Audit Results Only				
n-value	*30*	*7*	*1*	*38*
Min	64.0	80.0	92.0	64.0
Max	97.0	96.8	92.0	97.0
Mean	**89.4**	**90.3**	**92.0**	**88.0**
Median	92.0	92.1	92.0	92.0
Std. Dev.	8.4	7.2	NA	8.0
Total On-Site and Self-Audit				
n-value	*148*	*26*	*11*	*185*
Min	64.0	80.0	80.0	64.0
Max	98.0	97.0	95.0	98.0
Mean	**90.8**	**88.5**	**90.7**	**89.1**
Median	92.6	92.0	92.0	92.1
Std. Dev.	6.6	7.6	5.5	6.7

Figure 25 presents each efficiency value (in AFUE) for all fossil fuel furnaces. The current federal minimum efficiency standard for non-weatherized gas furnaces is 80 AFUE, which went into effect in 2015 for non-weatherized specifically but before that the 2007 federal standard for gas furnaces was also 80 AFUE. The furnaces that fall below the federal minimum were manufactured prior to 2007 (see Table 79 for heating equipment age distributions). The jump in furnace efficiency shown in the figure may be attributed to the equipment age – increased average efficiency trended from the oldest to the newest equipment. However, common efficiency ratings for furnaces fell into two general groups with values from 80-86 AFUE and 91+ AFUE.

Figure 25: Residential Grade Furnace AFUE by Home Type

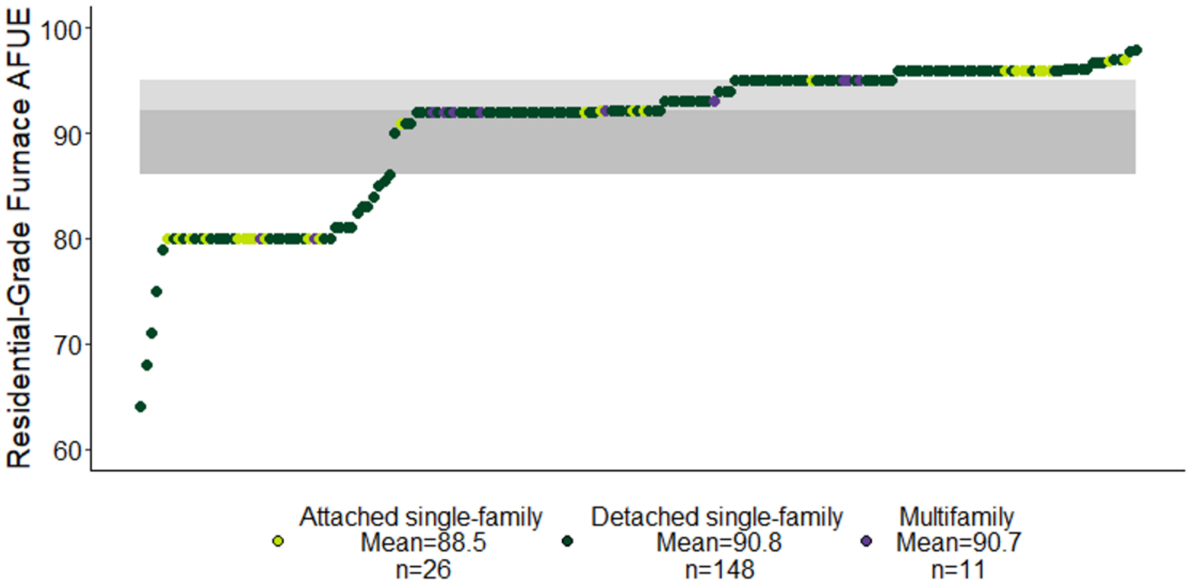


Table 83 and Table 84 show furnace efficiency by fuel type. Table 84 is only displaying data collected from onsite audits since there were no propane furnaces found in the self-audit data. Average statewide efficiencies were slightly higher for propane furnaces (91.3) than natural gas furnaces (89.9). All propane furnaces met the minimum federal requirement; however, some older natural gas furnaces had efficiencies that fell below the federal minimum efficiency requirement.

Table 83: Residential Grade Natural Gas Furnace AFUE by Home Type

(Base = Systems)

AFUE	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-Site Results Only				
n-value	*98*	*19*	*10*	*127*
Min	68.0	80.0	80.0	68.0
Max	98.0	97.0	95.0	98.0
Mean	**91.8**	**87.8**	**90.6**	**90.2**
Median	93.0	91.0	92.0	93.0
Std. Dev.	6.0	7.8	5.7	6.3
Self-Audit Results Only				
n-value	*25*	*7*	*1*	*33*
Min	64.0	80.0	92.0	64.0
Max	97.0	96.8	92.0	97.0
Mean	**91**.0	**90.3**	**92**.0	**89.4**
Median	95.0	92.1	92.0	93.0
Std. Dev.	8.3	7.2	--	7.9
Total On-site and Self-Audit				
n-value	*123*	*26*	*11*	*160*
Min	64.0	80.0	80.0	64.0
Max	98.0	97.0	95.0	98.0
Mean	**91.6**	**88.5**	**90.7**	**89.9**
Median	93.0	92.0	92.0	93.0
Std. Dev.	6.5	7.6	5.5	6.7

Table 84: Residential Grade Propane Furnace AFUE by Home Type

(Base = Systems, Site Visits)

AFUE	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*12*	--	--	*12*
Min	80.0	--	--	80.0
Max	96.0	--	--	96.0
Mean	**91.2**	--	--	**91.3**
Median	92.0	--	--	92.0
Std. Dev.	5.6	--	--	5.6

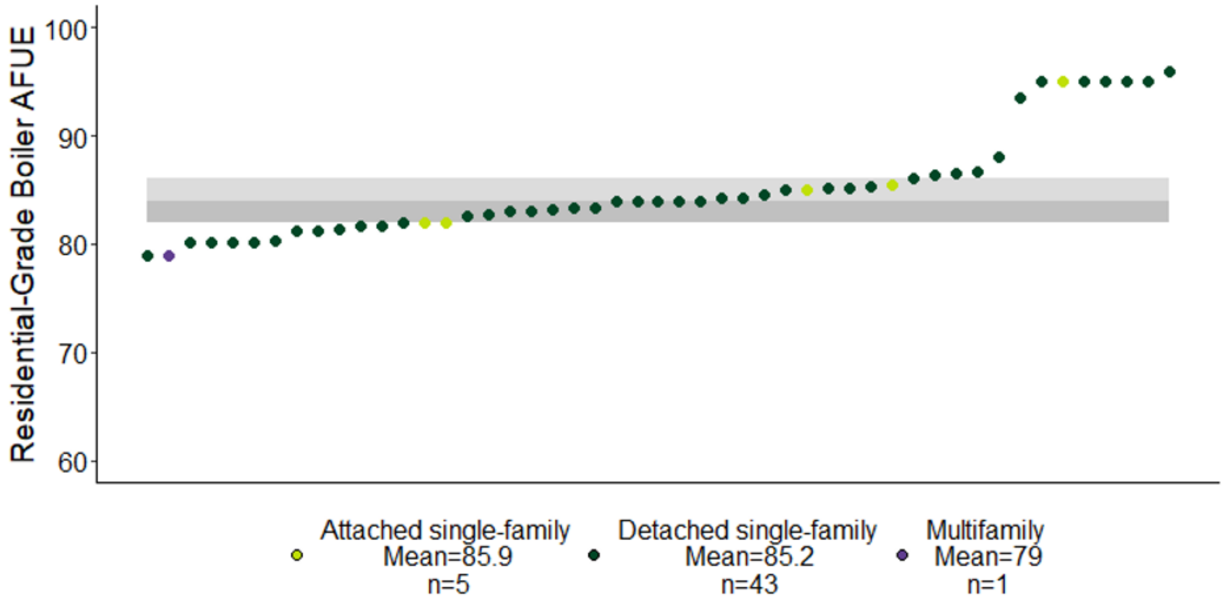
The statewide average efficiency for all residential boilers with known efficiency values was 85.4 AFUE (Table 85). When age-based defaults are included, the AFUE drops to 84.8.

Table 85: Residential Grade Boilers (All Fuel Types) by Home Type
(Base = Systems)

AFUE	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-site Results Only				
n-value	*31*	*2*	*1*	*34*
Min	79.0	82.0	79.0	79.0
Max	95.0	85.0	79.0	95.0
Mean	**85.6**	**83.5**	**79.0**	**85.6**
Median	84.2	83.5	79.0	84.1
Std. Dev.	5.1	2.1	--	5.0
Self-Audit Results Only				
n-value	*12*	*3*	--	*15*
Min	80.2	82.0	--	80.2
Max	96.0	95.0	--	96.0
Mean	**84.1**	**87.5**	**--**	**85.0**
Median	83.2	85.5	--	83.4
Std. Dev.	4.1	6.7	--	4.6
Total On-site and Self-Audit				
n-value	*43*	*5*	*1*	*49*
Min	79.0	82.0	79.0	79.0
Max	96.0	95.0	79.0	96.0
Mean	**85.2**	**85.9**	**79.0**	**85.4**
Median	84.0	85.0	79.0	84.0
Std. Dev.	4.8	5.3	--	4.8

Figure 26 displays the efficiency for each boiler in the full sample. Boilers with efficiency values below 80 AFUE were all manufactured before 2007. Boilers with efficiency values higher than 90 AFUE were mainly natural gas.

Figure 26: Residential Grade Boiler AFUE by Home Type



The average efficiencies for natural gas boilers appear in Table 86. Statewide, the average efficiency was 85.6 AFUE. Average efficiencies were consistent among single-family homes.

Table 86: Residential Grade Natural Gas Boiler AFUE by Home Type

(Base = Systems)

AFUE	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-Site Results Only				
n-value	*16*	*1*	*1*	*18*
Min	79.0	82.0	79.0	79.0
Max	95.0	82.0	79.0	95.0
Mean	**86.6**	**82.0**	**79.0**	**86.3**
Median	83.5	82.0	79.0	82.5
Std. Dev.	6.7	NA	NA	6.6
Self-Audit Results Only				
n-value	*6*	*2*	--	*8*
Min	80.2	82.0	--	80.2
Max	84.0	95.0	--	95.0
Mean	**82.1**	**88.5**	**--**	**83.5**
Median	82.1	88.5	--	82.4
Std. Dev.	1.4	9.2	--	4.7
Total On-site and Self-Audit				
n-value	*22*	*3*	*1*	*26*
Min	79.0	82.0	79.0	79.0
Max	95.0	95.0	79.0	95.0
Mean	**85.4**	**86.3**	**79.0**	**85.6**
Median	82.9	82.0	79.0	82.4
Std. Dev.	6.1	7.5	NA	6.1

Table 87 displays the average efficiency for all ASHP and ductless mini split systems. The average heating seasonal performance factor (HSPF2) was 7.5 statewide.[72] Figure 27 displays the HSPF2 for each ASHP and ductless mini split observed for the full sample. The average coefficient of performance (COP)[73] for Ground-source heat pumps (GSHP) was 4.3.[74]

[72] In cases where systems surveyed had an efficiency rating in HSPF rather than HSPF2, the SWE team converted these ratings from HSPF to HSPF2 using the following formula HSPF2= (HSPF - 0.0700)/1.1702. The equation for this conversion came from the Guidance Memo: Guidance for Claiming TRM Measure 2.2.1 High Efficiency Equipment: ASHP, CAC, GSHP, PTAC, PTHP in Phase IV (Revised) issued by the PA SWE on June 29, 2023.
[73] The coefficient of performance is an efficiency rating for heat pumps that shows the ratio of heating or cooling output over the mechanical work required. Higher values indicate greater efficiency.
[74] Only 10 out of 11 GSHPs had available efficiency data. Three GSHPs were found during audits and 8 were collected through self-audit data.

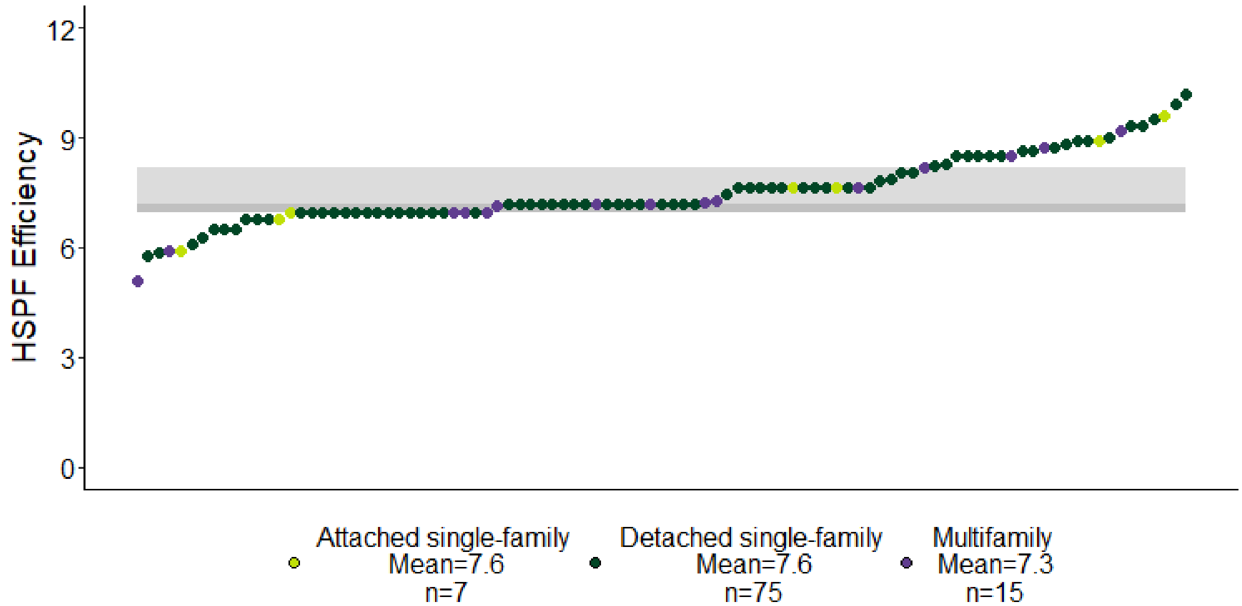
Table 87: ASHP and Ductless Mini Split HSPF2* by Home Type

(Base = Systems)

HSPF	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-Site Results Only				
n-value	*52*	*7*	*15*	*74*
Min	5.8	5.9	5.1	5.1
Max	10.2	9.6	9.2	10.2
Mean	**7.6**	**7.6**	**7.3**	**7.5**
Median	7.2	7.6	7.2	7.2
Std. Dev.	0.9	1.3	1.0	1.0
Self-Audit Results Only				
n-value	*23*	--	--	*23*
Min	5.9	--	--	5.9
Max	9.9	--	--	9.9
Mean	**7.6**	**--**	**--**	**7.7**
Median	7.2	--	--	7.2
Std. Dev.	1.0	--	--	1.0
Total On-site and Self-Audit				
n-value	*75*	*7*	*15*	*97*
Min	5.8	5.9	5.1	5.1
Max	10.2	9.6	9.2	10.2
Mean	**7.6**	**7.6**	**7.3**	**7.5**
Median	7.2	7.6	7.2	7.2
Std. Dev.	0.9	1.3	1.0	1.0

*HSPF to HSPF2 conversions can be found in Table 201.

Figure 27: ASHP and Ductless Mini Split HSPF2 by Home Type



8.1.5 Furnace ECMs

An electronically communicated motor (ECM) is a brushless DC motor that offers efficiency gains relative to the industry standard permanent split capacitor (PSC) Motor.[75] Statewide, 51% of furnaces were equipped with ECMs, which is a drastic increase from the 2018 baseline (Table 88). In cases where it was unknown if a furnace had an ECM motor, the SWE team assumed systems with efficiencies of 95 AFUE or higher had an ECM motor. This assumption may explain some of the increase in the proportion of furnaces with ECM motors compared to the 2018 study. In addition, there are newer equipment and a higher average AFUE for residential furnaces compared to 2018 (the average furnace AFUE increased from 87.9 to 89.1). This may also be a contributing factor as to why the number of ECMs has increased by 35% since the last baseline.

[75] ECMs offer two major advantages over PSC motors. First, ECMs use significantly less electricity than PSC motors while producing comparable air flow. Second, ECMs are variable speed motors with the flexibility to adjust air flow depending on the demand being called for by the furnace or central air conditioning system – PSC motors operate like on/off switches. Not all ENERGY STAR-qualified furnaces have ECM motors – some have multi-speed fans but not fully variable ECMs.

Table 88: ECM Motors in All Furnaces by Home Type

(Base = Systems)

ECM	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-Site Results Only				
n-value	*122*	*19*	*19*	*160*
Yes	51%	53%	69%	54%
No	49%	47%	31%	46%
Self-Audit Results Only				
n-value	*64*	*11*	*4*	*79*
Yes	39%	36%	--	34%
No	61%	64%	100%	66%
Total On-site and Self-Audit				
n-value	*186*	*30*	*23*	*239*
Yes	47%	47%	58%	51%
No	53%	53%	42%	49%

8.1.6 Heating Capacity

Table 89 presents the heating capacity per square foot of conditioned floor area for audited homes with residential heating equipment. Total capacity information for systems is obtained from nameplate and model numbers. There were several systems for which total heating capacity information was not available. The total capacity (in BTUh.) of all heating equipment in each home is summed and then divided by the square feet of conditioned floor area in the home. The calculated values ranged widely from a low of 2.8 BTUh/sq.ft to a high of 115.7 BTUh/sq.ft. On a statewide level the average heating capacity per square foot was 38.7 BTUh/sq.ft. Multifamily homes had the lowest average heating capacity.

Table 89: Heating System Capacity (BTUh/sq.ft.)

(Base = Homes, Site Visits)

BTUh/sq.ft.	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*187*	*28*	*46*	*261*
Min	2.8	13.2	7.0	2.8
Max	115.7	111.9	77.0	115.7
Mean	**39.8**	**42.2**	**31.5**	**38.7**
Median	36.9	40.4	26.6	35.6
Std. Dev.	21.8	25.1	17.3	21.6

8.1.7 Supplemental Heating Equipment

Supplemental heating equipment was present at 39% of audited homes.[76] Table 90 presents the fuel distribution of all supplemental heating systems. The most common fuel types for supplemental heating equipment were electricity (56%), natural gas (16%), and wood (13%).

Table 90: Supplemental Heating Fuel by Home Type

(Base= Systems, Site Visits)

Fuel	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*153*	*3*	*17*	*173*
Electric	56%	50%	100%	56%
Natural Gas	20%	50%	--	16%
Wood - logs	9%	--	--	13%
Propane	9%	--	--	9%
Wood - pellets	4%	--	--	3%
Oil	1%	--	--	2%
Coal	1%	--	--	1%

The most common type of supplementary heating systems were fireplace inserts/stoves (35%, Table 91).[77] Electric baseboards and portable space heaters each comprised 14% of supplemental heating systems. ASHPs and ductless mini splits combined represented 11% of supplemental heating equipment.

[76] Self-audit data was excluded from the supplemental heating tables because of small sample size and in the absence of an on-site audit it was difficult to determine which systems were supplemental.

Table 91: Supplemental Heating Equipment by Home Type
(Base= Systems, Site Visits)

Type	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*153*	*3*	*17*	*173*
Fireplace insert/Wood stove	**33%**	**67%**	**6%**	**35%**
Electric	33%	0%	--	34%
Natural Gas	26%	100%	--	26%
Wood - logs	23%	0%	--	23%
Wood - pellets	13%	0%	--	10%
Coal	3%	0%	--	5%
Propane	3%	0%	--	2%
Electric baseboard	**13%**	**--**	**53%**	**14%**
Portable space heater	**18%**	**33%**	**18%**	**14%**
Electric	96%	100%	100%	99%
Natural Gas	4%	0%	0%	1%
Open hearth/fireplace	**13%**	**--**	**--**	**13%**
Wood - logs	20%	--	--	42%
Natural Gas	60%	--	--	41%
Propane	20%	--	--	16%
ASHP (Electric)	**6%**	**--**	**6%**	**7%**
Wall Furnace/Space Heater	**5%**	**--**	**--**	**5%**
Propane	57%	–	–	68%
Natural Gas	43%	–	–	32%
Furnace	**5%**	**--**	**6%**	**4%**
Propane	50%	--	--	63%
Natural Gas	37%	--	--	23%
Oil	13%	--	--	14%
Mini-split (Electric)	**5%**	**--**	**--**	**4%**
Electric radiant surface	**1%**	**--**	**6%**	**2%**
Boiler	**1%**	**--**	**--**	**1%**
Oil	100%	--	--	100%

8.2 Cooling Equipment

The following section describes residential space cooling equipment observed during audits and submitted via self-audit. Residential systems are defined by their cooling output capacities and must be lower than 60,000 BTUh. Any cooling system with an output capacity greater than 60,000 BTUh is classified as commercial. Multifamily units surveyed were cooled by either a system serving a single unit or multiple units. Commercial equipment, shared equipment, and equipment serving only common spaces (e.g., hallways in large multifamily buildings) is excluded from analysis unless otherwise noted.

Supplemental cooling systems serving communal areas were found in three multifamily homes. Three multifamily homes had systems serving multiple units.

Table 92 displays a penetration table of cooling systems, permanent and removable, found by home type. It includes commercial systems and systems serving multiple units. Statewide, 93% of homes had a cooling system. A small minority (2%) possessed a room air conditioner in addition to their permanent space cooling system.

Table 92: Space Cooling Penetration by Home Type

(Base= Homes, Site Visits)

System Type	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*189*	*28*	*69*	*286*
Central Air-split	52%	54%	20%	44%
Room Air Conditioner	19%	18%	32%	23%
ASHP	19%	25%	14%	21%
Mini-split	2%	--	4%	2%
GSHP	2%	--	--	1%
PTHP	--	--	4%	1%
Chiller	--	--	1%	<1%
Portable AC	--	--	1%	<1%
PTAC	--	--	1%	<1%
VRF Heat Pump	--	--	1%	<1%
WSHP	--	--	1%	<1%
None	7%	4%	17%	7%

* Totals may not equal sum of column or row due to rounding.

8.2.1 Residential Permanent Space Cooling

This section describes residential-scale permanent space cooling systems surveyed by the SWE team. These systems include central air conditioners, air source heat pumps (ASHP), ductless heat pumps (Ductless HP), ground source heat pumps (GSHP), packaged terminal air conditioners (PTACs), and packaged terminal heat pumps (PTHPs).

Table 93 describes residential permanent cooling system penetration by home type. Statewide, around 70% of homes surveyed contained a form of permanent cooling system. Multifamily homes were less likely to have permanent cooling systems than detached and attached single-family homes. The most common type of permanent cooling system was central air conditioners (42%), followed by ASHP (21%). Central air conditioners and ASHPs were more common in detached and attached single-family than multifamily, but this difference was partially offset by the prevalence of PTAC or PTHP systems.[78] Seven homes had multiple types of permanent cooling.

As noted above, the rest of this section excludes commercial grade systems. There were ten commercial cooling systems found during audits: six central air conditioners, two variable refrigerant flow heat pumps, one water-source heat pump, and one chiller. The capacity of the eight commercial-grade cooling systems with capacity information available averaged 146,500 BTUh. The central air conditioners had an average SEER of 12.6. Both of the variable refrigerant flow heat pumps had a SEER of 17.6. All ten commercial-grade systems were in multifamily buildings.

Table 93: Permanent Cooling Penetration by Home Type

(Base= Homes, Site Visits)

System Type	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*189*	*28*	*69*	*286*
Central Air-split	54%	49%	16%	42%[1]
ASHP	25%	19%	14%	21%
Mini-split	--	2%	4%	2%
GSHP	--	2%	--	1%
PTHP	--	--	4%	1%
PTAC	--	--	1%	<1%
None	21%	29%	59%	33%

[1] This table excludes commercial and shared equipment which explains the difference in central air-splits from the space cooling penetration.
* Totals may not equal sum of column or row due to rounding.

Table 94 summarizes the vintages of permanent cooling systems. The average age for permanent cooling systems was around ten years, and one half (50%) were manufactured between 2016 and 2023.

[78] PTACs and PTHPs were only found in multifamily buildings.

Table 94: Permanent Cooling Vintages by Home Type

(Base = Systems)

Vintage	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-Site Results Only				
n-value	*168*	*23*	*35*	*226*
2019 to 2023	27%	30%	39%	32%
2016 to 2018	12%	13%	12%	14%
2011 to 2015	19%[b]	43%	21%	21%
2006 to 2010	15%	4%	15%	15%
2001 to 2005	12%	9%	3%	10%
1991 to 2000	14%	--	6%	7%
1981 to 1990	1%	--	3%	2%
1980 or earlier	--	--	--	--
Self-Audit Results Only				
n-value	*85*	*12*	*2*	*99*
2019 to 2023	31%	14%	100%	34%
2016 to 2018	28%	29%	--	20%
2011 to 2015	17%	14%	--	25%
2006 to 2010	11%	--	--	13%
2001 to 2005	7%	43%	--	6%
1991 to 2000	7%	--	--	3%
1981 to 1990	--	--	--	--
1980 or earlier	--	--	--	--
Total On-Site and Self-Audit				
n-value	*253*	*35*	*37*	*325*
2019 to 2023	28%	27%	41%	33%
2016 to 2018	17%	17%	12%	17%
2011 to 2015	18%	37%	21%	21%
2006 to 2010	14%	3%	15%	14%
2001 to 2005	10%	17%	3%	9%
1991 to 2000	12%	--	6%	5%
1981 to 1990	--	--	3%	2%
1980 or earlier	--	--	--	--

* Totals may not equal sum of column or row due to rounding.

The ENERGY STAR status of permanent space cooling systems is displayed in Table 95. Statewide, more than one-half (51%) of systems were ENERGY STAR qualified.

Table 95: Permanent Cooling ENERGY STAR Status by Home Type

(Base = Systems)

ENERGY STAR	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-Site Results Only				
n-value	*162*	*23*	*33*	*218*
Yes	46%	35%	36%	50%
No	54%	65%	64%	50%
Self-Audit Results Only				
n-value	*81*	*7*	*1*	*89*
Yes	47%	43%	100%	57%
No	53%	57%	0%	43%
Total On-site and Self-Audit				
n-value	*243*	*30*	*34*	*307*
Yes	47%	37%	38%	51%
No	53%	63%	62%	49%

* Totals may not equal sum of column or row due to rounding.

Table 96 presents statistics on the new standards for seasonal energy-efficiency ratings, or SEER2, found statewide.[79] A SEER2 rating is a ratio of the cooling output for a typical cooling season and the total electric energy input during the same period.[80] A higher rating is indicative of a more efficient system.

Statewide, the average SEER2 rating was 13.9, but the surveyed systems varied widely from a low of 9.0 to a high of 20.0. Across all home types the mean SEER2 rating was consistent.

[79] In cases where systems surveyed had an efficiency rating in SEER rather than SEER2, the SWE team converted these ratings from SEER to SEER2 using the following formula SEER2= (SEER + 2.8674)/1.2476. The equation for this conversion came from the Guidance Memo: Guidance for Claiming TRM Measure 2.2.1 High Efficiency Equipment: ASHP, CAC, GSHP, PTAC, PTHP in Phase IV (Revised) issued by the PA SWE on June 29, 2023.

[80] In some cases, systems surveyed had an efficiency rating in EER rather than SEER. In these cases, the SWE team would convert the EER ratings to SEER when possible using the following formula: SEER = (1.12-√(1.2544-0.08 x EER)) / 0.04.

Table 96: Permanent Cooling System SEER2 Rating by Home Type

(Base = Systems)

SEER	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-Site Results Only				
n-value	*157*	*23*	*28*	*208*
Min	10.0	10.0	9.0	9.0
Max	20.0	18.0	19.0	20.0
Mean	**13.6**	**14.0**	**13.7**	**13.8**
Median	14.0	14.0	14.0	14.0
Std. Dev.	2.3	1.7	2.7	2.3
Self-Audit Results Only				
n-value	*45*	*3*	--	*48*
Min	9.4	10.5	--	9.4
Max	19.9	15.1	**--**	19.9
Mean	**14.2**	**12.4**	**--**	**14.4**
Median	13.5	11.7	--	13.5
Std. Dev.	2.1	2.4	--	2.1
Total On-site and Self-Audit				
n-value	202	26	28	256
Min	9.0	10.0	9.0	9.0
Max	20.0	18.0	19.0	20.0
Mean	**13.7**	**13.8**	**13.7**	**13.9**
Median	14.0	14.0	14.0	14.0
Std. Dev.	2.2	1.9	2.7	2.2

*SEER to SEER2 conversions can be found in Table 200.

Table 97 summarizes the SEER2 ratings of central air-conditioners. The average SEER2 is 13.2 and when converted back to SEER it is 13.6. This is above the current federal standard of 13.0. However, that standard only applies to systems manufactured after January 1, 2015. The central air-conditioners with SEER values less than 10.0 were all at least 17 years old.

Table 97: Central Air Conditioner SEER2 Rating

(Base = Systems)

SEER	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-Site Results Only				
n-value	*104*	*16*	*12*	*132*
Min	9.5	11.4	10.3	9.5
Max	15.9	15.1	14.3	15.9
Mean	**12.7**	**13.5**	**12.5**	**13.1**
Median	12.7	13.5	12.7	12.7
Std. Dev.	1.7	0.9	1.3	1.6
Self-Audit Results Only				
n-value	*21*	*3*	--	*24*
Min	9.4	10.5	--	9.4
Max	15.1	15.1	--	15.1
Mean	**13.2**	**12.4**	**--**	**13.2**
Median	13.5	11.7	--	13.5
Std. Dev.	1.5	2.4	--	1.6
Total On-site and Self-Audit				
n-value	*125*	*19*	*12*	*156*
Min	9.4	10.5	10.3	9.4
Max	15.9	15.1	14.3	15.9
Mean	**12.8**	**13.4**	**12.5**	**13.2**
Median	12.7	13.5	12.7	12.7
Std. Dev.	1.6	1.2	1.3	1.6

Table 98 summarizes the SEER2 ratings of air-source heat pumps and ductless mini splits. The average SEER2 of 14.8 is higher than that of conventional central air conditioners since heat pumps can reach higher levels of efficiency. The average energy efficiency ratio (EER) for Ground-source heat pumps (GSHPs) was 21.9.[81]

[81] Only 9 out of 11 GSHPs had available cooling efficiency data. Three GSHPs were found during audits and 8 were collected through self-audit data.

Table 98: ASHP/Ductless Mini Split SEER2 Rating

(Base = Systems)

SEER	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-site Results Only				
n-value	*53*	*7*	*15*	*75*
Min	10.3	10.3	8.6	8.6
Max	20.3	18.1	19.1	20.3
Mean	**15.0**	**14.5**	**14.7**	**14.8**
Median	14.3	14.7	13.9	14.3
Std. Dev.	2.4	2.7	2.9	2.5
Self-Audit Results Only				
n-value	*23*	--	--	*23*
Min	10.3	--	--	10.3
Max	19.9	--	--	19.9
Mean	**15.0**	--	--	**15.5**
Median	14.3	--	--	14.3
Std. Dev.	2.2	--	--	2.2
Total On-Site and Self-Audit				
n-value	*76*	*7*	*15*	*98*
Min	10.3	10.3	8.6	8.6
Max	20.3	18.1	19.1	20.3
Mean	**15.0**	**14.5**	**14.7**	**14.8**
Median	14.3	14.7	13.9	14.3
Std. Dev.	2.4	2.7	2.9	2.4

Table 99 shows the total cooling capacity per home normalized by conditioned floor area.[82] This table excludes multifamily systems that serve multiple units or common area. Statewide, the mean capacity per square foot was 15.8 BTUh/sq.ft. Multifamily had a statistically significantly higher mean capacity per square foot than single-family homes at 24.8 BTUh/sq.ft. The calculated values ranged widely from a low of 3.2 BTUh/sq.ft. to a high of 73.8 BTUh/sq.ft..

[82] Systems that served multiple units were excluded from these calculations because it was impossible to determine exactly how many units, and thus the square footage, they served.

Table 99: Permanent Cooling System Capacity (BTUh/sq.ft.)

(Base= Homes, Site Visits)

	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*135*	*22*	*28*	*185*
Min	3.2	5.5	11.8	3.2
Max	37.5	57.8	73.8	73.8
Mean	**14.4**	**17.9**	**24.8**	**15.8**
Median	13.0	17.4	21.9	14.5
Std. Dev.	5.5	10.2	11.7	8.3

* Totals may not equal sum of column or row due to rounding.

8.2.2 Room Air Conditioners

This section summarizes room air conditioners found during audits and submitted by self-audit participants. Since some audits took place during heating seasons when room air conditioners were likely to be stored away, auditors asked occupants if they had any room air conditioners stored away. Table 100 displays room air conditioner saturation by home type. Statewide, around 23% of homes contained at least one room air conditioner. They were more prevalent in multifamily homes than single family homes. There were 11 homes surveyed that had three or more room air conditioners in total.

Table 100: Room Air Conditioner Saturation by Home Type

(Base= Homes, Site Visits)

Count	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*189*	*28*	*69*	*286*
0	81%	82%	70%	77%
1	8%	11%	22%	12%
2	5%	4%	7%	5%
3+	5%	4%	1%	6%

* Totals may not equal sum of column or row due to rounding.

Table 101 describes room air conditioner vintage by home type. The mean age of surveyed room air conditioners was 11 years, and close to two thirds (63%) were manufactured between 2011 and 2023. Forty-three percent of multifamily room air conditioners were manufactured within the last four years, a much larger proportion than any other home type.

Table 101: Room Air Conditioner Vintage by Home Type

(Base = Systems)

Age	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-Site Results Only				
n-value	*69*	*9*	*28*	*106*
2019 to 2023	25%	11%	50%	26%
2016 to 2018	14%	44%	20%	16%
2011 to 2015	19%	11%	5%	16%
2006 to 2010	21%	11%	10%	20%
2001 to 2005	12%	--	10%	9%
1991 to 2000	5%	22%	5%	9%
1981 to 1990	2%	--	--	2%
1980 or earlier	2%	--	--	2%
Self-Audit Results Only				
n-value	*31*	*17*	*3*	*51*
2019 to 2023	59%	67%	--	43%
2016 to 2018	9%	11%	--	10%
2011 to 2015	23%	11%	33%	16%
2006 to 2010	9%	11%	--	8%
2001 to 2005	--	--	33%	11%
1991 to 2000	--	--	33%	11%
1981 to 1990	--	--	--	--
1980 or earlier	--	--	--	--
Total On-Site and Self-Audit				
n-value	*100*	*26*	*31*	*157*
2019 to 2023	34%	39%	43%	33%
2016 to 2018	13%	28%	17%	14%
2011 to 2015	20%	11%	9%	16%
2006 to 2010	18%	11%	9%	18%
2001 to 2005	9%	--	13%	8%
1991 to 2000	4%	11%	9%	10%
1981 to 1990	1%	--	--	1%
1980 or earlier	1%	--	--	1%

* Totals may not equal sum of column or row due to rounding.

The ENERGY STAR status for room air conditioners is displayed in Table 102. Close to one third (32%) of room air conditioners were found to be ENERGY STAR qualified. The results were consistent across single family home types, but systems in multifamily homes were less likely than other home types to be ENERGY STAR qualified (24%).

Table 102: Room Air Conditioner ENERGY STAR Status by Home Type

(Base = Systems)

ENERGY STAR	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-Site Results Only				
n-value	*63*	*9*	*22*	*94*
Yes	33%	33%	23%	32%
No	67%	67%	77%	68%
Self-Audit Results Only				
n-value	*28*	*14*	*3*	*45*
Yes	36%	29%	33%	27%
No	64%	71%	67%	73%
Total On-site and Self-Audit				
n-value	*91*	*23*	*25*	*139*
Yes	34%	30%	24%	32%
No	66%	70%	76%	68%

Room air conditioner efficiencies are measured in the combined energy efficiency ratio (CEER), the ratio of measured cooling output to the measured average electrical power output and standby/off-mode consumption. The SWE converted EER ratings to CEER.[83] The statewide average CEER was 10.6 (Table 103). The mean efficiency was consistent across home types.

[83] In cases where systems surveyed had an efficiency rating in EER rather than CEER, the SWE team converted these ratings from EER to CEER using the following formula CEER = 0.9280 x EER + 0.6902. The equation for this conversion can be found at https://www.nmrgroupinc.com/wp-content/uploads/2019/09/IEPEC-Abstracts-2019-Yogi.pdf

Table 103: Room Air Conditioner CEER Rating by Home Type

(Base = Systems)

	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-Site Results Only				
n-value	*57*	*7*	*22*	*86*
Min	8.7	9.8	8.2	8.2
Max	15.0	12.0	12.1	15.0
Mean	**10.6**	**11.3**	**10.7**	**10.6**
Median	10.7	11.2	11.0	10.9
Std. Dev.	1.1	0.8	1.0	1.1
Self-Audit Results Only				
n-value	*27*	*17*	*3*	*47*
Min	8.1	9.5	9.5	8.1
Max	11.4	12.0	11.1	12.0
Mean	**10.6**	**10.7**	**10.4**	**10.6**
Median	11.0	10.8	10.6	11.0
Std. Dev.	0.8	0.8	0.8	0.8
Total On-Site and Self-Audit				
n-value	*84*	*24*	*25*	*133*
Min	8.1	9.5	8.2	8.1
Max	15.0	12.0	12.1	15.0
Mean	**10.6**	**10.9**	**10.7**	**10.6**
Median	10.8	11.0	11.0	10.9
Std. Dev.	1.0	0.8	1.0	1.0

Table 104 describes room air conditioner capacities by home type. The mean capacity was 7,161 BTUh, but the values varied from 5,000 to 18,000 BTUh. Attached single-family homes had a much higher capacity on average. Average CFA is included in the table below for reference.

Table 104: Room Air Conditioner Capacity by Home Type
(Base= Homes, Site Visits)

	Detached Single-family	Attached Single-family	Multifamily	Statewide
Average CFA	**2,551**	**1,559**	**946**	**2,131**
n-value	*62*	*9*	*21*	*92*
Min	5,000	6,000	5,000	5,000
Max	18,000	14,000	10,000	18,000
Mean	**6,937**	**9,244**	**6,598**	**7,161**
Median	6,000	8,000	6,000	6,000
Std. Dev.	2,658	2,736	1,591	2,546

8.3 Water Heating Equipment

This section presents the water heating equipment types, fuels, capacities, and efficiencies found during onsite audits and submitted by self-audit participants. Two single-family detached homes had two water heating systems. There were 16 homes for which auditors were unable to find or access the water heating system. Two of them were detached single-family and the rest were multifamily.

Like in the heating and cooling sections, commercial and shared equipment are excluded from analysis unless otherwise noted. Shared water heating systems were present at 14 multifamily buildings, providing hot water for multiple units or the common areas (i.e., laundry facilities and bathrooms). Shared water heating equipment was typically located in mechanical rooms or basements. Statewide, the average efficiency of shared water heaters was 0.84 Uniform Energy Factor (UEF) for nine systems with data available. The average thermal efficiency (TE) was 88% in four systems with data available.[84,85]

8.3.1 Water Heater Fuel

Table 105 presents the water heater fuel type for each home in the sample. The number of homes who used electricity for water heating has increased since the last baseline in 2018 from 35% to 45% in audited homes. This increase could be driven by sample variation between the two studies and an increase in electric heating. Electricity as a primary heating fuel has also increased since the last baseline from 23% to 31%, which may play a role in the increase of electric water heating. Unlike other home types, multifamily homes were more likely to use electric water heaters (75%) than any other fuel.

[84] There were no commercial water heaters found. Electric standalones with capacity greater than 120 gallons and natural gas standalones with capacity greater than 100 gallons were considered commercial sized equipment.
[85] Thermal efficiency is the amount of energy delivered as heated water compared to the energy consumption of the water heater and is a typical efficiency metric for commercial-grade water heaters. Residential water heater efficiency was previously rated as an Energy Factor (EF), which has since been superseded by the UEF. See Section 8.3.5 for a discussion of efficiency measures for residential water heaters.

Table 105: Water Heating Fuel by Home Type

(Base = Homes)

Fuel	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-Site Results Only				
n-value	*187*	*28*	*55*	*270*[1]
Natural Gas	54%	64%	27%	48%
Electric	39%	36%	73%	45%
Oil	4%	--	--	5%
Propane	3%	--	--	2%
Self-Audit Results Only				
n-value	*162*	*21*	*12*	*195*
Electric	40%	60%	83%	50%
Natural Gas	56%	40%	17%	47%
Propane	4%	--	--	3%
Oil	1%	--	--	<1%
Total On-site and Self-Audit				
n-value	*349*	*49*	*67*	*465*
Natural Gas	55%	54%	25%	48%
Electric	39%	46%	75%	47%
Oil	3%	--	--	3%
Propane	3%	--	--	2%

[1] The total on-site sample does not equal 286 due to 16 homes where water heating systems were not accessible.

* Totals may not equal sum of column or row due to rounding.

8.3.2 Water Heater Type and Fuel

Table 106 shows the breakdown of residential water heater systems and fuel types. The vast majority of water heaters observed during onsite audits were standalone systems. Standalone water heaters were primarily fueled by electricity (50%) and natural gas (48%). Multifamily homes were more likely to have electric standalone systems than natural gas systems. Conversely, detached and attached single-family units were more likely to have natural gas standalone systems than electric systems.

Table 106: DHW Type and Fuel by Home Type

(Base = Homes)

Type and Fuel	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-Site Results Only				
n-value	*187*	*28*	*55*	*270*[1]
Storage, Stand-alone	**85%**	**93%**	**93%**	**85%**
Natural Gas	58%	62%	25%	50%
Electric	40%	38%	75%	49%
Propane	3%	0%	0%	2%
Tankless Coil	**4%**	**0%**	**0%**	**5%**
Oil	7(100%)	–	–	100%
Instantaneous	**2%**	**7%**	**5%**	**3%**
Natural Gas	100%	100%	67%	89%
Electric	0%	0%	33%	11%
Storage, Heat pump (Electric)	**5%**	**0%**	**2%**	**3%**
Storage, Indirect heat	**3%**	**0%**	**0%**	**3%**
Natural Gas	50%	–	–	69%
Oil	17%	–	–	11%
Propane	17%	–	–	11%
Electric	17%	–	–	9%
Combi Boiler	**1%**	**0%**	**0%**	**1%**
Natural Gas	2(100%)	–	–	100%
Self-Audit Results Only				
n-value	*162*	*21*	*12*	*195*
Storage, Stand-alone	**90%**	**90%**	**100%**	**92%**
Electric	42%	61%	83%	51%
Natural Gas	55%	39%	17%	47%
Propane	3%	0%	0%	3%
Instantaneous	**5%**	**5%**	**0%**	**3%**
Natural Gas	88%	100%	–	98%
Propane	12%	0%	–	2%
Storage, Heat pump (Electric)	**1%**	**5%**	**0%**	**2%**
Storage, Indirect heat	**2%**	**0%**	**0%**	**2%**
Natural Gas	40%	–	–	45%
Electric	20%	–	–	32%
Oil	40%	–	–	22%
Combi Boiler	**1%**	**0%**	**0%**	**1%**
Natural Gas	50%	–	–	50%
Propane	50%	–	–	50%
Total On-Site and Self-Audit				
n-value	*349*	*49*	*67*	*465*

Storage, Stand-alone	**87%**	**92%**	**94%**	**87%**
Electric	41%	48%	76%	50%
Natural Gas	57%	52%	24%	48%
Propane	3%	0%	0%	2%
Instantaneous	**3%**	**6%**	**4%**	**3%**
Natural Gas	92%	100%	67%	91%
Electric	0%	0%	33%	8%
Propane	8%	0%	0%	1%
Storage, Indirect heat	**3%**	**0%**	**0%**	**3%**
Natural Gas	45%	–	–	66%
Electric	18%	–	–	15%
Oil	27%	–	–	14%
Propane	9%	–	–	5%
Tankless Coil	**2%**	**0%**	**0%**	**3%**
Oil	7(100%)	–	–	100%
Storage, Heat pump (Electric)	**3%**	**2%**	**1%**	**2%**
Combi Boiler	**1%**	**0%**	**0%**	**1%**
Natural Gas	75%	–	–	82%
Propane	25%	–	–	18%

[1] The total on-site sample does not equal 286 due to 16 homes where water heating systems were not accessible.

* Totals may not equal sum of column or row due to rounding.

8.3.3 Water Heater Age

Table 107 displays the age distribution of water heater equipment observed during the onsite audits.[86] The average water heater age is 11 years. More than two-thirds of water heaters were manufactured between 2011 and 2023 (72%).

[86] Some water heater ages were unidentifiable due to tank wrap covering nameplates, inaccessible nameplates, or manufacturing companies becoming obsolete or unresponsive.

Table 107: Water Heater Vintages by Home Type

(Base = Systems)

Vintage	Detached Single-family	Attached Single-family	Multifamily	Statewide[1]
On-Site Results Only				
n-value	*187*	*28*	*42*	*257*
2019 to 2023	28%	30%	24%	25%
2016 to 2018	18%	33%	24%	22%
2011 to 2015	21%	22%	26%	22%
2006 to 2010	14%	11%	21%	17%
2001 to 2005	11%	4%	5%	8%
1991 to 2000	7%	--	--	5%
1981 to 1990	1%	--	--	<1%
1980 or earlier	--	--	--	--
Self-Audit Results Only				
n-value	*163*	*21*	*12*	*196*
2019 to 2023	31%	38%	38%	33%
2016 to 2018	11%	12%	12%	13%
2011 to 2015	29%	31%	38%	33%
2006 to 2010	16%	19%	12%	14%
2001 to 2005	8%	--	--	5%
1991 to 2000	4%	--	--	1%
1981 to 1990	1%	--	--	<1%
1980 or earlier	--	--	--	--
Total On-Site and Self-Audit				
n-value	*350*	*49*	*54*	*453*
2019 to 2023	29%	33%	26%	28%
2016 to 2018	15%	26%	22%	18%
2011 to 2015	25%	26%	28%	26%
2006 to 2010	15%	14%	20%	18%
2001 to 2005	10%	2%	4%	7%
1991 to 2000	6%	--	--	4%
1981 to 1990	1%	--	--	<1%
1980 or earlier	--	--	--	--

* Totals may not equal sum of column or row due to rounding.

8.3.4 Water Heater ENERGY STAR Status

Statewide, 13% of water heaters were verified to be ENERGY STAR qualified (Table 108). The analysis excludes water heaters that did not fall into current ENERGY STAR classifications (i.e., indirect water heaters with storage tanks and tankless coils). Detached and attached single-family homes were more likely to have ENERGY STAR qualified water heaters than multifamily homes. For the EDCs Duquesne Light, Met Ed, and Penn Power had the highest shares of ENERGY STAR qualified water heaters at 23%, 34%, and 22%, respectively (Table 235).

Table 108: Water Heater ENERGY STAR Status by Home Type

(Base = Systems)

ENERGY STAR	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-Site Results Only				
n-value	*173*	*28*	*43*	*244*
Yes	19%	25%	5%	15%
No	81%	75%	95%	85%
Self-Audit Results Only				
n-value	*156*	*21*	*12*	*189*
Yes	17%	16%	18%	12%
No	83%	84%	82%	88%
Total On-Site and Self-Audit				
n-value	*329*	*49*	*55*	*433*
Yes	18%	21%	7%	13%
No	82%	79%	93%	87%

8.3.5 Water Heater Efficiency

Table 109 shows the average UEF for water heaters by home type and statewide. The UEF is an energy performance metric for water heaters that went into effect December 19, 2016.[87] Prior to the implementation of the UEF metric, energy efficiency was rated using the Energy Factor (EF) metric. The SWE team used RESNET protocols to convert EF ratings to UEF ratings. [88] Table 109 includes all systems with UEF or EF ratings except seven tankless coil systems and seven indirect systems for which there are no RESNET protocols to convert EF ratings to UEF ratings. Statewide, the average UEF is 0.82. Across single-family homes, the mean UEF rating was consistent. Multifamily homes were found to have a higher rating than the statewide average at 0.97 which is significantly different than the average for detached and attached single-family homes.

87 https://www.regulations.gov/document?D=EERE-2015-BT-TP-0007-0042

88 Water heaters with Energy Factor (EF) ratings were converted to the Uniform Energy Factor using the RESNET conversion worksheet. It should be noted that indirect water heaters with storage tanks and tankless coils do not have conversion factors from the EF to the UEF; efficiency values reported utilize the EF rating, noted in the table.

Table 109: Water Heater UEF by Home Type

(Base = Systems)

	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-Site Results Only				
n-value	*163*	*28*	*42*	*233*
Min	0.53	0.56	0.56	0.53
Max	3.71	0.97	3.34	3.71
Mean	**0.82**	**0.75**	**1.00**	**0.83**
Median	0.67	0.70	0.92	0.89
Std. Dev.	0.48	0.16	0.54	0.47
Self-Audit Results Only				
n-value	*154*	*19*	*12*	*185*
Min	0.54	0.58	0.65	0.54
Max	3.88	2.44	0.95	3.88
Mean	**0.78**	**0.90**	**0.88**	**0.81**
Median	0.69	0.91	0.92	0.72
Std. Dev.	0.33	0.40	0.10	0.33
Total On-site and Self-Audit				
n-value	*317*	*47*	*54*	*418*
Min	0.53	0.56	0.56	0.53
Max	3.88	2.44	3.34	3.88
Mean	**0.80**	**0.81**	**0.97**	**0.82**
Median	0.68	0.90	0.92	0.87
Std. Dev.	0.41	0.29	0.48	0.41

* Totals may not equal sum of column or row due to rounding.

Table 110 presents the statewide average UEF or EF for each residential water heater system type observed onsite. The SWE team calculated Energy Factors for indirect water heaters as 92% of boiler efficiency. For tankless coil systems, energy factors were based on home occupancy.[89] The statewide average efficiency of fossil fuel-fired storage tank water heaters is 0.62 UEF. The average efficiency for electric standalone systems was 0.92 UEF, while the combined average efficiency for all electric equipment types was 1.07 UEF. Heat pump water heaters (HPWH) had a much higher UEF (3.20) than any other system type.

[89] Based on Northeast Home Energy Rating System Alliance protocols, the EF was assumed as 0.45 for three occupants, 0.50 for four occupants, 0.55 for five occupants, 0.60 for six occupants, and 0.65 for seven occupants.

Table 110: Average Residential Water Heater Efficiency

(Base = Systems, Site Visits)

Uniform Energy Factor	*n-value*	Statewide
Storage, Standalone (Fossil Fuels, UEF)	*115*	0.62
Storage, Standalone (Electric, UEF)	*104*	0.92
Instantaneous (UEF)	*7*	0.93
Indirect w/ Storage Tank (EF)	*4*	0.80
Tankless Coil (EF)	*7*	0.48
Heat Pump Water Heater (UEF)	*7*	3.20

Insulating (hot water) pipe wrap and storage tank wrap increases efficiency by mitigating thermal losses. Thirteen percent of water heaters had fully insulated pipes, 7% had mostly insulated pipes, and 80% had no pipe insulation. Statewide, 3% of standalone water heaters were wrapped with insulation, with an average R-value of 5.4.

8.3.6 Standalone Water Heater Volume

Table 111 displays the storage volume of all residential-sized standalone water heaters. Statewide, the majority (79%) of storage tank water heaters ranged in size from 40-55 gallons. This was the most prevalent size for all home types. Larger tank sizes (above 75 gallons) were most common in detached single-family homes (6%). Water heaters that served multifamily sites with multiple units and common areas were excluded but the majority were greater than 75 gallons of storage volume.

Table 111: Standalone Water Heater Capacity (Gallons) by Home Type

(Base = Systems)

Gallons	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-Site Results Only				
n-value	*160*	*26*	*39*	*225*
<40	7%	15%	38%	11%
40 to 55	82%	85%	56%	77%
55 to 75	4%	0%	0%	4%
>75	7%	0%	5%	8%
Self-Audit Results Only				
n-value	*146*	*19*	*12*	*177*
<40	8%	18%	9%	6%
40 to 55	85%	82%	82%	85%
55 to 75	3%	0%	9%	5%
>75	4%	0%	0%	4%
Total On-site and Self-Audit				
n-value	*306*	*45*	*51*	*402*
<40	7%	16%	32%	10%
40 to 55	83%	84%	62%	79%
55 to 75	4%	0%	2%	4%
>75	6%	0%	4%	7%

* Totals may not equal sum of column or row due to rounding.

8.3.7 Faucets and Shower Heads

Auditors looked for aerators on all faucets and shower heads and recorded nominal flow rates when visible.[90] Overall, homes had an average of 3.9 sinks, including 1.2 kitchen sinks, 2.3 bathroom sinks, and 0.4 utility sinks (Table 112). Aerators were present on 90% of faucets and low-flow aerators (i.e., having a flow rate less than or equal to 1.5 gallons/minute) were on 66% of faucets (Table 113). This is an increase from the previous study, which found low-flow aerators on 57% of faucets. The average overall flow rate for all sink types was 1.8 gallons/minute (Table 114).

[90] Nominal flow rates were recorded for 37% of faucets and 27% of shower heads. Flow rates are nominal (i.e. as labeled on the aerator) and not a measurement of actual water flow at the faucet or showerhead.

Table 112: Average Number of Faucets

Type	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*188*	*28*	*69*	*285*
Kitchen	1.2	1.1	1.1	1.2
Bathroom	2.7	2.2	1.4	2.3
Utility	0.5	0.3	0.1	0.4
Overall	3.7	4.6	3.5	3.9

Table 113: Share of Faucets with Low-Flow Aerators

Type	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*1,141*	*132*	*241*	*1,514*
Yes	64%	65%	79%	66%
No	36%	35%	21%	34%

Table 114: Average Faucet Flow Rate

Type	Detached Single-family	Attached Single-family	Multifamily	Statewide
Kitchen *(n=147)*	1.8	1.7	1.7	1.8
Bathroom *(n=235)*	1.6	1.7	1.5	1.6
Utility *(n=14)*	1.9	2.2	1.8	2.1
Overall *(n=396)*	1.8	1.8	1.7	1.8

The average home had 1.7 shower heads. Eleven percent of shower heads were low flow (i.e., had a flow rate less than 2.0 gallons/minute) and the average flow rate was 2.0 gallons/minute (Table 115).

Table 115: Shower Head Count, Aerators, and Flow Rate

Type	Detached Single-family	Attached Single-family	Multifamily	Statewide
Count of showerheads	*332*	*31*	*71*	*434*
Avg # Per Home	1.9	1.5	1.2	1.7
Low Flow %	10%	6%	18%	11%
Average Flow Rate	2.1	2.2	2.0	2.0

8.4 Ventilation

Data were collected on mechanical ventilation systems found onsite, including heat recovery ventilation (HRV) and energy recovery ventilation (ERV) systems.[91] This study did not assess bath fans as ventilation strategies and only considered full house ventilation technologies. Only one ERV system was found during the onsite audits. ERV systems are a “balanced ventilation system” that supply fresh air to the home while expelling stale air. The ERV system was in a multifamily home in PPL territory. The ERV was controlled with a humidistat and had a sensible recovery rate of 72% and a total recovery rate of 72%. Five sites were recorded with a whole house fan, used for exhaust only, and controlled with local manual switches.

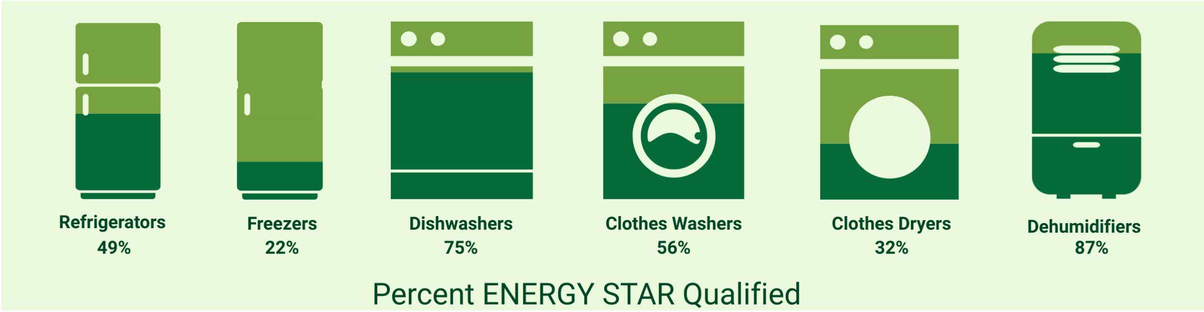
[91] The difference between an Energy Recovery Ventilator (ERV) and a Heat Recovery Ventilator (HRV) is that in an ERV, the heat exchanger transmits some amount of water vapor along with the heat energy, whereas only heat is transferred in an HRV.

Section 9 Appliances

This chapter presents the SWE team's statewide findings for appliances observed during audits and collected through the self-audit web survey. The SWE team collected data on refrigerators, standalone freezers, ovens and ranges, dishwashers, clothes washers, clothes dryers, and dehumidifiers.

Data was collected onsite and nameplate information was collected for all appliances whenever possible. The self-audit photo submission process attempts to mirror the on-site visual verification and photo data collection efforts (i.e., nameplate and appliance overview).[92] The SWE team utilized the nameplate information collected or submitted (primarily manufacturer's model and serial numbers) to look up information uncollected or unable to be confirmed onsite. This includes appliance energy consumption, vintage, efficiency, ENERGY STAR status, and other appliance-specific details. Some appliances, primarily older-vintage models, did not have specifications available online or onsite. In these instances, the SWE team applied age-based default characteristics.

Figure 28: Appliance Results Highlights



9.1 Refrigerators

This section describes the SWE team's key findings for refrigerators. As expected, Table 116 shows there was at least one refrigerator present in most of the sites audited.[93] Further shown in Table 116, 78 (27%) of the sites surveyed had a secondary refrigerator and nine (3%) sites had three or more refrigerators.[94] Larger home types are more likely to have multiple refrigerators as shown by detached single-family homes being the most likely (40%), followed by attached single-family (18%). Multifamily units were least likely to contain a secondary refrigerator unit.

[92] Respondents to the self-audit were allowed to submit photos of appliances for a small incentive ($5 per appliance), but were required to submit one photo of the nameplate and one photo that showed an overview of the appliance. Tips and photos of common nameplate locations were included in the web-survey to increase the accuracy and clarity of photo submissions.

[93] Three sites were recorded without a refrigerator. All three sites were undergoing renovations, with some major appliances removed. They have been excluded from the table.

[94] Mini Fridges were recorded separately from normal-sized models by the SWE team but were included in these counts.

Table 116: Number of Refrigerators Per Household

(Base: Homes, Site Visits)

Count	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*188*	*28*	*67*	*283*
1	60%	82%	93%	69%
2	34%	18%	7%	27%
3+	6%	--	--	3%[1]

[1]Two sites contained four refrigerators.

Table 117 describes surveyed refrigerator vintages, when available, divided into eight distinct vintage buckets.[95] The average age of refrigerators was 11 years. Primary refrigerators were newer on average (10 years) than secondary refrigerators (15 years; Table 118).

[95] While the report uses generalized vintage bins for all appliances and mechanical equipment for consistency, note that the current federal standards for refrigerators went into effect in 2014 and the previous standard was applicable from 2001 to 2014.

Table 117: Refrigerator Vintages by Home Type

(Base: Refrigerators)

Vintage	Detached Single-family	Attached Single-family	Multifamily	Statewide
On-Site Results Only				
n-value	*264*	*33*	*69*	*366*
2019 to 2023	21%	18%	29%	21%
2016 to 2018	17%	24%	19%	19%
2011 to 2015	26%	27%	28%	24%
2006 to 2010	17%	15%	12%	19%
2001 to 2005	8%	6%	6%	6%
1991 to 2000	9%	9%	6%	10%
1981 to 1990	1%	--	1%	1%
1980 or earlier	<1%	--	--	<1%
Self-Audit Results Only				
n-value	*184*	*27*	*19*	*230*
2019 to 2023	28%	19%	16%	28%
2016 to 2018	16%	30%	21%	15%
2011 to 2015	21%	30%	47%	22%
2006 to 2010	17%	15%	--	15%
2001 to 2005	10%	4%	11%	10%
1991 to 2000	7%	4%	5%	7%
1981 to 1990	2%	--	--	3%
1980 or earlier	--	--	--	--
Total On-site and Self-Audit				
n-value	*448*	*60*	*88*	*596*
2019 to 2023	24%	18%	26%	23%
2016 to 2018	17%	27%	19%	19%
2011 to 2015	24%	28%	32%	23%
2006 to 2010	17%	15%	9%	18%
2001 to 2005	8%	5%	7%	7%
1991 to 2000	8%	7%	6%	9%
1981 to 1990	1%	--	1%	1%
1980 or earlier	<1%	--	--	<1%

* Totals may not equal sum of column or row due to rounding.

Table 118: Refrigerator Vintage by Usage Status

(Base: Refrigerators, Site Visits)

Vintage	Primary	Secondary	Tertiary	Statewide
n-value	*282*	*79*	*5*	*366*
2019+	25%	10%	40%	21%
2016 to 2018	20%	10%	20%	19%
2011 to 2015	28%	23%	20%	24%
2006 to 2010	15%	20%	20%	19%
2001 to 2005	6%	11%	--	6%
1991 to 2000	6%	19%	--	10%
1981 to 1990	--	5%	--	1%
1980 or earlier	--	1%	--	<1%

* Totals may not equal sum of column or row due to rounding.

Table 119 describes refrigerator configuration. Statewide, most refrigerators had a top freezer door (43%) or bottom freezer (35%) configuration. Multifamily units surveyed were almost entirely (83%) comprised of top freezer models.

Table 119: Refrigerator Door Configuration by Home Type

(Base: Refrigerators, Site Visits)

Door Configuration	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*276*	*33*	*72*	*381*
Top Freezer	35%	61%	83%	43%
Bottom Freezer	39%	18%	8%	35%
Side by Side	19%	18%	7%	18%
Single Door	4%	3%	1%	2%
Internal Freezer	2%	--	--	1%
No Freezer	<1%	--	--	<1%

* Totals may not equal sum of column or row due to rounding.

Table 120 describes refrigerators by their internal storage volume. Statewide, the average refrigerator volume was 21.0 ft^3 and was relatively consistent across home types. However, refrigerators in multifamily units were smaller than refrigerators in other home types.

Table 120: Refrigerator Volume by Home Type
(Base: Refrigerators)

Categories	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*268*	*32*	*69*	*369*
Min	1.3	4.5	2.7	1.3
Max	34.3	26.0	25.3	34.3
Mean	**21.0**	**19.4**	**17.6**	**20.7**
Median	22.0	19.8	18.0	20.8
Sd.	6.3	4.8	3.7	5.9
Self-Audit Results Only				
n-value	*188*	*27*	*19*	*234*
Min	1.7	3.3	14.0	1.7
Max	29.7	28.1	26.8	29.7
Mean	**22.4**	**20.1**	**19.1**	**21.7**
Median	23.0	19.7	18.2	22.0
Sd.	4.7	5.0	3.1	4.7
Total On-site and Self-Audit				
n-value	*456*	*59*	*88*	*603*
Min	1.3	3.3	2.7	1.3
Max	34.3	28.1	26.8	34.3
Mean	**21.6**	**19.7**	**17.9**	**21.0**
Median	22.1	19.7	18.0	21.6
Sd.	5.7	4.9	3.6	5.6

Table 121 and Table 122 display the average energy consumption and the ENERGY STAR status of surveyed refrigerators, respectively. Statewide, the average energy consumption was 565.2 kWh per year. Note this does not account for capacity and is thus not a reflection of efficiency.

Table 122 describes the ENERGY STAR status of refrigerators. Around half (49%) of refrigerators statewide were ENERGY STAR qualified. Multifamily homes were less likely to have ENERGY STAR qualified refrigerators than single-family home types.

Table 121: Refrigerator kWh Consumption per Year
(Base: Refrigerators)

Categories	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*267*	*33*	*69*	*369*
Min	208.0	258.0	214.0	208.0
Max	1,278.0	1,000.0	1,058.0	1,278.0
Mean	**570.6**	**494.8**	**477.3**	**552.9**
Median	582.0	462.0	430.0	546.0
Sd.	156.1	147.9	142.7	157.6
Self-Audit Results Only				
n-value	*188*	*27*	*19*	*234*
Min	274.0	218.0	382.0	218.0
Max	1,323.0	821.0	715.0	1,323.0
Mean	**603.3**	**525.9**	**513.6**	**595.6**
Median	607.0	563.0	452.0	587.0
Sd.	161.7	147.9	112.3	159.7
Total On-site and Self-Audit				
n-value	*455*	*60*	*88*	*603*
Min	208.0	218.0	214.0	208.0
Max	1,323.0	1,000.0	1,058.0	1,323.0
Mean	**584.1**	**508.8**	**485.2**	**565.2**
Median	587.0	468.0	435.0	570.0
Sd.	159.1	147.5	137.0	159.5

Table 122: Refrigerator ENERGY STAR Status by Home Type

(Base: Refrigerators)

Categories	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*245*	*32*	*64*	*341*
Yes	51%	47%	34%	48%
No	49%	53%	66%	52%
Self-Audit Results Only				
n-value	*177*	*26*	*16*	*219*
Yes	51%	50%	75%	52%
No	49%	50%	25%	48%
Total On-site and Self-Audit				
n-value	*422*	*58*	*80*	*560*
Yes	51%	48%	42%	49%
No	49%	52%	57%	51%

* Totals may not equal sum of column or row due to rounding.

9.2 Freezers

This section covers key findings related to standalone freezers. Table 123 describes standalone freezer counts by home type. Statewide, auditors found 119 standalone freezers during site visits. Most freezers were found in detached or attached single-family homes, with multifamily units being less likely (7%) to contain a standalone freezer appliance.

Table 123: Standalone Freezer Counts by Home Type

(Base: Homes, Site Visits)

Counts	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*28*	*189*	*69*	*286*
0	61%	54%	93%	64%
1	39%	38%	7%	31%
2	--	7%	--	4%
3+	--	1%	--	1%

As show in Table 124, freezer door configuration was split almost evenly. There were variations across home types, but sample sizes are too low to make reliable comparisons in multifamily and attached single-family homes.

Table 124: Freezer Door Configuration by Home Type
(Base: Freezers, Site Visits)

Door Configuration	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*101*	*11*	*5*	*117*
Chest	50%	64%	100%	55%
Upright	50%	36%	--	45%

Table 125 displays freezer vintages. Statewide, the average freezer age was 13 years. The largest proportion of freezers were manufactured after the year 2000.[96]

[96] While the report uses generalized vintage bins for all appliances and mechanical equipment for consistency, note that the current federal standards for freezers went into effect in 2014 and the previous standard was applicable from 2001 to 2014.

Table 125: Freezer Vintages by Home Type

(Base: Freezers)

Vintages	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*89*	*11*	*5*	*105*
2019 to 2023	18%	45%	0%	18%
2016 to 2018	17%	0%	20%	17%
2011 to 2015	18%	27%	0%	18%
2006 to 2010	21%	18%	40%	18%
2001 to 2005	12%	9%	20%	13%
1991 to 2000	8%	0%	0%	8%
1981 to 1990	2%	0%	0%	3%
1980 or earlier	3%	0%	20%	6%
Self-Audit Results Only				
n-value	*42*	*11*	*2*	*55*
2019 to 2023	19%	45%	50%	32%
2016 to 2018	12%	0%	50%	7%
2011 to 2015	24%	9%	0%	13%
2006 to 2010	17%	45%	0%	23%
2001 to 2005	17%	0%	0%	18%
1991 to 2000	5%	0%	0%	2%
1981 to 1990	5%	0%	0%	4%
1980 or earlier	2%	0%	0%	2%
Total On-site and Self-Audit				
n-value	*131*	*22*	*7*	*160*
2019 to 2023	18%	45%	14%	21%
2016 to 2018	15%	0%	29%	14%
2011 to 2015	20%	18%	0%	16%
2006 to 2010	20%	32%	29%	20%
2001 to 2005	14%	5%	14%	14%
1991 to 2000	7%	0%	0%	5%
1981 to 1990	3%	0%	0%	3%
1980 or earlier	3%	0%	14%	7%

* Totals may not equal sum of column or row due to rounding.

Table 126 describes freezer capacities, which were 10.9 ft^3 on average statewide. Their capacities ranged broadly, from a minimum of 1.2 ft^3 to a maximum 25.0 ft^3.

Table 126: Freezer Capacity by Home Type
(Base: Freezers)

Categories	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*93*	*11*	*5*	*109*
Min	1.2	5.0	5.0	1.2
Max	25.0	16.7	10.7	25.0
Mean	**12.0**	**9.1**	**7.6**	**11.0**
Median	12.0	7.0	7.2	11.0
Sd.	*93*	*11*	*5*	6.0
Self-Audit Results Only				
n-value	*45*	*10*	*2*	*57*
Min	3.5	3.0	7.1	3.0
Max	24.0	15.7	13.8	24.0
Mean	**12.5**	**7.7**	**10.4**	**11.2**
Median	10.6	7.0	10.4	10.0
Sd.	5.9	4.5	4.7	5.9
Total On-site and Self-Audit				
n-value	*138*	*21*	*7*	*166*
Min	1.2	3.0	5.0	1.2
Max	25.0	16.7	13.8	25.0
Mean	**12.2**	**8.5**	**8.4**	**10.9**
Median	12.0	7.0	7.2	10.6
Sd.	6.0	4.6	3.2	5.9

Table 127 describes the average annual energy consumption, in kWh/year, by home type. Freezer annual energy consumption averaged around 400 kWh per year statewide, but the range of values varied widely. This is expected given the broad range of freezer capacities shown in Table 126.

Table 127: Freezer Energy Consumption by Home Type (kWh/year)

(Base: Freezers)

Categories	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*92*	*11*	*4*	*107*
Min	144.0	215.0	218.0	144.0
Max	1,066.0	682.0	438.0	1,066.0
Mean	**409.3**	**334.2**	**289.0**	**409.2**
Median	427.5	250.0	250.0	397.0
Sd.	192.8	163.3	103.6	188.9
Self-Audit Results Only				
n-value	*45*	*10*	*2*	*57*
Min	172.0	193.0	248.0	172.0
Max	1,104.0	466.0	436.0	1,104.0
Mean	**436.4**	**276.4**	**342.0**	**396.4**
Median	431.0	245.0	342.0	357.0
Sd.	210.2	86.8	132.9	200.4
Total On-site and Self-Audit				
n-value	*137*	*21*	*6*	*164*
Min	144.0	193.0	218.0	144.0
Max	1,104.0	682.0	438.0	1,104.0
Mean	**418.2**	**306.7**	**306.7**	**407.1**
Median	431.0	250.0	264.5	379.5
Sd.	198.3	132.7	103.6	192.4

Table 128 describes the ENERGY STAR status of freezers surveyed statewide by home type. The SWE team was able to determine that 22% of freezers surveyed qualify as ENERGY STAR.

Table 128: Freezer ENERGY STAR Status by Home Type

(Base: Freezers)

Categories	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*85*	*11*	*4*	*100*
Yes	22%	9%	0%	19%
No	78%	91%	100%	81%
Self-Audit Results Only				
n-value	*43*	*10*	*2*	*55*
Yes	37%	20%	0%	27%
No	63%	80%	100%	73%
Total On-site and Self-Audit				
n-value	*128*	*21*	*6*	*155*
Yes	27%	14%	0%	22%
No	73%	86%	100%	78%

9.3 Ovens and Ranges

This section presents the key features and characteristics of in-home cooking appliances. “Oven and Range” refers to the standard kitchen appliance found throughout most sites surveyed, containing both an oven and range system within one singular appliance. Conversely, “Oven only” and “Range only” refers to standalone oven and range systems, respectively.

Table 129 describes the counts of oven and range combinations, standalone ovens, and standalone ranges found by the auditors. Statewide, roughly 83% of appliances surveyed were combination oven and ranges, while the rest contained a combination of the two standalone units.

Table 129: Oven and Range Type by Home Type

(Base: Ovens and ranges)

Categories	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*228*	*30*	*67*	*325*
Oven and Range	78%	87%	99%	80%
Oven only	12%	7%	--	11%
Range only	10%	7%	1%	9%
Self-Audit Results Only				
n-value	*132*	*18*	*18*	*168*
Oven and Range	92%	83%	94%	88%
Oven only	6%	6%	6%	8%
Range only	2%	11%	--	3%
Total On-site and Self-Audit				
n-value	*360*	*48*	*85*	*493*
Oven and Range	83%	85%	98%	83%
Oven only	10%	6%	1%	9%
Range only	7%	8%	1%	8%

* Totals may not equal sum of column or row due to rounding.

Table 130 and Table 131 display the fuel types for oven only, range only, and oven and range configurations. Range only configurations were primarily fueled by electricity (67% electric, 29% natural gas, 4% propane). Oven only configurations were primarily fueled by electricity (80% fuel, 20% natural gas). Combined oven and ranges were primarily fueled by electricity (59% electric, 39% natural gas, 2% propane). When considering all cooking equipment observed at site visits and submitted via self-audits, multifamily homes were more likely to have electric ovens and ranges (76%) than detached and attached single-family homes (56% and 45%, respectively). Of the electric ranges, 20% were induction ranges.

Table 130: Oven and Range Fuel Type by Home Type

(Base: Ovens and ranges)

Categories	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*206*	*28*	*66*	*300*
Electric	57%	46%	79%	62%
Natural Gas	39%	54%	21%	35%
Propane	4%	--	--	3%
Self-Audit Results Only				
n-value	*128*	*16*	*18*	*162*
Electric	55%	44%	67%	56%
Natural Gas	44%	56%	33%	44%
Propane	1%	--	--	<1%
Total On-site and Self-Audit				
n-value	*334*	*44*	*84*	*462*
Electric	56%	45%	76%	61%
Natural Gas	41%	55%	24%	37%
Propane	3%	--	--	2%

* Totals may not equal sum of column or row due to rounding.

Table 131: Oven and Range Fuel Type by Home Type

(Base: Site visits)

Categories	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
n-value	*189*	*28*	*69*	*286*
Electric	48%	43%	75%	56%
Natural Gas	46%	57%	22%	39%
Propane	5%	--	--	3%
No Oven or Range	1%	--	3%	1%

* Totals may not equal sum of column or row due to rounding.

Table 132 displays the saturation of convection ovens. Statewide, roughly 41% of surveyed ovens were convection ovens.

Table 132: Convection Oven Saturation

(Base: Ovens)

Convection Oven	n-value	Percent
On-Site Results Only		
Yes	*115*	38%
No	*185*	62%
Self-Audit Results Only		
Yes	*63*	48%
No	*69*	52%
Total On-site and Self-Audit		
Yes	*178*	41%
No	*254*	59%

9.4 Dishwashers

This section describes the key characteristics of dishwashers found throughout the study. Table 133 displays dishwasher penetration by home type. Of the 286 homes audited by the SWE team, 77% had a full-sized dishwasher present.

Table 133: Dishwasher Penetration by Home Type

(Base: Dishwashers, site visits only)

Categories	Detached Single-family	Attached Single-Family	Multifamily	Statewide
n-value	*189*	*28*	*69*	*286*
Full (8+ settings)	86%	82%	43%	77%
No Dishwasher	13%	18%	57%	23%
Compact (<8 settings)	2%	--	--	1%

* Totals may not equal sum of column or row due to rounding.

Table 134 displays dishwasher vintages by home type. The average age for surveyed dishwashers was ten years, and nearly three fourths (74%) of dishwashers have been manufactured since 2011.

Table 134: Dishwasher Vintages by Home Type

(Base: Dishwashers)

Vintage	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*161*	*22*	*28*	*211*
2019 to 2023	29%	18%	32%	27%
2016 to 2018	17%	27%	29%	18%
2011 to 2015	21%	32%	11%	23%
2006 to 2010	15%	18%	14%	16%
2001 to 2005	11%	5%	14%	11%
1991 to 2000	3%	--	--	1%
1981 to 1990	3%	--	--	2%
1980 or earlier	1%	--	--	1%
Self-Audit Results Only				
n-value	*94*	*11*	*13*	*118*
2019 to 2023	31%	0%	31%	24%
2016 to 2018	21%	27%	38%	24%
2011 to 2015	33%	36%	15%	39%
2006 to 2010	10%	18%	15%	8%
2001 to 2005	3%	18%	--	3%
1991 to 2000	2%	--	--	2%
1981 to 1990	--	--	--	--
1980 or earlier	--	--	--	--
Total On-site and Self-Audit				
n-value	*255*	*33*	*41*	*329*
2019 to 2023	29%	12%	32%	26%
2016 to 2018	19%	27%	32%	21%
2011 to 2015	25%	33%	12%	27%
2006 to 2010	13%	18%	15%	14%
2001 to 2005	8%	9%	10%	10%
1991 to 2000	3%	--	--	1%
1981 to 1990	2%	--	--	1%
1980 or earlier	<1%	--	--	<1%

* Totals may not equal sum of column or row due to rounding.

Table 135 and Table 136 show the annual electricity consumption and ENERGY STAR status of dishwashers, respectively. The average energy consumption statewide was roughly 294 kWh per year, with systems ranging from 70 to 717 kwh per year. Statewide, 75% of surveyed dishwashers were ENERGY STAR qualified.

Table 135: Dishwasher Consumption (kWh/year)

(Base: Dishwashers)

kWh/yr	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*158*	*21*	*28*	*207*
Min	70.0	240.0	234.0	70.0
Max	717.0	357.0	548.0	717.0
Mean	**301.8**	**279.7**	**300.8**	**295.7**
Median	270.0	270.0	270.0	270.0
Sd.	74.2	29.0	75.6	71.2
Self-Audit Results Only				
n-value	*93*	*10*	*13*	*116*
Min	234.0	243.0	255.0	234.0
Max	574.0	442.0	296.0	574.0
Mean	**285.4**	**302.0**	**270.2**	**286.6**
Median	270.0	277.5	270.0	270.0
Sd.	49.0	58.6	10.8	47.4
Total On-site and Self-Audit				
n-value	*251*	*31*	*41*	*323*
Min	70.0	240.0	234.0	70.0
Max	717.0	442.0	548.0	717.0
Mean	**295.7**	**286.9**	**291.1**	**293.2**
Median	270.0	270.0	270.0	270.0
Sd.	66.4	41.3	64.0	64.0

Table 136: Dishwasher ENERGY STAR Status
(Base: Dishwashers)

ENERGY STAR	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*156*	*22*	*29*	*207*
Yes	74%	77%	72%	70%
No	26%	23%	28%	30%
Self-Audit Results Only				
n-value	*93*	*13*	*13*	*119*
Yes	85%	77%	92%	89%
No	15%	23%	8%	11%
Total On-site and Self-Audit				
n-value	*249*	*35*	*42*	*326*
Yes	78%	77%	79%	75%
No	22%	23%	21%	25%

9.5 In-home Clothes Washers

Table 137 describes the statewide penetration of in-home clothes washers. Of the 286 homes surveyed, 87% have an in-home clothes washer. Only 36% of multifamily units contained an in-home system. This is in part due to the presence of shared washers occasionally found within many multifamily buildings. A small number (2%) of sites have more than one clothes washer.

Table 137: In-home Clothes Washer Penetration by Home Type

Categories	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
n-value	*189*	*28*	*69*	*286*
0	1%	11%	64%	12%
1	96%	86%	36%	85%
2	3%	4%	--	2%

* Totals may not equal sum of column or row due to rounding.

Statewide, the average clothes washer age was nine years. As shown in Table 138, the majority (72%) of clothes washers sampled were manufactured since 2011.

Table 138: Clothes Washer Vintages by Home Type

(Base: In-home clothes washers)

Vintage	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*178*	*23*	*26*	*227*
2019 to 2023	28%	13%	15%	27%
2016 to 2018	26%	26%	15%	24%
2011 to 2015	19%	30%	42%	20%
2006 to 2010	15%	17%	15%	16%
2001 to 2005	6%	--	8%	8%
1991 to 2000	4%	13%	4%	4%
1981 to 1990	2%	--	--	1%
Self-Audit Results Only				
n-value	*76*	*13*	*10*	*99*
2019 to 2023	24%	23%	20%	25%
2016 to 2018	25%	38%	50%	32%
2011 to 2015	24%	15%	30%	20%
2006 to 2010	11%	15%	--	8%
2001 to 2005	9%	--	--	10%
1991 to 2000	5%	8%	--	5%
1981 to 1990	1%	--	--	1%
1980 or earlier	1%	--	--	<1%
Total On-site and Self-Audit				
n-value	*254*	*36*	*36*	*326*
2019 to 2023	27%	17%	17%	26%
2016 to 2018	26%	31%	25%	26%
2011 to 2015	20%	25%	39%	20%
2006 to 2010	13%	17%	11%	15%
2001 to 2005	7%	--	6%	9%
1991 to 2000	5%	11%	3%	4%
1981 to 1990	2%	--	--	1%
1980 or earlier	<1%	--	--	<1%

* Totals may not equal sum of column or row due to rounding.

Table 139 displays the average configuration for surveyed clothes washers. The majority (61%) of clothes washers statewide were top load clothes washers. Attached single-family homes were more likely to have top load washers than detached single-family and multifamily homes.

Table 139: Clothes Washer Configuration
(Base: In-home clothes washers)

Type	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*188*	*26*	*26*	*240*
Top Load	66%	73%	65%	62%
Front Load	34%	27%	35%	38%
Self-Audit Results Only				
n-value	*79*	*14*	*10*	*103*
Top Load	62%	86%	60%	59%
Front Load	38%	14%	40%	41%
Total On-site and Self-Audit				
n-value	*267*	*40*	*36*	*343*
Top Load	65%	78%	64%	61%
Front Load	35%	22%	36%	39%

Table 140 displays the average clothes washer capacity. The statewide average was roughly 4.0 ft^3. Like the other appliances, capacities ranged broadly from a low of 1.5 ft^3 to a high of 5.8 ft^3. Average capacities were consistent across home types, but clothes washers in multifamily units were more likely to have smaller capacities. Again, this is likely due to space constraints inherent to these home types.

Table 140: Clothes Washer Capacity (ft^3)

(Base: In-home clothes washers)

Cubic Feet	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*171*	*22*	*26*	*219*
Min	2.1	2.5	1.5	1.5
Max	5.8	5.3	4.5	5.8
Mean	**4.0**	**3.8**	**3.4**	**3.9**
Median	4.2	3.8	3.5	4.0
Sd.	0.7	0.7	0.7	0.7
Self-Audit Results Only				
n-value	*76*	*13*	*10*	*99*
Min	3.0	2.6	2.3	2.3
Max	5.3	5.5	4.6	5.5
Mean	**4.2**	**4.1**	**3.8**	**4.1**
Median	4.3	4.2	4.0	4.3
Sd.	0.5	0.8	0.7	0.6
Total On-site and Self-Audit				
n-value	*247*	*35*	*36*	*318*
Min	2.1	2.5	1.5	1.5
Max	5.8	5.5	4.6	5.8
Mean	**4.1**	**3.9**	**3.5**	**4.0**
Median	4.2	3.9	3.6	4.2
Sd.	0.7	0.8	0.7	0.7

Table 141 displays the efficiencies of clothes washers as measured by the Integrated Modified Energy Factor (IMEF).[97] A higher IMEF indicates a more efficient appliance. Clothes washers across the state were found with an average IMEF of 2.2, with little variation between home types.

[97] Some clothes washers surveyed reported their efficiencies in the Modified Energy Factor (MEF). In these cases, the SWE team converted their efficiencies to IMEF units using the formula prescribed by RESNET: IMEF = 0.503 +0.95*MEF.

Table 141: Clothes Washer Efficiency (IMEF)

(Base: In-home clothes washers)

IMEF	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*150*	*19*	*34*	*203*
Min	0.7	1.2	1.3	0.7
Max	3.8	3.3	3.5	3.8
Mean	**2.2**	**2.1**	**2.1**	**2.2**
Median	2.1	1.7	1.8	2.1
Sd.	0.7	0.6	0.7	0.7
Self-Audit Results Only				
n-value	*78*	*7*	*9*	*94*
Min	0.9	1.3	1.3	0.9
Max	3.4	2.8	2.9	3.4
Mean	**2.3**	**2.0**	**2.2**	**2.2**
Median	2.4	1.7	2.1	2.4
Sd.	0.7	0.6	0.7	0.7
Total On-site and Self-Audit				
n-value	*228*	*26*	*43*	*297*
Min	0.7	1.2	1.3	0.7
Max	3.8	3.3	3.5	3.8
Mean	**2.2**	**2.1**	**2.2**	**2.2**
Median	2.1	1.7	1.8	2.1
Sd.	0.7	0.6	0.7	0.7

Table 142 describes the ENERGY STAR status of surveyed in-home clothes washers. On average, roughly 56% of surveyed in-home clothes washers were verified as ENERGY STAR qualified. Of the homes surveyed, detached single-family units were the most likely to have an ENERGY STAR qualified clothes washer in-home, and multifamily units were the least likely.

Table 142: Clothes Washer ENERGY STAR Status

(Base: In-home clothes washers)

ENERGY STAR	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*175*	*24*	*26*	*225*
Yes	53%	42%	35%	52%
No	47%	58%	65%	48%
Self-Audit Results Only				
n-value	*76*	*13*	*10*	*99*
Yes	67%	46%	50%	63%
No	33%	54%	50%	37%
Total On-site and Self-Audit				
n-value	*251*	*37*	*36*	*324*
Yes	57%	43%	39%	56%
No	43%	57%	61%	44%

9.6 Shared Clothes Washers

For clothes washers in shared spaces of multifamily buildings, the majority (81%) of units were made after 2011. Unfortunately, the sample sizes are too small to draw any conclusions based on the occupancy of these multifamily buildings.

Table 143: Shared Clothes Washer Vintages by Building Size

(Base: Shared clothes washers, site visits)

Vintage	2-4 units	5-19 units	20-49 units	50+ units	Statewide
n-value	*3*	*1*	*0*	*5*	*9*
2019 to 2023	0%	100%	--	20%	28%
2016 to 2018	33%	--	--	20%	16%
2011 to 2015	67%	--	--	20%	37%
2006 to 2010	--	--	--	20%	9%
2001 to 2005	--	--	--	20%	9%

The IMEF is an energy performance metric for residential clothes washers used by ENERGY STAR as of March 7, 2015.[98] The higher the IMEF, the more energy efficient the clothes washer is. Prior to the IMEF transition, the Modified Energy Factor (MEF) performance metric was used for clothes washers. Note that clothes washers found in common areas included both residential and commercial models. The ENERGY STAR requirements for commercial models use the MEF

[98] Current ENERGY STAR minimum requirements for clothes washer IMEF are as follows: residential top-load (2.06), residential front-load (2.76), and commercial front-load (2.20 MEF).

performance metric as of February 5, 2018.[99] The statewide average IMEF for shared washing machines was 1.9 (Table 144).

Table 144: Shared Clothes Washer Efficiency (IMEF) by Building Size

(Base: Shared clothes washers, site visits)

IMEF	2-4 units	5-19 units	20-49 units	50+ units	Statewide
n-value	*2*	*0*	*0*	*4*	*6*
Min	1.6	--	--	1.3	1.3
Max	2.8	--	--	2.2	2.8
Mean	**2.2**	**--**	**--**	**1.8**	**1.9**
Median	2.2	--	--	1.9	1.9
Std. Dev.	0.8	--	--	0.5	0.6

The statewide average annual rated energy consumption of shared clothes washers was 185 kWh/year.[100] Note due to small sample sizes, the ability to compare clothes washer consumption by building size is limited (Table 145).

Table 145: Shared Clothes Washer Rated Energy Consumption by Building Size (kWh/Year)

(Base: Shared clothes washers, site visits)

kWh/Year	2-4 units	5-19 units	20-49 units	50+ units	Statewide
n-value	*2*	*1*	*0*	*4*	*7*
Min	85.0	150.0	--	90.0	85.0
Max	208.0	150.0	--	488.0	488.0
Mean	**146.5**	**150.0**	**--**	**213.0**	**185.0**
Median	146.5	150.0	--	137.0	150.0
Std. Dev.	87.0	N/A	--	188.6	142.4

Table 146 displays the ENERGY STAR status for shared clothes washers. Statewide, forty-four percent of clothes washers in common areas were ENERGY STAR qualified.

[99] A conversion factor was applied to clothes washers rated in MEF to determine an equivalent IMEF. IMEF = (MEF-.503)/.95.

[100] Information regarding the rated energy consumption (in kWh/year) was not available for 44 clothes washers.

Table 146: Shared Clothes Washer ENERGY STAR Status by Building Size

(Base: Shared clothes washers, site visits)

ENERGY STAR	2-4 units	5-19 units	20-49 units	50+ units	Statewide
n-value	*3*	*1*	*0*	*5*	*9*
Yes	67%	0%	--	40%	44%
No	33%	100%	--	60%	56%

9.7 In-home Clothes Dryers

This section describes the SWE team's key findings for in-home clothes dryers. Table 147 describes the statewide clothes dryer penetration by home type. Of the 286 sites surveyed by the SWE team, 89% contained at least one in-home clothes dryer. Attached single-family homes are most likely to have a clothes dryer (98%), while multifamily homes are least likely to have an in-home clothes dryer (46%). This is likely to be a result of home size, as well as the presence of shared units in the common areas in some multifamily buildings.

Table 147: In-home Clothes Dryer Penetration

Count	Detached Single-family	Attached Single-family	Multifamily	Statewide
n-value	*28*	*189*	*69*	*286*
0	11%	2%	54%	11%
1+	89%	98%	46%	89%

Table 148 describes clothes dryer vintages by home type. The average clothes dryer age was 11 years and over half (62%) of those clothes dryers were newer than 2011.

Table 148: Clothes Dryer Vintages by Home Type

(Base: In-home clothes dryers)

Categories	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*184*	*24*	*23*	*231*
2019 to 2023	24%	21%	17%	22%
2016 to 2018	21%	12%	9%	18%
2011 to 2015	17%	38%	35%	21%
2006 to 2010	21%	17%	13%	22%
2001 to 2005	9%	4%	13%	9%
1991 to 2000	4%	8%	13%	7%
1981 to 1990	2%	--	--	1%
1980 or earlier	2%	--	--	1%
Self-Audit Results Only				
n-value	*72*	*11*	*8*	*91*
2019 to 2023	17%	45%	38%	20%
2016 to 2018	25%	--	38%	24%
2011 to 2015	25%	18%	25%	29%
2006 to 2010	21%	27%	--	16%
2001 to 2005	4%	--	--	8%
1991 to 2000	7%	9%	--	4%
1981 to 1990	1%	--	--	<1%
1980 or earlier	--	--	--	--
Total On-site and Self-Audit				
n-value	*256*	*35*	*31*	*322*
2019 to 2023	22%	29%	23%	21%
2016 to 2018	22%	9%	16%	19%
2011 to 2015	19%	31%	32%	22%
2006 to 2010	21%	20%	10%	21%
2001 to 2005	7%	3%	10%	9%
1991 to 2000	5%	9%	10%	7%
1981 to 1990	2%	--	--	<1%
1980 or earlier	1%	--	--	<1%

* Totals may not equal sum of column or row due to rounding.

Table 149 displays clothes dryers by fuel type. Over four fifths (82%) were electric, while the other fifth (17%) were natural gas. Very few of the clothes dryers (1%) at audited homes utilized propane as their fuel source. Electric clothes dryers were most common in attached single-family homes (94%).

Table 149: Clothes Dryer Fuel Types

(Base: In-home clothes dryers)

Clothes Dryer Fuel	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*187*	*25*	*23*	*235*
Electric	76%	96%	91%	82%
Natural Gas	22%	4%	9%	16%
Propane	2%	--	--	2%
Self-Audit Results Only				
n-value	*76*	*11*	*8*	*95*
Electric	78%	91%	75%	79%
Natural Gas	22%	9%	25%	21%
Total On-site and Self-Audit				
n-value	*263*	*36*	*31*	*330*
Electric	76%	94%	87%	82%
Natural Gas	22%	6%	13%	17%
Propane	2%	--	--	1%

Some clothes dryers possess moisture sensing technology, which enables them to prematurely end the drying cycle if it senses its load has reached the desired level of dryness, reducing the system's overall run-time and energy consumption. Table 150 describes the moisture sensing capabilities of surveyed clothes dryers. Overall, roughly 93% of all clothes dryers statewide utilize moisture sensing technology. Attached single-family homes were slightly less likely to contain clothes dryers with moisture sensing capabilities.

Table 150: Clothes Dryer Moisture Sensing Feature

(Base: In-home clothes dryers)

Moisture Sensing	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*179*	*23*	*21*	*223*
Yes	93%	87%	95%	91%
No	7%	13%	5%	9%
Self-Audit Results Only				
n-value	*68*	*11*	*7*	*86*
Yes	99%	91%	100%	99%
No	1%	9%	--	1%
Total On-site and Self-Audit				
n-value	*247*	*34*	*28*	*309*
Yes	95%	88%	96%	93%
No	5%	12%	4%	7%

Table 151 provides a summary of the Combined Energy Factor (CEF) of all surveyed clothes dryers by home type. CEF is a measure of the energy efficiency that reflects the energy use of the clothes dryer, and higher CEF values represent a more efficient unit. The average CEF for clothes dryers across the state is 3.3, and there is not a significant difference between home types. (For dryers with a provided EF value instead of a CEF value, a RESNET conversation factor of 1.15 was used.)

Table 151: Clothes Dryer Efficiency (CEF) by Home Type

(Base: In-home clothes dryers)

Categories	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*144*	*19*	*15*	*178*
Min	2.3	2.4	2.4	2.3
Max	3.9	3.9	3.9	3.9
Mean	**3.3**	**3.5**	**3.3**	**3.3**
Median	3.5	3.7	3.7	3.5
Sd.	0.5	0.5	0.6	0.5
Self-Audit Results Only				
n-value	*66*	*7*	*7*	*80*
Min	2.3	2.6	2.7	2.3
Max	3.9	3.9	3.9	3.9
Mean	**3.4**	**3.4**	**3.4**	**3.5**
Median	3.7	3.7	3.7	3.7
Sd.	0.5	0.6	0.5	0.5
Total On-site and Self-Audit				
n-value	*210*	*26*	*22*	*258*
Min	2.3	2.4	2.4	2.3
Max	3.9	3.9	3.9	3.9
Mean	**3.3**	**3.5**	**3.3**	**3.4**
Median	3.5	3.7	3.7	3.7
Sd.	0.5	0.6	0.5	0.5

Table 152 shows that 32% of all in-home dryers surveyed are designated as ENERGY STAR clothes dryers.[101] Multifamily homes are less likely (21%) to have an in-home ENERGY STAR dryer, compared to detached single family (29%) and attached single-family (34%) homes.

[101] None of the clothes dryers were heat pump clothes dryers.

Table 152: Clothes Dryer ENERGY STAR Status by Home Type
(Base: In-home clothes dryers)

ENERGY STAR	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*178*	*24*	*22*	*224*
Yes	25%	29%	14%	27%
No	75%	71%	86%	73%
Self-Audit Results Only				
n-value	*70*	*11*	*7*	*88*
Yes	40%	45%	43%	49%
No	60%	55%	57%	51%
Total On-site and Self-Audit				
n-value	*248*	*35*	*29*	*312*
Yes	29%	34%	21%	32%
No	71%	66%	79%	68%

9.8 Shared Clothes Dryers

Fifteen of the sampled multifamily buildings had shared clothes dryers located in a common space. Every shared clothes dryer observed in this survey used electric heat. Most shared clothes dryers were manufactured since 2011 (78%). No shared clothes dryers with available data met ENERGY STAR qualifications.

Moisture sensors were installed in 100% of shared clothes dryers (Table 153) with available data. Moisture sensors help reduce energy consumption of clothes dryers by ceasing operation when clothes are dry, rather than using a timer to cease operation.

Table 153: Moisture Sensors in Shared Clothes Dryers by Building Size
(Base: Shared dryers)

Sensor	2-4 units	5-19 units	20-49 units	50+ units	Statewide
n-value	*6*	*3*	*5*	*5*	*19*
Yes	100%	100%	--	100%	88%
No	--	--	--	--	0%
Unknown	--	--	100%	--	12%

9.9 Dehumidifiers

This section describes dehumidifiers found during audits. Table 154 shows dehumidifier penetration by home types. The SWE team observed 84 dehumidifiers during audits. In total, 32% out of 286 sites visited had at least one dehumidifier. Detached single-family homes were the most likely (38%) to contain a dehumidifier, and multifamily homes were the least likely (3%) to contain a dehumidifier. The prevalence of dehumidifiers is most likely correlated with the increased presence of basements in single-family homes, which tend to be cool and damp.

Table 154: Dehumidifier Penetration by Home Type

(Base: Homes, Site Visits only)

Quantity	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
n-value	*189*	*28*	*69*	*286*
0	62%	79%	97%	68%
1	35%	18%	3%	30%
2	2%	4%	--	2%
3+	1%	--	--	<1%

* Totals may not equal sum of column or row due to rounding.

Table 155 displays dehumidifier vintages by home type. Statewide, the average dehumidifier age was seven years and the vast majority (91%) of dehumidifiers have been manufactured since 2011.

Table 155: Dehumidifier Vintages by Home Type

(Base: Dehumidifiers)

Vintages	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*73*	*6*	*1*	*80*
2019 to 2023	47%	17%	100%	41%
2016 to 2018	26%	17%	--	32%
2011 to 2015	21%	17%	--	18%
2006 to 2010	5%	--	--	3%
2001 to 2005	--	33%	--	3%
1991 to 2000	1%	--	--	1%
1981 to 1990	--	--	--	1%
1980 or earlier	--	17%	--	2%
Self-Audit Results Only				
n-value	*28*	*2*	*0*	*30*
2019 to 2023	43%	50%	–	50%
2016 to 2018	18%	50%	–	22%
2011 to 2015	14%	--	–	10%
2006 to 2010	18%	--	–	17%
2001 to 2005	--	--	–	--
1991 to 2000	--	--	–	--
1981 to 1990	4%	--	–	1%
1980 or earlier	4%	--	–	1%
Total On-site and Self-Audit				
n-value	*101*	*8*	*1*	*110*
2019 to 2023	46%	25%	100%	40%
2016 to 2018	24%	25%	--	33%
2011 to 2015	19%	12%	--	16%
2006 to 2010	9%	--	--	6%
2001 to 2005	--	25%	--	2%
1991 to 2000	1%	--	--	1%
1981 to 1990	1%	--	--	1%
1980 or earlier	1%	12%	--	1%

* Totals may not equal sum of column or row due to rounding.

Table 156 displays dehumidifier capacity in pints per day. Statewide, the average dehumidifier capacity was 50 pints/day. Small sample sizes prohibit comparisons between home types.

Table 156: Dehumidifier Capacity by Home Type (pints/day)

(Base: Dehumidifiers)

Pints/day	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*75*	*7*	*0*	*82*
Min	9.0	35.0	--	9.0
Max	85.0	95.0	--	95.0
Mean	**51.0**	**59.3**	--	**52.3**
Median	50.0	50.0	--	50.0
Sd.	16.9	21.9	--	17.4
Self-Audit Results Only				
n-value	*31*	*0*	*0*	*31*
Min	20.0	--	--	20.0
Max	136.0	--	--	136.0
Mean	**45.7**	--	--	**46.6**
Median	45.0	--	--	45.0
Sd.	22.0	--	--	22.0
Total On-site and Self-Audit				
n-value	*106*	*9*	*0*	*115*
Min	9.0	22.0	--	9.0
Max	136.0	95.0	--	136.0
Mean	**49.5**	**54.1**	--	**51.2**
Median	50.0	50.0	--	50.0
Sd.	18.6	22.7	--	18.9

Table 157 describes dehumidifier ENERGY STAR qualification status by home type. Statewide, nearly 87% of all models surveyed were ENERGY STAR qualified. The small sample size makes it difficult to make direct comparisons between home types.

Table 157: Dehumidifier ENERGY STAR Status by Home Type

(Base: Dehumidifiers)

ENERGY STAR	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*75*	*6*	*2*	*83*
Yes	89%	100%	100%	90%
No	11%	--	--	10%
Self-Audit Results Only				
n-value	*31*	*2*	*0*	*33*
Yes	81%	100%	--	70%
No	19%	--	--	30%
Total On-site and Self-Audit				
n-value	*106*	*8*	*2*	*116*
Yes	87%	100%	100%	87%
No	13%	--	--	13%

Table 158 and Table 159 summarize the Energy Factor (EF) and Integrated Energy Factor (IEF) ratings of dehumidifiers surveyed. Both terms represent the efficiency of a dehumidifier, expressed in liters of per kilowatt-hour, where a higher number represents higher efficiency. IEF is a newer metric, intended to replace EF, as it includes dehumidifier energy use when the unit has cycled off. The statewide average IEF is 1.8, and the statewide average EF is 1.9. The small sample size makes it difficult to make direct comparisons between home types.

Table 158: Dehumidifier Efficiency (IEF) by Home Type

IEF	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*30*	*0*	*0*	*30*
Min	1.3	--	--	1.3
Max	2.0	--	--	2.0
Mean	**1.8**	--	--	**1.7**
Median	1.8	--	--	1.8
Sd.	0.2	--	--	0.2
Self-Audit Results Only				
n-value	*12*	*0*	*0*	*12*
Min	1.6	--	--	1.6
Max	1.9	--	--	1.9
Mean	**1.8**	--	--	**1.8**
Median	1.8	--	--	1.8
Sd.	0.1	--	--	0.1
Total On-site and Self-Audit				
n-value	*42*	*0*	*0*	*42*
Min	1.3	--	--	1.3
Max	2.0	--	--	2.0
Mean	**1.8**	--	--	**1.8**
Median	1.8	--	--	1.8
Sd.	0.2	--	--	0.2

Table 159: Dehumidifier Efficiency (EF) by Home Type

EF	Detached Single-Family	Attached Single-Family	Multifamily	Statewide
On-Site Results Only				
n-value	*43*	*4*	*0*	*47*
Min	1.2	1.6	--	1.2
Max	2.4	2.9	--	2.9
Mean	**1.9**	**2.0**	--	**1.9**
Median	2.0	1.7	--	2.0
Sd.	0.2	0.6	--	0.3
Self-Audit Results Only				
n-value	*14*	*0*	*0*	*14*
Min	1.4	--	--	1.4
Max	2.0	--	--	2.0
Mean	**1.7**	--	--	**1.7**
Median	1.8	--	--	1.8
Sd.	0.3	--	--	0.3
Total On-site and Self-Audit				
n-value	*57*	*4*	*0*	*61*
Min	1.2	1.6	--	1.2
Max	2.4	2.9	--	2.9
Mean	**1.8**	**2.0**	--	**1.8**
Median	2.0	1.8	--	2.0
Sd.	0.2	0.5	--	0.3

Section 10 Lighting

This section details findings from data collected on lighting technology at homes in the on-site sample. The SWE team analyzed lighting data to determine levels of penetration (the percentage of homes with at least one observation of a specific lighting technology) and saturation (the percentage of total sockets filled by each technology type).

Key findings:

- LED bulbs were found in virtually all (99%) homes in the statewide sample. Incandescent bulbs were found in three-quarters (75%) of homes, and CFLs, in just over one-half (54%) of homes.
- LED saturation now far surpasses any other technologies' saturation–over double the saturation rate of the next-highest type, and over 50% of sockets in all but one EDC. LEDs are displacing both efficient (CFL) and inefficient bulb types (incandescent).
- Combined, efficient bulb types filled just over two-thirds of sockets in the sample (70%), while incandescent (25%) and halogen (4%) bulbs filled most of the remainder.
- LED saturation rates have balanced out across EDCs. PPL, which converted to an exclusively-LED lighting program earlier than other EDCs, no longer has the highest LED saturation rate at 59%. It ranks third behind Met-Ed (71%, significantly higher) and Penelec (62%).
- LED saturation rates for in-home multifamily lighting (69%) were significantly higher than both detached and attached single-family rates (61% and 57%, respectively).

10.1 Lighting Data Collection

Auditors collected data on all light fixtures, including the location, fixture type (hard-wired or plug-in), number of sockets, and lamp types. CFLs, LEDs (including integrated LED fixtures), and fluorescent tubes are considered energy-efficient lamp types. Inefficient types include incandescent, halogen, and other uncommon types, such as xenon. The tables below include bulbs from all sockets observed in each home (or housing unit in the case of multifamily sites), including interior, exterior, hard-wired, and plug load. The main tables in this section exclude common area lighting data collected from multifamily sites; data for those bulbs can be found in Section 10.4.

10.2 Lighting Penetration

Nearly all homes statewide (99%) had at least one LED, the highest penetration rate of lighting technologies in the state (Table 160). Incandescent bulbs had the second-highest penetration rate at 75%. CFLs and other fluorescent bulbs were present in roughly half of homes (54% and 49%, respectively). Duquesne Light had the highest level of incandescent penetration at 93%, with the next-highest being Penelec at 83%. Penn Power had the highest level of CFL penetration at 94%, with the next-highest being Duquesne Light at 68%.

Table 160: Bulb Type Penetration by EDC

Type	PECO	PPL	Duquesne Light	Met-Ed	Penelec	Penn Power	West Penn Power	Statewide
n	*44*	*40*	*44*	*43*	*41*	*32*	*41*	*285*
LED	98%	98%	100%	100%	100%	100%	98%	99%
Incandescent	66%	72%	93%	49%	83%	81%	68%	75%
CFL	41%	48%	68%	53%	63%	94%	51%	54%
Fluorescent	36%	55%	59%	33%	49%	81%	59%	49%
Halogen	20%	28%	36%	28%	27%	25%	20%	28%
Empty Socket	5%	2%	36%	2%	10%	31%	17%	10%

Detached single-family homes had the highest level of LED bulb penetration in the sample at 100%, while attached single-family and multifamily sites had rates of 96% and 97%, respectively (Table 161). Multifamily units had the lowest level of incandescent (52%) and CFL (35%) penetration. Both single-family home types had incandescent and CFL penetration rates above 60%.

Table 161: Bulb Type Penetration by Home Type

Type	Detached single-family	Attached single-family	Multifamily	Statewide
n	*188*	*28*	*69*	*285*
LED	100%	96%	97%	99%
Incandescent	82%	61%	52%	75%
CFL	67%	61%	35%	54%
Fluorescent	60%	29%	41%	49%
Halogen	32%	25%	12%	28%
Empty Socket	19%	7%	6%	10%

10.3 Lighting Saturation

Bulb type saturation provides a better picture of the relative prevalence of efficient lighting than penetration, as it considers every socket in the sample. LED bulbs filled 59% of all sockets observed in the statewide sample (Figure 29), up from 20% observed in the previous baseline study and now surpassing all other bulb types in terms of socket saturation. Incandescent bulbs had the next-highest saturation rate in the statewide sample at 25%, followed by CFLs and other fluorescent bulbs, each at 6%. Efficient bulbs combined (LED, CFL, and fluorescent) fill up over two-thirds (70%) of all sockets statewide.[102] Halogen bulbs fill just 4% of all sockets, and no more than 5% for any specific EDC.

The saturation of LEDs (59%) was greater than that of other northeastern states with similar programs such as Maryland, Vermont, and New Hampshire. A 2022 Maryland study[103] found LED saturation of 55% in single-family homes; 45% in multifamily homes. Two 2020 studies in Vermont[104] and New Hampshire[105] found LED saturation of 55% and 51% in single-family homes, respectively.

Met-Ed stands out from other EDCs with the highest LED saturation rate (71%), well above the next-highest saturation of 62% (Penelec). The Met-Ed LED saturation rate is significantly higher than all other EDCs. At the other end of the spectrum, Duquesne Light has the lowest LED saturation rate (48%), significantly lower than all other EDCs. It also has the highest incandescent saturation rate, tied with two other EDCs (PECO and West Penn Power).

---

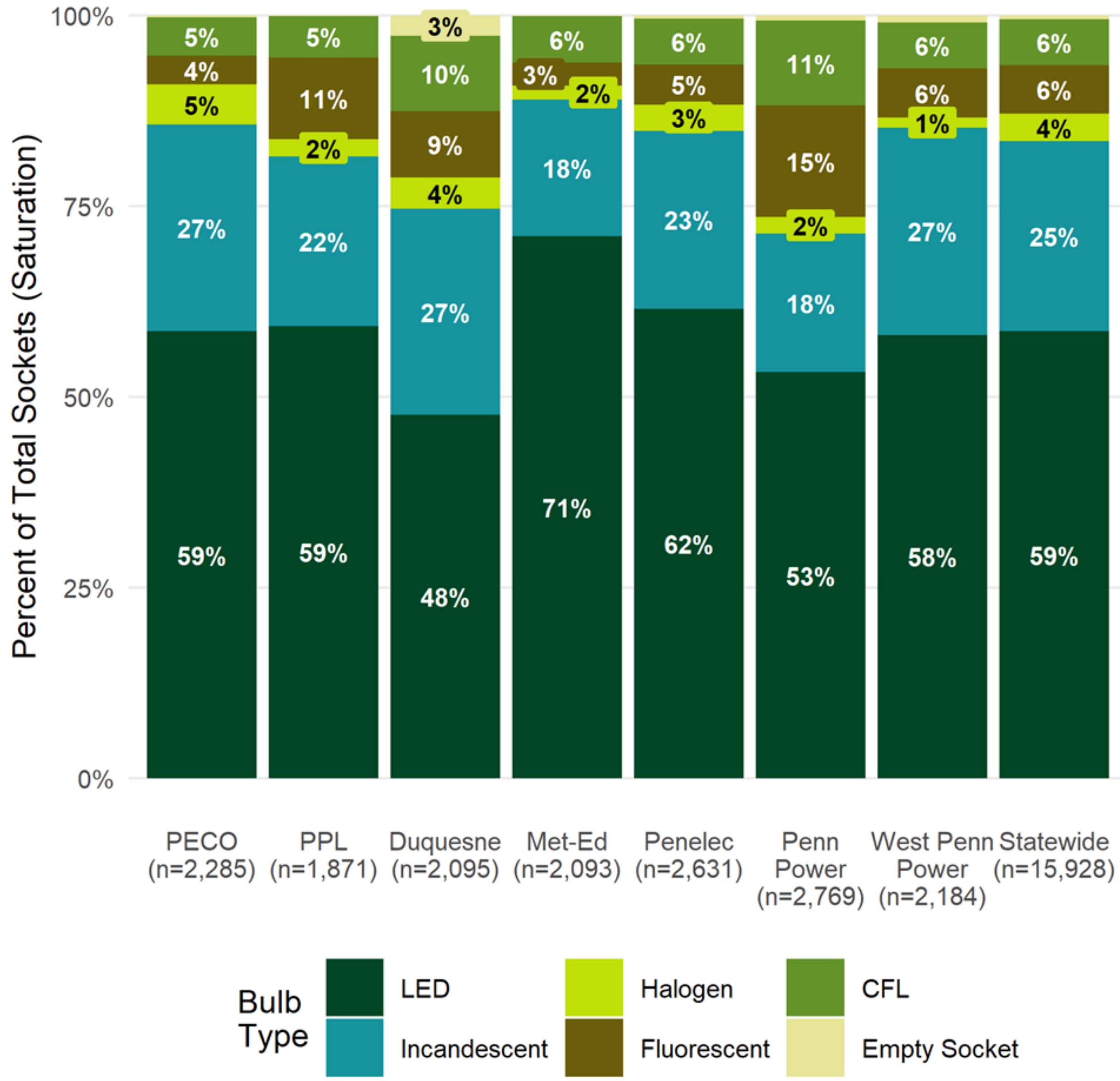
[102] Fluorescent tube lighting is considered an efficient bulb type for comparability with previous studies; however, LED tube replacements supersede the efficiency of standard fluorescent tube lighting.

[103] EmPOWER Maryland Residential Baseline Study. December 31, 2022. Submitted to EmPOWER Maryland by Applied Energy Group and Verdant Associates. https://verdantassoc.com/deep-dives/empower-maryland-residential-baseline-study/

[104] 2020 Vermont Single-Family Residential New Construction Baseline and Code Compliance Study. January 24, 2023. Submitted to the Vermont Department of Public Service by NMR Group, Inc. https://publicservice.vermont.gov/sites/dps/files/documents/VT_2020_SF_RNC_Baseline_Final_Report_Jan242023.pdf

[105] New Hampshire Residential Baseline Study. June 11, 2020. Submitted to the New Hampshire Evaluation, Measurement and Verification Working Group by Dunsky Energy Consulting. https://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/20200826-Electric-MER-NHSaves-Res-Baseline-Report-Final.pdf

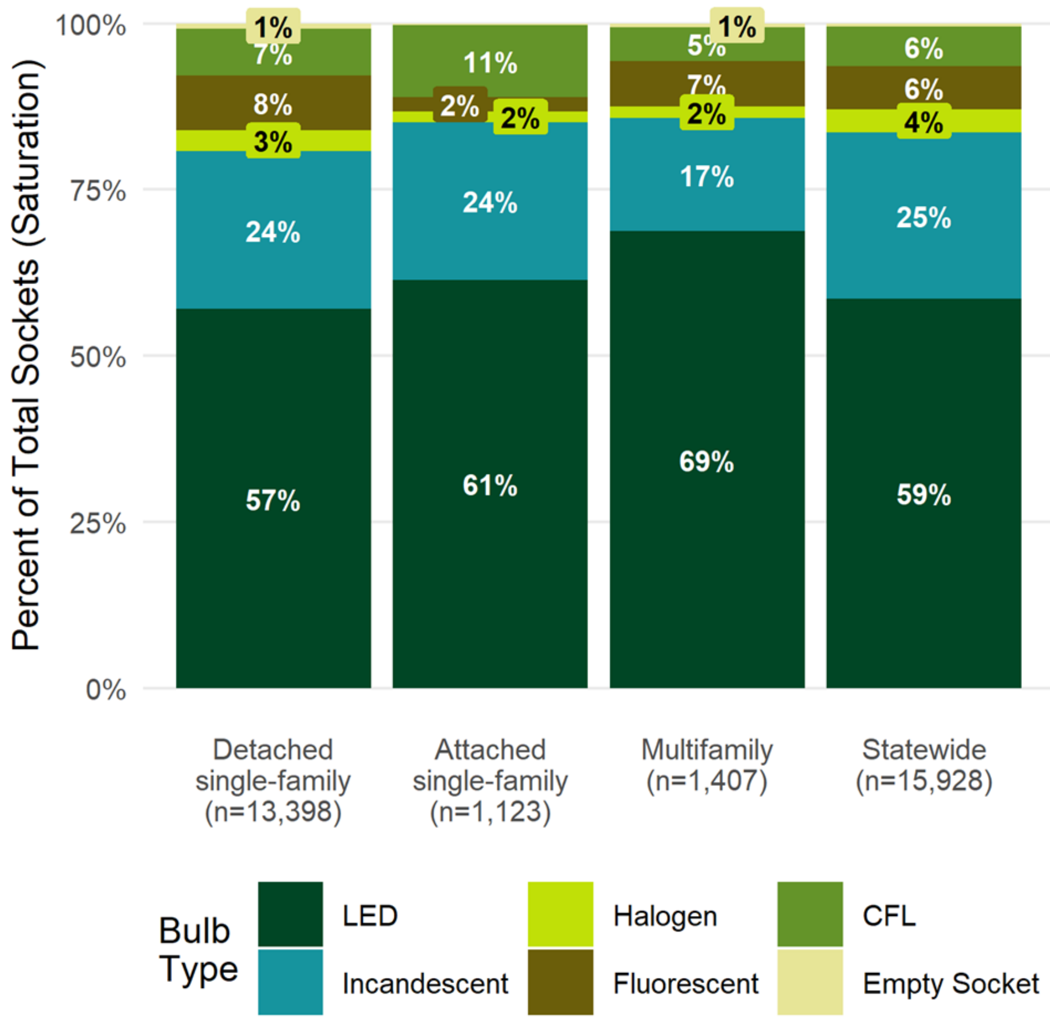
Figure 29: Bulb Type Saturation by EDC



Labels omitted for categories accounting for <1% of percent of total sockets.

LEDs occupied over two-thirds (69%) of multifamily home sockets, significantly higher than detached (57%) and attached single-family homes (61%). LED saturation in detached single-family homes was also significantly lower than in attached single-family homes. Incandescent saturation in multifamily home sockets (17%) was significantly lower than in detached and attached single-family homes' (24% each). Fluorescent saturation in attached single-family home sockets (2%) was significantly lower than detached single-family and multifamily homes. At the same time, CFL saturation was significantly higher in attached single-family home sockets (11%) than in detached single-family and multifamily homes (Figure 30). Halogen saturation was low overall, but significantly higher in detached single-family homes (3%) than attached single-family and multifamily homes' (2% each).

Figure 30: Bulb Type Saturation by Home Type



Labels omitted for categories accounting for <1% of percent of total sockets.

10.3.1 Average Bulb Type Saturation Per Home

Table 162 shows the average saturation of each bulb type on a per home basis (i.e., the percent of sockets that have a given bulb type in an average home). Overall, 62% of sockets in the average home had efficient bulbs (i.e., LED, CFL, or fluorescent). On average, 44% of sockets in a home had LED bulbs, double the figure from the previous baseline study. By comparison, 8% had CFL bulbs, down from 23% in the previous baseline study. Incandescent bulbs were installed in 25% of sockets per home, down from 38% in the previous baseline study.

Table 162: Average Bulb Type Saturation Per Home

Type	Detached single-family	Attached single-family	Multifamily	Statewide
n	*188*	*28*	*69*	*285*
LED	46%	46%	44%	44%
Incandescent	23%	28%	20%	25%
Fluorescent	11%	6%	11%	10%
Halogen	8%	5%	10%	9%
CFL	9%	13%	9%	8%
Empty Socket	3%	3%	6%	3%

10.4 Common Area Lighting Penetration

Statewide, LED bulbs were found in 72% of multifamily common areas, up from 41% in the previous baseline study, though the sample size was much smaller in this baseline study.[106] Fluorescent bulbs were the most common lighting technology observed in common areas statewide (77%). Fluorescent bulb penetration rates (Table 163) were much higher in common areas than in single-family and multifamily in-home residences (Table 161), while LED, CFL, and incandescent rates were much lower.

Table 163: Shared Space Lighting Penetration, Statewide

Type	Statewide
n	*9*
Fluorescent	77%
LED	72%
CFL	16%
Incandescent	16%
Halogen	5%

10.5 Common Area Lighting Saturation

Fluorescent bulbs filled the most common area lighting sockets statewide (57%; see Table 164). CFL bulbs were the second most common lighting technology, filling 18% of sockets, followed closely by LED (15% of sockets) and incandescent bulbs (10% of sockets).

[106] As described in Section 3 of the report, data collection in multifamily common areas was de-emphasized in the 2023 baseline study and limited to a sub-sample of multifamily visits. This was primarily due to a fundamental change in the initial multifamily recruitment practices which focused on tenant-level recruitment strategies.

Table 164: Shared Space Lighting Saturation, Statewide

Type	Statewide
n	*1,371*
Fluorescent	57%
CFL	18%
LED	15%
Incandescent	10%
Halogen	1%

Section 11 Electronics

This section presents findings on electronics recorded during on-site visits. Electronics data collection was primarily focused on televisions, computers, and advanced power strips. Time permitting, auditors also collected information on peripheral electronic equipment such as set-top boxes, video players, and printers. Auditors recorded information on the type of television and computer, as well as visually confirmed ENERGY STAR status for all eligible equipment. Auditors asked occupants about laptops and other portable electronics that might not have been present or visible during audits. However, data collection of electronics was considered a lower-priority data collection effort (compared to building shell, mechanical equipment, appliances, diagnostic testing, and lighting). In some cases, electronics data remained uncollected as auditors needed to minimize the burden (both time and privacy) upon participants and to prioritize data collection of higher energy consuming measures in the time allotted. In addition, auditors were shown vacant units on multiple occasions when performing multifamily audits, in which case electronics were not present, reducing the sample sizes even further.

Key Findings:

- The statewide average number of televisions per home is 3.4.
- Statewide, seventeen percent of televisions are ENERGY STAR qualified.
- Seven percent of computers are ENERGY STAR qualified.

Ninety-four percent of all homes measured contained at least one television that was actively plugged in. It was common for homes to have either one (28%) or two (28%) TVs in the home, but nearly as common were homes with four or more televisions (25%). The statewide average was 3.4 televisions per home. The most common television size is 40-49 inches diagonally (28%), with the majority (72%) of televisions within 30-59 inches. When looking at just flat screen (LED, LCD, and plasma) televisions, screen sizes skew smaller, with the most common size at 30-39 inches (35%).

Sixty-three percent of all homes visited contained at least one computer. Laptops were the most common computer type, representing nearly two-thirds of observed computers (63%), followed by desktops (36%). Laptops were slightly more common in single family homes than in multifamily homes (64% vs 56%).

ENERGY STAR status can be difficult to confirm while on-site. Typically, auditors rely on visual confirmation of the ENERGY STAR symbol on the equipment, as it can be difficult to access equipment nameplates while in the home or verify status after the fact. Table 165 displays the electronics that were observed to be ENERGY STAR qualified.

Table 165: Statewide Electronics ENERGY STAR Status

Categories	Equipment Count	ENERGY STAR Qualified (%)
Television	*259*	17%
Computer	*104*	7%
Set-Top Box	*87*	0%
Monitor	*86*	14%
Sound System	*37*	11%
DVD/Blue-ray	*36*	6%
Multi-function Copier	*24*	71%
Printer	*23*	65%

**Percentages indicate only confirmed ENERGY STAR electronics*

Section 12 Willingness to Pay Survey

As part of the residential baseline study, the SWE team included willingness-to-pay questions in the web-based recruitment survey to maximize the number of responses to willingness to pay questions. The previous baseline study only asked on-site participants willingness-to-pay questions, which resulted in lower overall sample sizes than the web-based survey approach. In addition, the willingness-to-pay survey questions were updated to provide insight into customers' likelihood to purchase higher efficiency options based under several different payback period scenarios. While the findings from the survey are presented in this report, these findings will be used as inputs in the follow-up energy-efficiency market potential study.

Key findings:

- Heat pumps, central air conditioners, refrigerators, and water heaters had the highest purchase likelihoods for all three sets of payback periods.
- Web survey respondents were most likely to report they would purchase a higher efficiency HVAC option (i.e., heat pump or central air conditioner) when the utility covered the entire incremental cost of the measure. Longer-term paybacks without utility support had average likelihood to purchase scores of 6.4 and lower.
- Respondents indicated that they were willing to pay for higher-efficiency water heaters, but they were more inclined to do so when the utility covered a portion of the cost, and when the payback period was shorter.
- Refrigerators were the highest rated appliance measure in multiple scenarios.
- Dehumidifiers, a cheaper appliance option, consistently scored low on the likelihood of purchasing higher efficiency options for all three sets of questions and payback periods.
- Insulation was consistently ranked the lowest likelihood for respondents to purchase a higher efficiency option, regardless of payback period or utility incentives. The low scores may be attributed to the more invasive process of adding insulation to a home. This deviates from 2018's Willingness to Pay findings, as insulation was ranked among the highest measures respondents were willing to pay for.

12.1 Survey Details

Web survey respondents were asked a series of questions regarding their willingness to pay for higher efficiency equipment if the existing equipment were to break and/or needed to be replaced. If survey respondents indicated that they had a heat pump or central air conditioner in their home, they were asked about the HVAC measure, and one randomly selected non-HVAC measure (i.e., water heaters, insulation, washing machines, refrigerators, and dehumidifiers). Those who did not have a heat pump or central air conditioner were asked about two randomly selected non-HVAC measures. The willingness-to-pay questions consisted of a battery of three willingness-to-pay questions for each of the two measures that were displayed:

1. The likelihood to purchase a higher-efficiency option if the additional purchase cost of the higher efficiency option paid for itself through electric bill savings over a payback period of eight years, six years, four years, two years, one year, and if the utility covered the entire cost difference (Figure 31).
2. The likelihood to purchase a higher-efficiency option if their electric utility covered 50% of the additional purchase cost of the higher-efficiency option, and the payback period was reduced to four years, two years, one year, and six months (Figure 32)
3. The likelihood to purchase a higher-efficiency option if their electric utility covered 25% of the additional purchase cost of the higher efficiency option, and the payback period was reduced to six years, three years, one and a half years, and nine months (Figure 33).

The survey used a scale of 0-10, where 0 corresponds with “not at all likely” and 10 corresponds with “extremely likely” to rate each respondent’s likelihood to pay for higher efficiency equipment. See Appendix M for the willingness to pay survey questions. Respondents who reported they were extremely likely to purchase the higher efficiency equipment at the longest payback scenario were skipped to the next technology to reduce respondent burden, as it was assumed they would provide the same response to shorter payback scenarios. For the purposes of the analysis, for these respondents, all responses were coded as the same score of extremely likely (e.g., 10) to the remaining scenarios of the same technology.

Table 166 indicates the number of responses by measure.[107] Willingness to Pay results were also analyzed at the EDC level. The results displayed in the subsection below are statewide results. EDC-specific willingness-to-pay results can be found in Appendix J.

Table 166: Willingness to Pay Responses by Measure

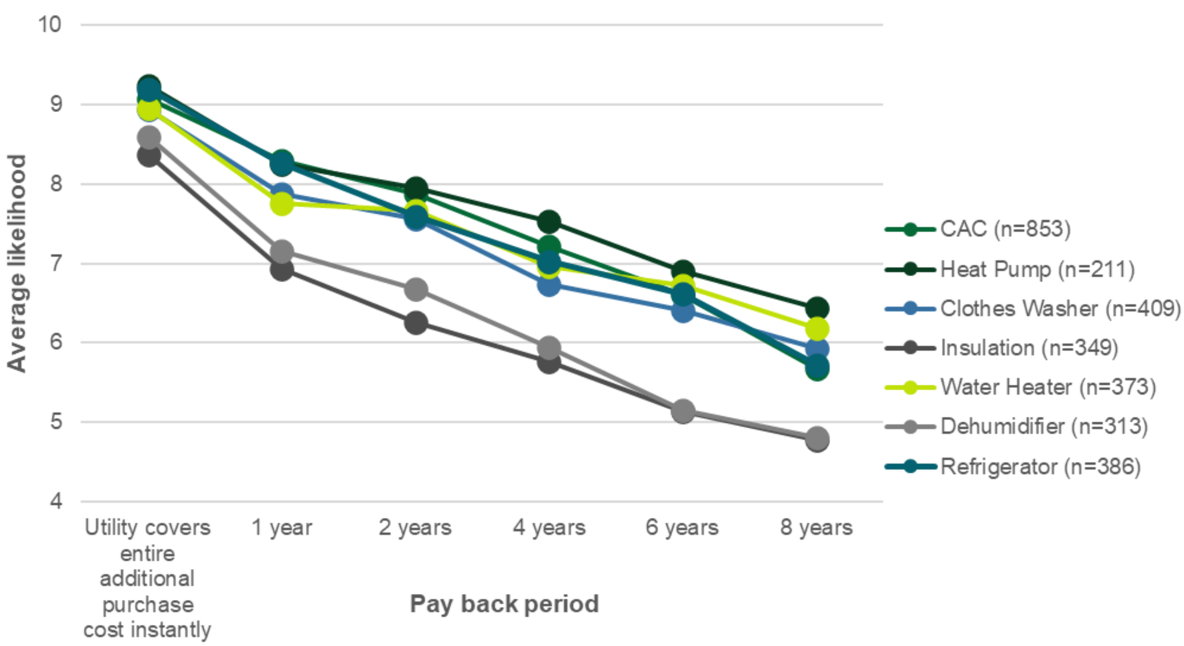
Equipment Type	Number of Responses (*n*=1541)	Percentage of Total Responses
CAC	853	55%
Heat Pump	211	14%
Clothes Washer	409	27%
Insulation	349	23%
Refrigerator	386	25%
Water Heater	373	24%
Dehumidifier	313	20%

[107] The number of respondents differs for each equipment type due to the random nature of questions regarding willingness to pay for each equipment type. Additionally, some respondents dropped out of the survey prior to finishing both question batteries in the willingness to pay section of the survey.

12.2 Willingness to Pay Results

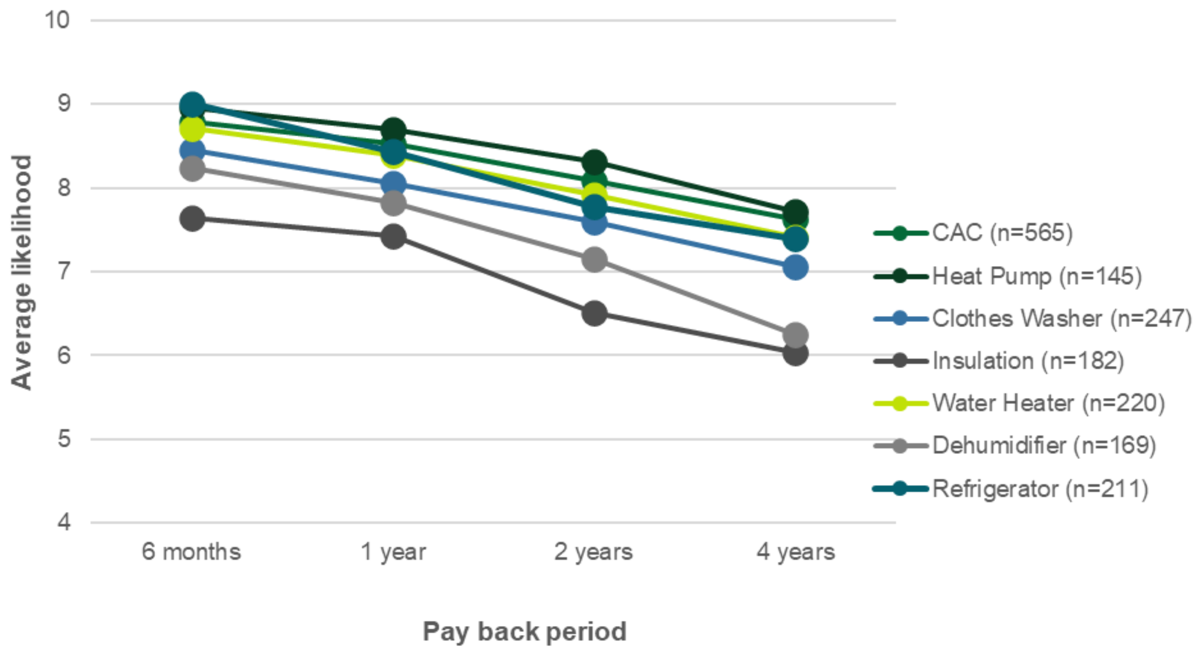
Figure 31 depicts the web survey respondents' average likelihood to purchase a higher efficiency measure if their utility covers the entire purchase cost. As expected, the lowest payback period (where the full purchase price is covered instantly) exhibited the highest average likelihood scores. The measure with the highest likelihood score for instant payback was a heat pump with an average score of 9.2. This was followed closely by refrigerators (9.2) and central air conditioners (9.1). Dehumidifiers and insulation represented the lowest average likelihood scores for the instant payback period, at 8.6 and 8.4, respectively. As the payback period increased, the average likelihood scores decreased. For the longest payback period of eight years, heat pumps maintained the highest average likelihood score amongst measures (6.4). Unlike the instant payback, water heaters and clothes washers had the next highest scores at 6.2 and 5.9. Insulation (4.8) and dehumidifiers (4.8) maintained the lowest scores among all measures for the eight-year payback period.

Figure 31: Likelihood to Purchase Higher Efficiency Measures by Payback Period and if their Utility Covers the Entire Purchase Cost of the Higher Efficiency Option



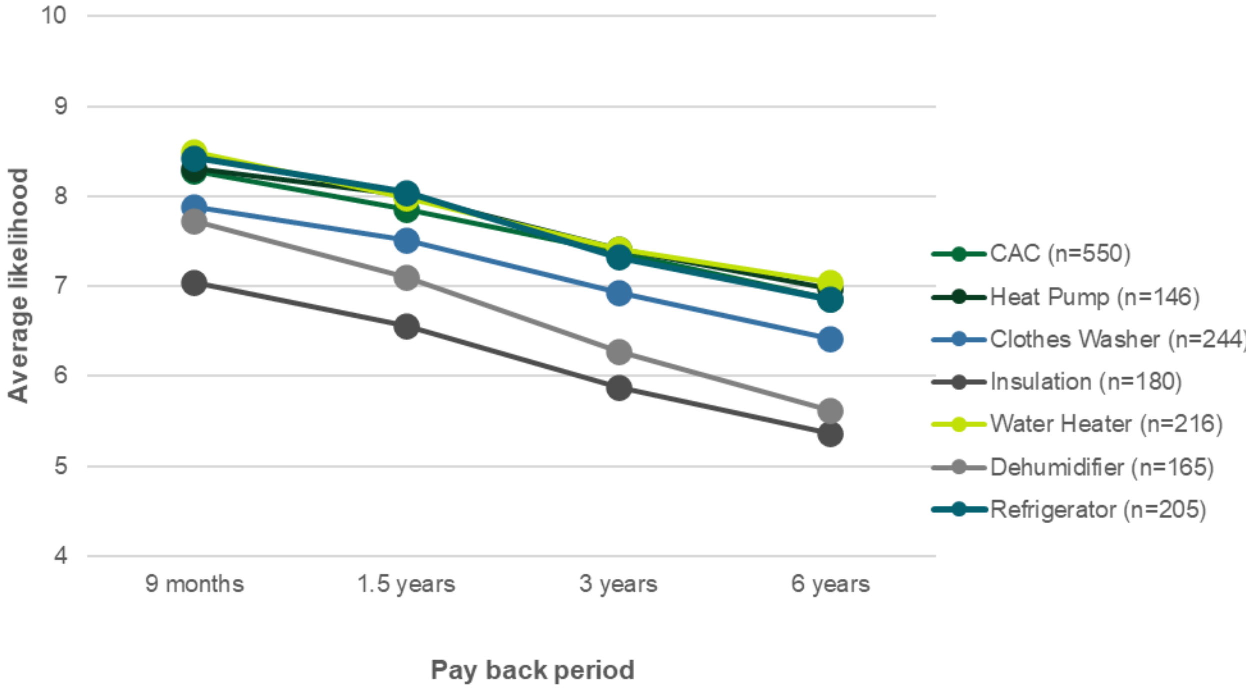
Respondents were asked a second set of questions regarding their likelihood to pay for a more expensive, higher-efficiency option but with a shorter payback period, and if their utility covers 50% of the purchase cost (Figure 32). For question two, the average likelihood scores appear to follow a more level trend compared to the first question's scores, but also decrease with each increase in payback period. For the shortest payback period of six months, refrigerators exhibited the highest average likelihood of 9.0, followed by heat pumps (9.0), and central air conditioners (8.8). Dehumidifiers (8.2) and insulation (7.7) again represented the lowest likelihood scores among equipment types for the shortest payback period. Heat pumps (7.7), central air conditioners (7.6), and water heaters (7.4) were the highest scoring measures for the four-year payback period. Water heaters replaced refrigerators with the highest non-HVAC measure score in the longest payback period. Additionally, dehumidifiers (6.3) and insulation (6.0) again represented the lowest scores. However, these scores were higher than the average likelihood scores for the longest payback period of eight years in question one, which saw likelihood scores of 4.8 and 4.8, respectively.

Figure 32: Likelihood to Purchase Higher Efficiency Measures by Payback Period if their Utility Covers 50% of the Purchase Cost



Respondents were asked a final set of questions regarding their likelihood to pay for a more expensive, higher-efficiency option but with shorter payback period, and if their utility covers only 25% of the purchase cost (Figure 33). Water heaters exhibited the highest likelihood score (8.5) for the lowest payback period of nine months, which is a departure from the first and second questions where HVAC measures received top scores. This was followed by refrigerators (8.4) and heat pumps (8.3). Again, dehumidifiers (7.7) and insulation (7.0) received the lowest average likelihood scores among all measures for the shortest payback period. The highest likelihood scores for the longest payback period were for water heaters (7.0), heat pumps (7.0), central air conditioners (6.9), and refrigerators (6.9). Dehumidifiers (5.6) and insulation (5.4), again, received the lowest average likelihood scores among all measures for the longest payback period of six years.

Figure 33: Likelihood to Purchase Higher Efficiency Measures by Payback Period if their Utility Covers 25% of the Purchase Cost



Appendix A Detailed Electricity Consumption Data

Table 167: Annual Electricity Consumption by EDC, Home Type, and Heating Fuel

EDC	Home Type	Heating Fuel	Consumption (MWh)	Customers	Per Customer (kWh)
PECO	Det. Single-family	Bottled, tank, or LP gas	1,448,570	150,743	9,610
PECO	Det. Single-family	Coal or coke	289,526	31,411	9,217
PECO	Det. Single-family	Electricity	3,114,031	238,961	13,032
PECO	Det. Single-family	Fuel oil, kerosene, etc.	2,342,109	249,344	9,393
PECO	Det. Single-family	No fuel used	44,303	4,024	11,009
PECO	Det. Single-family	Other fuel	126,970	12,751	9,958
PECO	Det. Single-family	Solar energy	10,966	1,482	7,401
PECO	Det. Single-family	Utility gas	2,455,732	281,463	8,725
PECO	Det. Single-family	Wood	725,907	71,414	10,165
PECO	Att. Single-family	Bottled, tank, or LP gas	104,264	10,722	9,724
PECO	Att. Single-family	Coal or coke	30,943	6,913	4,476
PECO	Att. Single-family	Electricity	636,152	58,806	10,818
PECO	Att. Single-family	Fuel oil, kerosene, etc.	296,548	37,236	7,964
PECO	Att. Single-family	No fuel used	4,728	300	15,784
PECO	Att. Single-family	Other fuel	18,570	1,374	13,515
PECO	Att. Single-family	Solar energy	-	-	-
PECO	Att. Single-family	Utility gas	790,566	100,015	7,904
PECO	Att. Single-family	Wood	24,544	2,093	11,729
PECO	Multifamily	Bottled, tank, or LP gas	50,252	5,082	9,887
PECO	Multifamily	Coal or coke	6,069	1,354	4,483
PECO	Multifamily	Electricity	774,346	106,329	7,283
PECO	Multifamily	Fuel oil, kerosene, etc.	83,665	13,480	6,206
PECO	Multifamily	No fuel used	12,988	1,835	7,079
PECO	Multifamily	Other fuel	6,236	920	6,781

PECO	Multifamily	Solar energy	1,155	599	1,928
PECO	Multifamily	Utility gas	300,662	51,175	5,875
PECO	Multifamily	Wood	3,503	908	3,857
PECO	Manuf./Mobile	Bottled, tank, or LP gas	183,279	24,123	7,598
PECO	Manuf./Mobile	Coal or coke	-	1,007	-
PECO	Manuf./Mobile	Electricity	100,765	10,896	9,248
PECO	Manuf./Mobile	Fuel oil, kerosene, etc.	212,523	26,520	8,014
PECO	Manuf./Mobile	No fuel used	10,112	213	47,567
PECO	Manuf./Mobile	Other fuel	19,927	2,151	9,266
PECO	Manuf./Mobile	Solar energy	-	-	-
PECO	Manuf./Mobile	Utility gas	63,290	7,540	8,393
PECO	Manuf./Mobile	Wood	6,544	737	8,884
PPL	Det. Single-family	Bottled, tank, or LP gas	721,326	57,730	12,495
PPL	Det. Single-family	Coal or coke	253,276	21,681	11,682
PPL	Det. Single-family	Electricity	3,478,844	191,183	18,196
PPL	Det. Single-family	Fuel oil, kerosene, etc.	2,299,287	211,256	10,884
PPL	Det. Single-family	No fuel used	36,471	2,331	15,644
PPL	Det. Single-family	Other fuel	111,388	7,526	14,800
PPL	Det. Single-family	Solar energy	17,911	1,229	14,572
PPL	Det. Single-family	Utility gas	2,561,750	249,002	10,288
PPL	Det. Single-family	Wood	506,272	39,728	12,743
PPL	Att. Single-family	Bottled, tank, or LP gas	41,741	3,892	10,724
PPL	Att. Single-family	Coal or coke	21,665	2,409	8,994
PPL	Att. Single-family	Electricity	776,175	54,513	14,238
PPL	Att. Single-family	Fuel oil, kerosene, etc.	352,092	36,510	9,644
PPL	Att. Single-family	No fuel used	5,030	518	9,719
PPL	Att. Single-family	Other fuel	7,813	678	11,518
PPL	Att. Single-family	Solar energy	662	65	10,252
PPL	Att. Single-family	Utility gas	1,065,642	114,647	9,295

PPL	Att. Single-family	Wood	12,493	954	13,098
PPL	Multifamily	Bottled, tank, or LP gas	33,371	4,211	7,925
PPL	Multifamily	Coal or coke	6,735	839	8,025
PPL	Multifamily	Electricity	1,188,431	123,927	9,590
PPL	Multifamily	Fuel oil, kerosene, etc.	108,037	14,034	7,698
PPL	Multifamily	No fuel used	23,361	2,810	8,315
PPL	Multifamily	Other fuel	8,829	1,592	5,547
PPL	Multifamily	Solar energy	1,014	193	5,247
PPL	Multifamily	Utility gas	585,668	86,492	6,771
PPL	Multifamily	Wood	3,101	282	11,010
PPL	Manuf./Mobile	Bottled, tank, or LP gas	134,201	13,143	10,211
PPL	Manuf./Mobile	Coal or coke	4,305	383	11,251
PPL	Manuf./Mobile	Electricity	93,792	6,324	14,832
PPL	Manuf./Mobile	Fuel oil, kerosene, etc.	193,745	19,280	10,049
PPL	Manuf./Mobile	No fuel used	4,184	271	15,447
PPL	Manuf./Mobile	Other fuel	6,528	666	9,800
PPL	Manuf./Mobile	Solar energy	14	2	8,172
PPL	Manuf./Mobile	Utility gas	62,007	6,340	9,781
PPL	Manuf./Mobile	Wood	19,201	1,973	9,731
Duquesne Light	Det. Single-family	Bottled, tank, or LP gas	43,326	4,097	10,576
Duquesne Light	Det. Single-family	Coal or coke	1,428	146	9,757
Duquesne Light	Det. Single-family	Electricity	250,109	19,066	13,118
Duquesne Light	Det. Single-family	Fuel oil, kerosene, etc.	65,813	6,208	10,601
Duquesne Light	Det. Single-family	No fuel used	5,068	598	8,469
Duquesne Light	Det. Single-family	Other fuel	4,886	512	9,544
Duquesne Light	Det. Single-family	Solar energy	233	52	4,479
Duquesne Light	Det. Single-family	Utility gas	2,499,207	296,461	8,430
Duquesne Light	Det. Single-family	Wood	16,101	1,520	10,593
Duquesne Light	Att. Single-family	Bottled, tank, or LP gas	5,997	888	6,754
Duquesne Light	Att. Single-family	Coal or coke	-	-	-

Duquesne Light	Att. Single-family	Electricity	66,359	7,448	8,910
Duquesne Light	Att. Single-family	Fuel oil, kerosene, etc.	3,428	525	6,524
Duquesne Light	Att. Single-family	No fuel used	1,604	180	8,919
Duquesne Light	Att. Single-family	Other fuel	140	29	4,902
Duquesne Light	Att. Single-family	Solar energy	-	-	-
Duquesne Light	Att. Single-family	Utility gas	354,010	48,998	7,225
Duquesne Light	Att. Single-family	Wood	334	41	8,070
Duquesne Light	Multifamily	Bottled, tank, or LP gas	18,568	3,008	6,174
Duquesne Light	Multifamily	Coal or coke	-	57	-
Duquesne Light	Multifamily	Electricity	384,432	59,977	6,410
Duquesne Light	Multifamily	Fuel oil, kerosene, etc.	2,322	456	5,090
Duquesne Light	Multifamily	No fuel used	6,547	1,570	4,170
Duquesne Light	Multifamily	Other fuel	5,407	1,157	4,673
Duquesne Light	Multifamily	Solar energy	-	44	-
Duquesne Light	Multifamily	Utility gas	442,953	86,298	5,133
Duquesne Light	Multifamily	Wood	-	10	-
Duquesne Light	Manuf./Mobile	Bottled, tank, or LP gas	7,100	781	9,090
Duquesne Light	Manuf./Mobile	Coal or coke	24	9	2,715
Duquesne Light	Manuf./Mobile	Electricity	12,547	966	12,994
Duquesne Light	Manuf./Mobile	Fuel oil, kerosene, etc.	6,682	895	7,470
Duquesne Light	Manuf./Mobile	No fuel used	706	130	5,430
Duquesne Light	Manuf./Mobile	Other fuel	1,111	101	10,943
Duquesne Light	Manuf./Mobile	Solar energy	-	-	-
Duquesne Light	Manuf./Mobile	Utility gas	13,630	2,112	6,452
Duquesne Light	Manuf./Mobile	Wood	904	99	9,112
FE: Met-Ed	Det. Single-family	Bottled, tank, or LP gas	300,566	24,157	12,442
FE: Met-Ed	Det. Single-family	Coal or coke	74,089	6,612	11,205
FE: Met-Ed	Det. Single-family	Electricity	1,403,272	81,342	17,252

FE: Met-Ed	Det. Single-family	Fuel oil, kerosene, etc.	942,098	87,617	10,752
FE: Met-Ed	Det. Single-family	No fuel used	12,796	863	14,833
FE: Met-Ed	Det. Single-family	Other fuel	53,098	3,501	15,168
FE: Met-Ed	Det. Single-family	Solar energy	6,860	646	10,623
FE: Met-Ed	Det. Single-family	Utility gas	1,074,162	102,164	10,514
FE: Met-Ed	Det. Single-family	Wood	169,570	13,447	12,610
FE: Met-Ed	Att. Single-family	Bottled, tank, or LP gas	18,500	1,702	10,869
FE: Met-Ed	Att. Single-family	Coal or coke	10,131	1,152	8,791
FE: Met-Ed	Att. Single-family	Electricity	331,307	24,527	13,508
FE: Met-Ed	Att. Single-family	Fuel oil, kerosene, etc.	144,367	15,302	9,435
FE: Met-Ed	Att. Single-family	No fuel used	1,834	235	7,798
FE: Met-Ed	Att. Single-family	Other fuel	4,282	375	11,413
FE: Met-Ed	Att. Single-family	Solar energy	178	18	9,719
FE: Met-Ed	Att. Single-family	Utility gas	456,802	50,377	9,068
FE: Met-Ed	Att. Single-family	Wood	5,063	414	12,233
FE: Met-Ed	Multifamily	Bottled, tank, or LP gas	10,023	1,356	7,390
FE: Met-Ed	Multifamily	Coal or coke	2,164	395	5,483
FE: Met-Ed	Multifamily	Electricity	402,067	44,889	8,957
FE: Met-Ed	Multifamily	Fuel oil, kerosene, etc.	39,222	5,508	7,121
FE: Met-Ed	Multifamily	No fuel used	12,884	1,002	12,864
FE: Met-Ed	Multifamily	Other fuel	2,542	461	5,509
FE: Met-Ed	Multifamily	Solar energy	169	73	2,304
FE: Met-Ed	Multifamily	Utility gas	171,674	26,423	6,497
FE: Met-Ed	Multifamily	Wood	405	57	7,089
FE: Met-Ed	Manuf./Mobile	Bottled, tank, or LP gas	48,620	5,121	9,494
FE: Met-Ed	Manuf./Mobile	Coal or coke	458	51	8,955
FE: Met-Ed	Manuf./Mobile	Electricity	37,623	2,673	14,074
FE: Met-Ed	Manuf./Mobile	Fuel oil, kerosene, etc.	59,246	6,170	9,603
FE: Met-Ed	Manuf./Mobile	No fuel used	2,694	211	12,768
FE: Met-Ed	Manuf./Mobile	Other fuel	2,802	328	8,542

FE: Met-Ed	Manuf./Mobile	Solar energy	-	-	-
FE: Met-Ed	Manuf./Mobile	Utility gas	26,807	2,590	10,350
FE: Met-Ed	Manuf./Mobile	Wood	4,048	455	8,894
FE: Penelec	Det. Single-family	Bottled, tank, or LP gas	199,461	20,776	9,601
FE: Penelec	Det. Single-family	Coal or coke	94,723	9,959	9,511
FE: Penelec	Det. Single-family	Electricity	864,869	62,360	13,869
FE: Penelec	Det. Single-family	Fuel oil, kerosene, etc.	769,197	85,659	8,980
FE: Penelec	Det. Single-family	No fuel used	14,353	998	14,388
FE: Penelec	Det. Single-family	Other fuel	37,962	3,692	10,281
FE: Penelec	Det. Single-family	Solar energy	1,229	191	6,450
FE: Penelec	Det. Single-family	Utility gas	1,206,417	159,986	7,541
FE: Penelec	Det. Single-family	Wood	226,482	23,456	9,656
FE: Penelec	Att. Single-family	Bottled, tank, or LP gas	4,452	547	8,137
FE: Penelec	Att. Single-family	Coal or coke	2,377	288	8,245
FE: Penelec	Att. Single-family	Electricity	75,015	7,744	9,687
FE: Penelec	Att. Single-family	Fuel oil, kerosene, etc.	23,803	3,167	7,515
FE: Penelec	Att. Single-family	No fuel used	1,039	110	9,403
FE: Penelec	Att. Single-family	Other fuel	495	47	10,470
FE: Penelec	Att. Single-family	Solar energy	25	3	9,658
FE: Penelec	Att. Single-family	Utility gas	83,183	13,143	6,329
FE: Penelec	Att. Single-family	Wood	3,035	284	10,670
FE: Penelec	Multifamily	Bottled, tank, or LP gas	9,366	1,558	6,011
FE: Penelec	Multifamily	Coal or coke	3,073	417	7,364
FE: Penelec	Multifamily	Electricity	236,452	32,482	7,280
FE: Penelec	Multifamily	Fuel oil, kerosene, etc.	18,903	3,011	6,279
FE: Penelec	Multifamily	No fuel used	4,014	1,132	3,545
FE: Penelec	Multifamily	Other fuel	2,355	537	4,388
FE: Penelec	Multifamily	Solar energy	93	37	2,509
FE: Penelec	Multifamily	Utility gas	144,297	30,365	4,752
FE: Penelec	Multifamily	Wood	3,487	289	12,076

FE: Penelec	Manuf./Mobile	Bottled, tank, or LP gas	47,074	5,820	8,088
FE: Penelec	Manuf./Mobile	Coal or coke	3,013	339	8,885
FE: Penelec	Manuf./Mobile	Electricity	66,423	5,399	12,302
FE: Penelec	Manuf./Mobile	Fuel oil, kerosene, etc.	111,116	14,435	7,698
FE: Penelec	Manuf./Mobile	No fuel used	880	99	8,865
FE: Penelec	Manuf./Mobile	Other fuel	8,275	886	9,342
FE: Penelec	Manuf./Mobile	Solar energy	9	1	6,439
FE: Penelec	Manuf./Mobile	Utility gas	48,548	7,360	6,597
FE: Penelec	Manuf./Mobile	Wood	15,435	1,841	8,382
FE: Penn Power	Det. Single-family	Bottled, tank, or LP gas	61,846	4,922	12,566
FE: Penn Power	Det. Single-family	Coal or coke	9,647	700	13,789
FE: Penn Power	Det. Single-family	Electricity	203,570	10,224	19,910
FE: Penn Power	Det. Single-family	Fuel oil, kerosene, etc.	82,452	6,097	13,523
FE: Penn Power	Det. Single-family	No fuel used	3,063	221	13,831
FE: Penn Power	Det. Single-family	Other fuel	11,157	914	12,204
FE: Penn Power	Det. Single-family	Solar energy	267	30	8,831
FE: Penn Power	Det. Single-family	Utility gas	902,067	82,650	10,914
FE: Penn Power	Det. Single-family	Wood	54,627	4,202	12,999
FE: Penn Power	Att. Single-family	Bottled, tank, or LP gas	1,561	118	13,236
FE: Penn Power	Att. Single-family	Coal or coke	-	9	-
FE: Penn Power	Att. Single-family	Electricity	14,449	1,120	12,899
FE: Penn Power	Att. Single-family	Fuel oil, kerosene, etc.	874	93	9,355
FE: Penn Power	Att. Single-family	No fuel used	116	17	6,707
FE: Penn Power	Att. Single-family	Other fuel	202	14	14,522
FE: Penn Power	Att. Single-family	Solar energy	27	2	13,055
FE: Penn Power	Att. Single-family	Utility gas	56,918	6,647	8,563
FE: Penn Power	Att. Single-family	Wood	925	66	14,040
FE: Penn Power	Multifamily	Bottled, tank, or LP gas	3,428	342	10,038

FE: Penn Power	Multifamily	Coal or coke	24	2	13,055
FE: Penn Power	Multifamily	Electricity	84,714	8,867	9,554
FE: Penn Power	Multifamily	Fuel oil, kerosene, etc.	784	81	9,733
FE: Penn Power	Multifamily	No fuel used	1,143	227	5,023
FE: Penn Power	Multifamily	Other fuel	1,333	239	5,584
FE: Penn Power	Multifamily	Solar energy	-	-	-
FE: Penn Power	Multifamily	Utility gas	83,521	12,833	6,509
FE: Penn Power	Multifamily	Wood	559	38	14,727
FE: Penn Power	Manuf./Mobile	Bottled, tank, or LP gas	16,829	1,473	11,424
FE: Penn Power	Manuf./Mobile	Coal or coke	386	37	10,435
FE: Penn Power	Manuf./Mobile	Electricity	17,672	1,007	17,547
FE: Penn Power	Manuf./Mobile	Fuel oil, kerosene, etc.	13,323	1,219	10,933
FE: Penn Power	Manuf./Mobile	No fuel used	165	16	10,339
FE: Penn Power	Manuf./Mobile	Other fuel	3,397	254	13,387
FE: Penn Power	Manuf./Mobile	Solar energy	-	-	-
FE: Penn Power	Manuf./Mobile	Utility gas	27,516	3,134	8,778
FE: Penn Power	Manuf./Mobile	Wood	4,289	324	13,257
FE: West Penn	Det. Single-family	Bottled, tank, or LP gas	224,814	17,052	13,184
FE: West Penn	Det. Single-family	Coal or coke	105,902	8,005	13,229
FE: West Penn	Det. Single-family	Electricity	1,117,616	61,072	18,300
FE: West Penn	Det. Single-family	Fuel oil, kerosene, etc.	910,720	73,784	12,343
FE: West Penn	Det. Single-family	No fuel used	24,458	1,315	18,600
FE: West Penn	Det. Single-family	Other fuel	52,250	3,637	14,366
FE: West Penn	Det. Single-family	Solar energy	1,936	214	9,030
FE: West Penn	Det. Single-family	Utility gas	2,826,439	263,977	10,707
FE: West Penn	Det. Single-family	Wood	324,177	24,542	13,209
FE: West Penn	Att. Single-family	Bottled, tank, or LP gas	7,278	708	10,278
FE: West Penn	Att. Single-family	Coal or coke	2,508	119	21,087

FE: West Penn	Att. Single-family	Electricity	120,514	9,286	12,978
FE: West Penn	Att. Single-family	Fuel oil, kerosene, etc.	28,312	2,398	11,808
FE: West Penn	Att. Single-family	No fuel used	1,596	141	11,335
FE: West Penn	Att. Single-family	Other fuel	952	65	14,650
FE: West Penn	Att. Single-family	Solar energy	34	3	13,176
FE: West Penn	Att. Single-family	Utility gas	206,224	23,811	8,661
FE: West Penn	Att. Single-family	Wood	5,134	357	14,393
FE: West Penn	Multifamily	Bottled, tank, or LP gas	21,582	2,322	9,294
FE: West Penn	Multifamily	Coal or coke	2,622	231	11,342
FE: West Penn	Multifamily	Electricity	448,099	47,492	9,435
FE: West Penn	Multifamily	Fuel oil, kerosene, etc.	25,519	2,916	8,750
FE: West Penn	Multifamily	No fuel used	6,318	1,317	4,796
FE: West Penn	Multifamily	Other fuel	5,751	808	7,122
FE: West Penn	Multifamily	Solar energy	205	60	3,423
FE: West Penn	Multifamily	Utility gas	319,424	48,685	6,561
FE: West Penn	Multifamily	Wood	3,985	259	15,370
FE: West Penn	Manuf./Mobile	Bottled, tank, or LP gas	57,240	4,935	11,599
FE: West Penn	Manuf./Mobile	Coal or coke	4,337	368	11,770
FE: West Penn	Manuf./Mobile	Electricity	91,855	5,685	16,156
FE: West Penn	Manuf./Mobile	Fuel oil, kerosene, etc.	155,977	14,506	10,753
FE: West Penn	Manuf./Mobile	No fuel used	1,156	92	12,542
FE: West Penn	Manuf./Mobile	Other fuel	7,079	611	11,590
FE: West Penn	Manuf./Mobile	Solar energy	14	2	8,784
FE: West Penn	Manuf./Mobile	Utility gas	73,839	8,147	9,063
FE: West Penn	Manuf./Mobile	Wood	20,350	1,777	11,451

Appendix B Data Inputs

Table 168 through Table 173 detail the data inputs collected at each type of audit. Single-family diagnostic audits received full energy modeling and required the most comprehensive data collection including air leakage testing, duct leakage testing, and data on all envelope walls. Single-family basic audits were simplified and included only data on key measures such as exterior walls, appliances, lights, and mechanical equipment. Multifamily audits involved a similar level of data collection as the basic audits, with the addition of some shell measures and details on the ownership of the complex for subsample of the multifamily visits. This study also added data collection via a self-audit component, in which web survey respondents could upload photos of different types of appliances and mechanical equipment in their homes. The data collected for self-audits, specifically data associated with household characteristics is based on self-reported responses from the web survey, while auditors were able to capture most household characteristic data during the site visit.[108] In addition, auditors prioritized collecting specific data and measures over others, so that if a visit was cut short on time for any reason, the highest priority data was collected.

Table 168: Detailed Data Inputs: General Information

Measure	Single-family Diagnostic	Single-family Basic	Multifamily	Self-Audit
House Type	✓	✓	✓	✓
Vintage	✓	✓	✓	✓
Stories	✓	✓	✓	
Bedrooms	✓	✓	✓	✓
Occupants	✓	✓	✓	✓
Income Status	✓	✓	✓	✓
Primary Heating Fuel	✓	✓	✓	✓
Conditioned Floor Area	✓	✓	✓	
Conditioned Volume	✓			
Willingness to Pay Survey	✓	✓	✓	✓

[108] Auditors did not ask site visit participants willingness to pay questions and income status questions. These were only collected via the web survey.

Table 169: Detailed Data Inputs: Insulation/Shell Measures

Measure	Single-family Diagnostic	Single-family Basic	Multifamily	Self-Audit
Exterior Walls	✓	✓	✓	
All Envelope Walls	✓			
Ceilings	✓	✓	✓	
Frame Floors	✓	✓	✓	
Rim/Band Joists	✓			
Windows	✓	✓	✓	
Skylights	✓	✓	✓	
Slab Floors	✓			
Foundation Walls	✓	✓	✓	

Table 170: Detailed Data Inputs: Mechanical Equipment

Measure	Single-family Diagnostic	Single-family Basic	Multifamily	Self-Audit
Heating Equipment	✓	✓	✓	✓
Water Heating Equipment	✓	✓	✓	✓
Cooling Equipment	✓	✓	✓	✓
Duct Insulation	✓	✓	✓	
Renewables	✓	✓	✓	
Faucets and Showerheads	✓	✓	✓	

Table 171: Detailed Data Inputs: General Fixtures and Appliances

Measure	Single-family Diagnostic	Single-family Basic	Multifamily	Self-Audit
Thermostats	✓	✓	✓	
Faucets	✓	✓	✓	
Lighting Type and Controls	✓	✓	✓	
Electronics	✓	✓	✓	
Refrigerators	✓	✓	✓	✓
Dishwashers	✓	✓	✓	✓
Ovens and Ranges	✓	✓	✓	✓
Clothes Washers/Dryers	✓	✓	✓	✓
Pools	✓	✓	✓	

Table 172: Detailed Data Inputs: Diagnostic Testing

Measure	Single-family Diagnostic	Single-family Basic	Multifamily	Self-Audit
Blower Door Tests	✓			
Duct Blaster Tests	✓			

Table 173: Detailed Data Inputs: Priority

Measure	Data Points	Priority
General characteristics	Home type, age, stories, bedrooms, occupants, income status, thermal boundary, foundation type, conditioned floor area, conditioned volume	1
Building Shell		
Walls	Location, framing details, insulation material, insulation depth, R value (cavity and continuous), insulation grade, exterior cladding, area	1
Ceilings	Type, framing details, insulation material, insulation depth, R value (cavity and continuous), insulation grade, area	1
Frame floors	Location, framing details, insulation material, insulation depth, R value (cavity and continuous), insulation grade, area	1

Rim/band joists	Location, framing details, insulation material, insulation depth, R value (cavity and continuous), insulation grade, area, presence of seal	2
Windows	Location, area, orientation, frame material, number of panes, lo-e coating, gas fill, U-value, SHGC, overhang	1
Slab floors	Type, depth, area, perimeter, radiant floor, perimeter insulation, under slab insulation, R value	2
Foundation walls	Location, material, framing details, insulation material, insulation depth, R value (cavity and continuous), insulation grade, area, depth above grade	1
Air leakage	Blower door test results: CFM50, conditioned volume, ACH50, interior/ exterior temperature, elevation	1
Mechanical Equipment		
Heating equipment	Type, location, fuel, distribution type, make, model, age, capacity, efficiency, efficiency unit, Energy Star status	1
Cooling equipment	Type, location, make, model, age, capacity, efficiency, efficiency unit, Energy Star status	1
Water heating	Type, location, fuel, make, model, age, capacity, efficiency, efficiency unit, Energy Star status, pipe insulation, tank insulation	1
Ducts	Type, location, material, insulation, sealing, total leakage, leakage to outside	1
Appliances and Fixtures		
Faucets and showerheads	Type, presence of aerator, flow rate	2
Thermostats	Type, winter set point, summer set point	2
Lighting	Type, number of bulbs, hardwired, controls	1
Refrigerators	Configuration, location, primacy, make, model, size, kWh/year, Energy Star status, icemaker, defrost type	2
Freezers	Configuration, location, primacy, make, model, size, kWh/year, Energy Star status, defrost type	2
Dishwashers	Location, capacity, make, model, kWh/year, Energy Star status	2
Ovens and ranges	Type, fuel, convection, induction	2
Clothes washers	Configuration, location, make, model, efficiency, capacity, Energy Star status	2

Clothes dryers	Configuration, location, fuel, make, model, efficiency, Energy Star status, venting	2
Dehumidifiers	Location, capacity, efficiency, Energy Star status, usage	2
Electronics		
Televisions	Type, size, Energy Star status	3
Computers	Type, size, Energy Star status	3
Smart power strips	Configuration, location, plug loads	3
Printers/ copiers	Type, Energy Star status	3
Entertainment systems	Type, Energy Star status	3

Appendix C Detailed Diagnostic Results

This appendix splits diagnostic results (e.g., HERS Index score, ACH50, and duct leakage to outside) by additional factors such as heating fuel, income status, and EDC not shown in Section 5 Diagnostic Sub-Sample Results.

Table 174: HERS Index Score by Primary Heating Fuel

	Electricity	Natural Gas	Propane	Oil	Coal/Wood	Statewide
n-value	*17*	*46*	*4*	*4*	*1*	*72*
Min	61.0	58.0	67.0	94.0	488.0	58.0
Max	168.0	230.0	78.0	196.0	488.0	488.0
Mean	**89.7**	**101.6**	**72.5**	**123.5**	**488.0**	**107.8**
Median	77.0	89.5	72.5	102.0	488.0	86.0
Std. Dev.	30.5	38.9	4.9	48.5	NA	59.4

Table 175: HERS Index Score by Low-income Status

	No	Yes	Refused	Statewide
n-value	*58*	*12*	*2*	*72*
Min	58.0	63.0	91.0	58.0
Max	196.0	488.0	99.0	488.0
Mean	**94.0**	**152.2**[a]	**95.0**	**107.8**
Median	85.5	112.0	95.0	86.0
Std. Dev.	31.2	119.7	5.6	59.4

[a] Significantly different from the low-income sample at the 95% confidence level.

Table 176: HERS Index Score by EDC

	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
n-value	*13*	*10*	*10*	*10*	*9*	*9*	*11*	*72*
Min	64.0	61.0	72.0	58.0	62.0	59.0	73.0	58.0
Max	115.0	196.0	230.0	85.0	488.0	122.0	168.0	488.0
Mean	**85.5**[c]	**112.5**	**133.5**	**70.5**[a,b,c]	**137.7**	**85.4**	**107.9**[a,d]	**107.8**
Median	86.0	91.0	119.5	69.5	96.0	86.0	107.0	86.0
Std. Dev.	16.8	52.6	51.1	8.2	134.3	17.3	31.9	59.4

[a] Significantly different from PECO at the 95% confidence level.

[b] Significantly different from PPL at the 95% confidence level.

[c] Significantly different from Duquesne Light at the 95% confidence level.
[d] Significantly different from Med-Ed at the 95% confidence level.

Table 177: ACH50 by Primary Heating Fuel

	Electricity	Natural Gas	Propane	Oil	Coal/Wood	Statewide
n-value	*17*	*46*	*4*	*4*	*1*	*72*
Min	1.6	3.3	4.0	8.6	52.9	1.6
Max	18.3	36.9	9.4	19.8	52.9	52.9
Mean	**7.3**	**11.8**	**5.8**	**11.8**	**52.9**	**11.4**
Median	5.9	9.1	4.8	9.5	52.9	8.6
Std. Dev.	4.6	8.3	2.5	5.3	NA	9.0

Table 178: ACH50 by EDC

	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
n-value	*13*	*10*	*10*	*10*	*9*	*9*	*11*	*72*
Min	3.2	2.5	3.7	1.6	3.6	5.9	3.3	1.6
Max	22.3	24.7	36.9	6.6	52.9	23.7	27.0	52.9
Mean	**8.9**[c]	**9.2**[c]	**17.4**	**4.6**[a,c]	**14.3**	**11.7**	**11.4**[d]	**11.4**
Median	6.8	6.4	15.9	4.5	7.6	9.1	12.5	8.6
Std. Dev.	5.1	7.6	9.4	1.4	16.5	5.7	7.1	9.0

[a] Significantly different from PECO at the 95% confidence level.
[c] Significantly different from Duquesne Light at the 95% confidence level.
[d] Significantly different from Med-Ed at the 95% confidence level.

Table 179 presents the ACH50 for homes built prior to 2000, based on a qualitative assessment by field technicians as to whether the audited home had a larger, whole home renovation, was partially renovated, or appeared to be the original conditions. This analysis, while qualitative in nature, is to show how the air leakage in older homes can be mitigated with upgrades to insulation and air-sealing.

Table 179: ACH50 by Qualitative Renovation Assessment

	Before 1940			1940-1959			1960-1979			1980-1999			
Renovation	Yes	Partial	No	Yes	Partial	No	Yes	Partial	No	Yes	Partial	No	Statewide
n	*5*	*2*	*4*	*2*	*9*	*2*	*3*	*4*	*5*	*3*	*0*	*9*	*48*
Min	5.6	9.5	20.8	8.6	9.3	22.3	5.8	6.8	8.6	3.7	N/A	3.3	3.3
Max	13.1	15.4	52.9	10.8	23.7	29.9	14.4	8.9	25.5	8.7	N/A	18.3	52.9
Mean	**9.7**	**12.5**	**34.4**	**9.7**	**15.9**	**26.1**	**8.8**	**7.7**	**16.6**	**6.4**	**N/A**	**10.1**	**14.0**

Median	9.5	12.5	32.0	9.7	15.3	26.1	6.3	7.6	16.2	6.7	N/A	9.6	11.0
Std. Dev.	2.8	4.2	14.0	1.5	4.9	5.3	4.8	0.9	7.5	2.5	N/A	4.8	9.4

Table 180: Duct Leakage to Outside by Heating Fuel (CFM25/100 sq.ft.)

(Base = Systems)

	Electricity	Natural Gas	Propane	Oil	Coal/Wood	Statewide
n-value	*14*	*47*	*4*	*2*	*1*	*68*
Min	0.0	0.0	7.0	12.9	19.6	0.0
Max	29.9	27.1	15.9	15.0	19.6	29.9
Mean	**7.6**	**6.8**	**5.5**	**13.9**	**19.6**	**7.6**
Median	2.7	4.3	3.2	13.9	19.6	4.7
Std. Dev.	9.9	7.7	7.5	1.4	NA	8.1

Table 181: Duct Leakage to Outside by Low-income Status (CFM25/100 sq.ft.)

(Base = Systems)

	No	Yes	Refused	Statewide
n-value	*55*	*11*	*2*	*68*
Min	0.0	0.0	0.0	0.0
Max	29.9	26.6	17.6	29.9
Mean	**6.7**	**9.9**	**8.8**	**7.6**
Median	3.7	7.3	8.8	4.7
Std.Dev.	7.8	9.3	12.4	8.1

Table 182: Duct Leakage to Outside by EDC (CFM25/100 sq.ft.)

(Base = Systems)

	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
n-value	*13*	*8*	*10*	*10*	*7*	*10*	*10*	*68*
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Max	17.6	29.9	27.1	15.9	23.5	23.2	12.4	29.9
Mean	**5.3**	**8.2**	**12.2**	**3.7**[c]	**11.1**	**8.6**	**4.1**[c]	**7.6**
Median	3.4	5.7	12.2	5.4	10.6	5.9	2.1	4.7
Std. Dev.	6.1	10.1	10.9	5.9	8.3	8.5	5.1	8.1

[c] Significantly different from Duquesne Light at the 95% confidence level.

Appendix D Building Envelope Results by EDC

D.1 Above Grade Walls

D.1.1 Primary Wall Insulation

Table 183: Primary Ambient Wall Insulation by EDC

Insulation Type	PECO	PPL	Duquesne Light	Met-Ed	Penelec	Penn Power	West Penn Power	Statewide
n-value	*44*	*41*	*44*	*43*	*41*	*32*	*41*	*286*
Fiberglass Batt (FGB)	80%	83%	39%	63%	59%	66%	59%	71%
No Insulation	14%	12%	34%	21%	15%	3%	20%	14%
Blown-in Cellulose	5%	2%	7%	7%	5%	9%	10%	5%
FGB + Rigid Foam	2%	--	7%	5%	12%	16%	2%	4%
Rigid Foam[1]	--	2%	5%	5%	2%	--	10%	2%
Blown-in Fiberglass	--	--	7%	--	--	--	--	1%
Closed-cell Spray Foam + Rigid Foam	--	--	--	--	5%	--	--	1%
Open-cell Spray Foam + Rigid Foam	--	--	2%	--	2%	6%	--	1%

[1] Rigid foam includes expanded polystyrene (EPS), extruded polystyrene (XPS), and polyisocyanurate.
* Totals may not equal sum of column or row due to rounding.

D.1.2 Average R-value

Table 184: Average Ambient Wall R-values by EDC

	PECO	PPL	Duquesne Light	Met-Ed	Penelec	Penn Power	West Penn Power	Statewide
n-value	*44*	*41*	*44*	*43*	*41*	*32*	*41*	*286*
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	22.0	21.0	24.4	24.0	38.7	27.4	26.3	38.7
Mean	**12.6**	**12.9**	**9.2**	**13.5**	**14.6**	**15.6**	**11.3**	**13.0**
Median	13.0	13.0	9.9	18.7	14.0	15.5	13.0	13.0
Std. Dev.	5.9	5.8	7.9	8.1	8.0	4.8	7.4	7.2

* Totals may not equal sum of column or row due to rounding.

D.2 Ceilings

D.2.1 Flat Ceilings

D.2.1.1 Primary Flat Ceiling Insulation

Table 185: Primary Flat Ceiling Insulation by EDC

Insulation Type	PECO	PPL	Duquesne Light	Met-Ed	Penelec	Penn Power	West Penn Power	Statewide
n-value	*29*	*27*	*28*	*35*	*31*	*28*	*23*	*201*
Fiberglass Batt (FGB)	66%	44%	43%	46%	45%	57%	48%	51%
Blown-in Cellulose	10%	26%	25%	20%	26%	21%	26%	20%
Blown-in Fiberglass	14%	26%	29%	26%	10%	4%	13%	19%
No insulation	7%	4%	--	9%	3%	--	9%	4%
Blown-in Cellulose + FGB	3%	--	4%	0%	6%	7%	--	3%
Blown-in Fiberglass + FGB	--	--	--	--	--	7%	4%	1%

Blown-in Rock Wool	--	--	--	--	6%	--	--	1%
Open-cell Spray Foam + Rigid Foam[1]	--	--	--	--	--	4%	--	<1%
Rock Wool Batt	--	--	--	--	3%	--	--	<1%

* Totals may not equal sum of column or row due to rounding.
[1] Rigid foam includes expanded polystyrene (EPS), extruded polystyrene (XPS), and polyisocyanurate.

D.2.1.2 Flat Ceiling Average R-value

Table 186: Average Flat Ceiling R-value by EDC

	PECO	PPL	Duquesne Light	Met-Ed	Penelec	Penn Power	West Penn Power	Statewide
n-value	*29*	*27*	*28*	*35*	*31*	*28*	*23*	*201*
Minimum	0.0	0.0	4.5	0.0	0.0	6.8	0.0	0.0
Maximum	49.0	66.7	39.4	45.0	44.4	62.4	44.4	66.7
Mean	**26.3**	**28.5**	**23.5**	**26.2**	**28.0**	**29.8**	**25.2**	**26.8**
Median	30.0	30.0	20.2	30.0	30.0	30.0	25.0	30.0
Std. Dev.	9.8	12.5	9.2	11.5	10.4	13.2	11.8	11.2

D.2.2 Vaulted Ceilings

D.2.2.1 Primary Vaulted Ceiling Insulation

Table 187: Primary Vaulted Ceiling Insulation by EDC

Insulation Type	PECO	PPL	Duquesne Light	Met-Ed	Penelec	Penn Power	West Penn Power	Statewide
n-value	*7*	*5*	*5*	*4*	*5*	*7*	*8*	*41*
Fiberglass Batt (FGB)	71%	60%	40%	75%	80%	100%	75%	75%
No insulation	29%	20%	40%	--	--	--	12%	16%

Rigid Foam	--	20%	--	--	--	--	--	5%
Blown-in Cellulose	--	--	20%	25%	--	--	12%	3%
Closed-cell Spray Foam + Rigid Foam	--	--	--	--	20%	--	--	1%

* Totals may not equal sum of column or row due to rounding.

D.2.2.2 Vaulted Ceiling Average R-value

Table 188: Average Vaulted Ceiling R-value by EDC

	PECO	PPL	Duquesne Light	Met-Ed	Penelec	Penn Power	West Penn Power	Statewide
n-value	*7*	*5*	*5*	*4*	*5*	*7*	*8*	*41*
Minimum	0.0	7.0	0.0	19.0	13.0	19.0	0.0	0.0
Maximum	34.0	65.9	35.0	30.0	38.0	38.0	40.3	65.9
Mean	**18.0**	**29.0**	**14.6**	**23.7**	**26.0**	**28.3**	**22.7**	**22.9**
Median	18.7	30.0	19.0	22.8	28.0	30.0	25.5	26.3
Std. Dev.	14.2	23.1	14.8	5.4	9.5	7.0	13.8	13.5

D.3 Frame Floors

D.3.1 Primary Insulation Type

Table 189: Primary Frame Floor Insulation Type by EDC

Insulation Type	PECO	PPL	Duquesne Light	Met-Ed	Penelec	Penn Power	West Penn Power	Statewide
n-value	*16*	*14*	*13*	*19*	*13*	*12*	*14*	*101*
No Insulation	88%	50%	100%	32%	77%	83%	86%	70%
Fiberglass Batt (FGB)	6%	50%	--	68%	23%	17%	14%	28%
Rigid Foam	6%	--	--	--	--	--	--	2%

* Totals may not equal sum of column or row due to rounding.

D.3.2 Average R-value

Table 190: Average Frame Floor R-value by EDC

	PECO	PPL	Duquesne Light	Met-Ed	Penelec	Penn Power	West Penn Power	Statewide
n-value	*16*	*14*	*13*	*19*	*13*	*12*	*14*	*101*
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	11.0	38.0	0.0	38.0	38.0	30.0	19.0	38.0
Mean	**1.1**	**11.3**	**0.0**	**17.0**	**7.5**	**5.0**	**2.7**	**1.1**
Median	0.0	5.5	0.0	19.0	0.0	0.0	0.0	0.0
Std. Dev.	3.1	13.1	0.0	13.7	14.4	11.7	6.9	11.8

D.4 Conditioned Foundation Walls

D.4.1 Primary Foundation Wall Insulation

Table 191: Primary Foundation Wall Insulation by EDC

Insulation Type	PECO	PPL	Duquesne Light	Met-Ed	Penelec	Penn Power	West Penn Power	Statewide
n-value	*19*	*14*	*14*	*17*	*14*	*15*	*17*	*110*
No insulation	37%	57%	64%	29%	43%	33%	35%	41%
Fiberglass Batt (FGB)	42%	43%	36%	47%	14%	27%	29%	38%
Rigid Foam[1]	16%	--	--	12%	36%	20%	35%	16%
Blown-in Cellulose	5%	--	--	--	--	--	--	2%
FGB + Rigid Foam	--	--	--	12%	7%	13%	--	2%
Open-cell Spray Foam + Rigid Foam[1]	--	--	--	--	--	7%	--	<1%

* Totals may not equal sum of column or row due to rounding.
[1] Rigid foam includes expanded polystyrene (EPS), extruded polystyrene (XPS), and polyisocyanurate.

D.4.2 Average Foundation Wall R-value

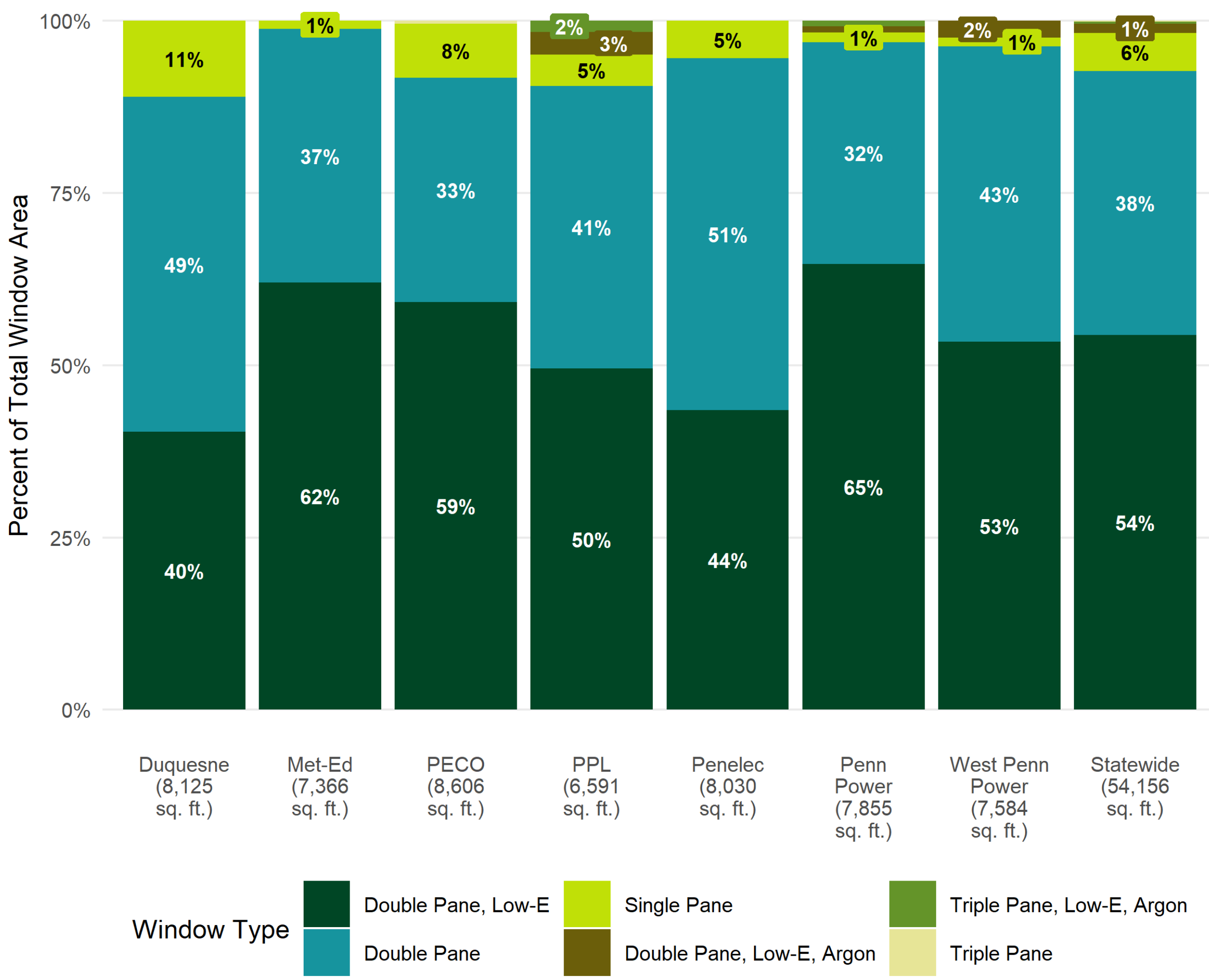
Table 192: Average Foundation Wall R-value

R-Values	PECO	PPL	Duquesne Light	Met-Ed	Penelec	Penn Power	West Penn Power	Statewide
n-value	*19*	*14*	*14*	*17*	*14*	*15*	*17*	*110*
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	21.0	14.5	20.0	27.3	15.5	27.7	19.0	27.7
Mean	**8.1**	**5.4**	**5.2**	**11.7**	**4.7**	**11.5**	**6.4**	**7.4**
Median	10.6	0.0	0.0	12.5	2.5	13.0	5.0	8.4
Std. Dev.	7.0	6.5	7.5	9.2	5.5	7.8	6.5	7.6

D.5 Windows

D.5.1 Glazing Types

Figure 34: Glazing Types by Window Square Footage (EDC)



D.5.2 Exterior Glazing Percentages

Table 193: Glazing as a Percent of Exterior Wall Area (EDC)

	Attached single-family	Detached single-family	Multifamily	Statewide
n-value	*28*	*189*	*69*	*286*
Minimum	6%	3%	2%	2%
Maximum	32%	69%	48%	69%
Mean	**14%**	**13%**	**15%**	**13%**
Median	12%	11%	14%	12%
Std. Dev.	6%	7%	8%	7%

Appendix E Insulation Grades

The Residential Energy Services Network (RESNET) provides guidelines and definitions for defining the quality of insulation installation. RESNET has specified three grades for designating the quality of insulation installation; the grades range from Grade I (the best) to Grade III (the worst). REM/Rate energy models take insulation grade into account when calculating shell measure efficiency – building assemblies that are recorded as having Grade I installations perform better in the energy simulation than those modeled as Grade II or Grade III, for example.

The RESNET definitions of Grade I, Grade II, and Grade III installation are provided below.[109]

Grade I: "Grade I" shall be used to describe insulation that is generally installed according to manufacturer's instructions and/or industry standards. A "Grade I" installation requires that the insulation material uniformly fills each cavity side-to-side and top-to-bottom, without substantial gaps or voids around obstructions (such as blocking or bridging), and is split, installed, and/or fitted tightly around wiring and other services in the cavity... To attain a rating of "Grade I", wall insulation shall be enclosed on all six sides, and shall be in substantial contact with the sheathing material on at least one side (interior or exterior) of the cavity…Occasional very small gaps are acceptable for "Grade I"… Compression or incomplete fill amounting to 2% or less, if the empty spaces are less than 30% of the intended fill thickness, are acceptable for "Grade I".

Grade II: "Grade II" shall be used to describe an installation with moderate to frequent installation defects: gaps around wiring, electrical outlets, plumbing and other intrusions; rounded edges or "shoulders"; or incomplete fill amounting to less than 10% of the area with 70% or more of the intended thickness (i.e., 30% compressed); or gaps and spaces running clear through the insulation amounting to no more than 2% of the total surface area covered by the insulation.

Grade III: "Grade III" shall be used to describe an installation with substantial gaps and voids, with missing insulation amounting to greater than 2% of the area, but less than 5% of the surface area is intended to occupy. More than 5% of missing insulation shall be measured and modeled as separate, uninsulated surfaces.

Below are some examples of insulation installation and the corresponding grade applied by auditors. A brief description of the reasoning behind the grade designation is provided for each example. Please note that these photographs were not all taken during the site visits for this study, and they are not meant to show the good and bad building practices observed during the site visits. Rather, these pictures are meant to provide visual examples of typical insulation installation grades.

[109] Residential Energy Services Network. (2013). *Mortgage Industry National Home Energy Rating Systems Standards.* Oceanside, CA: Residential Energy Services Network.

Figure 35 shows a conditioned attic with closed-cell spray foam applied to the walls. This installation received a Grade I installation because the closed-cell spray foam has little to no gaps, has no compression, and the cavity is enclosed on all six sides.[110]

Figure 35: Grade I Closed-Cell Spray Foam – Exterior Walls

Figure 36 shows a Grade II install of unfaced fiberglass batts in a conditioned basement.[111] The insulation has gaps in the corners of certain bays and there is some compression – though relatively minor compression overall. The insulation is enclosed on all six sides including the air barrier, warranting a Grade II designation.

Figure 36: Grade II Fiberglass Batts – Basement Walls

[110] In the case of spray foam, a cavity may be open to the attic and still receive a Grade I installation because the spray foam itself is an air barrier.
[111] The basement in this case was considered conditioned volume, not conditioned floor area.

Figure 37 shows R-21 fiberglass batts in a 2x4 wall cavity. This installation automatically receives a Grade III designation due to the fact that the insulation is not enclosed on the vented attic side. According to the RESNET standards on Grade III installation, “This designation shall include wall insulation that is not in substantial contact with the sheathing on at least one side of the cavity, or wall insulation in a wall that is open (unsheathed) on one side and exposed to the exterior, ambient conditions or a vented attic or crawlspace.”

Figure 37: Grade III Fiberglass Batts – Attic Knee Walls

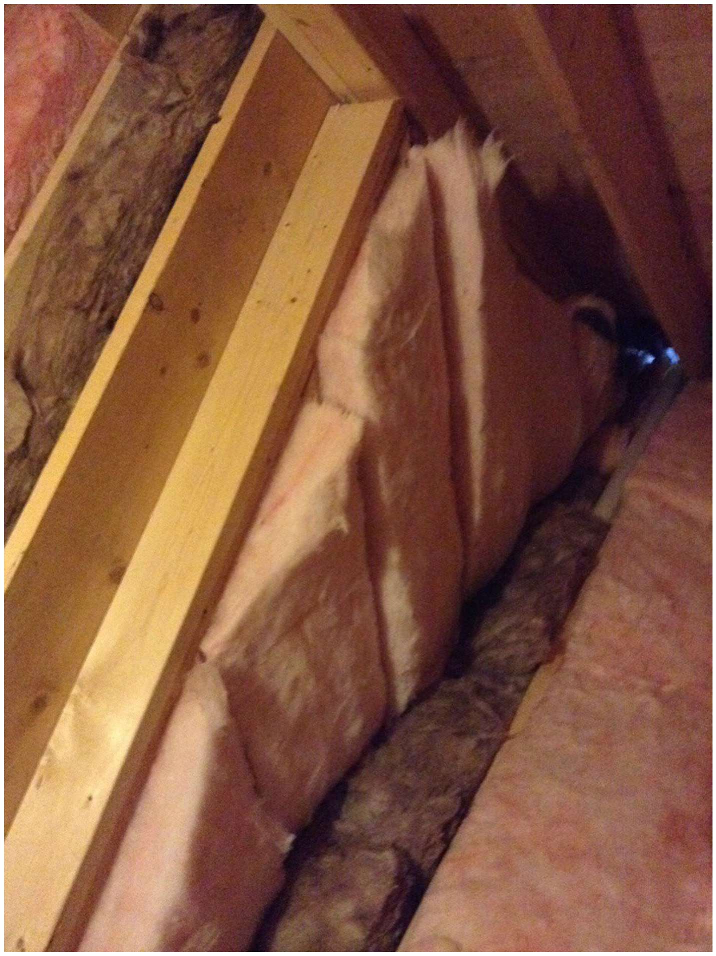


Figure 38 shows a Grade II installation of fiberglass batts in a frame floor cavity. While the insulation has a fair amount of compression, the gaps are minimal. The primary reason for the Grade II designation is that the fiberglass batts are in substantial contact with the subfloor. This example shows an installation that is right on the boundary of Grade II and Grade III installation. It should be noted that the bay with ductwork on the right side of the image would certainly represent a Grade III installation with substantial gaps and compression.

Figure 38: Grade II Fiberglass Batts – Frame Floor

Figure 39 shows frame floor insulation that received a Grade III designation. The insulation was installed incorrectly with the batting cut and installed perpendicular because the width was not the correct size. This install creates excessive gaps, compression, and sagging in the insulation. The sagging insulation creates an air space between the insulation and the subfloor, which ultimately diminishes the insulating characteristics of the fiberglass batts.

Figure 39: Grade III Fiberglass Batts – Frame Floor

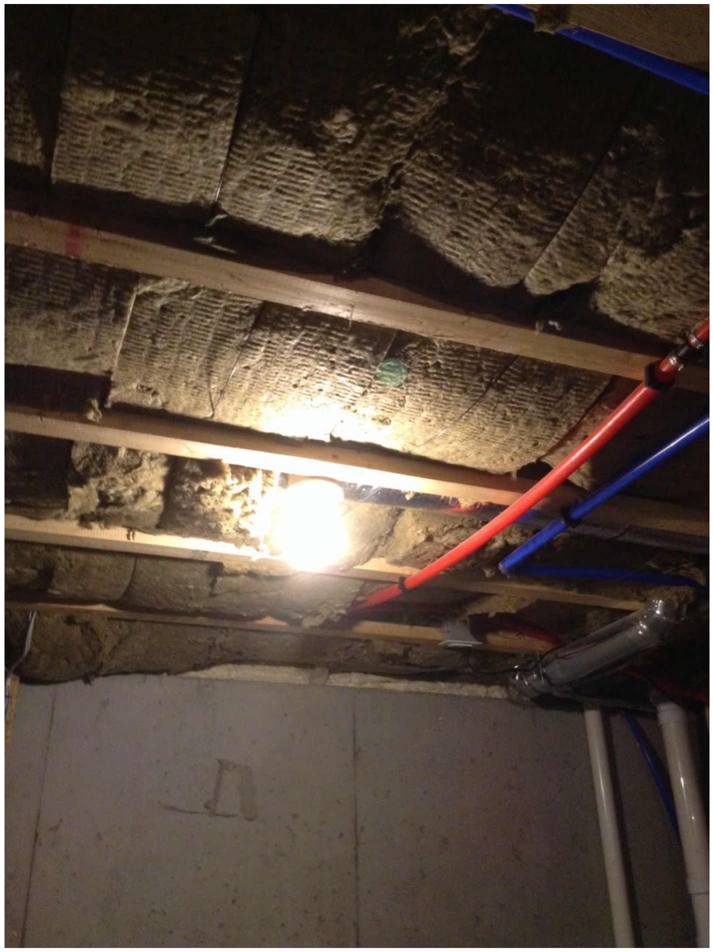


Figure 40 shows a Grade I installation of blown cellulose in an attic. This received a Grade I designation because the cellulose is blown in evenly, filling all the cavities with no gaps or voids and little to no compression. In addition, this attic has baffles at the eaves, which is required for attic insulation to achieve a Grade I installation.

Figure 40: Grade I Blown Cellulose – Attic

Appendix F Duct Results By EDC

Table 194: Supply Duct Location by EDC
(Base: Homes with ducts)

	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
n-value	*36*	*33*	*36*	*26*	*30*	*27*	*28*	*216*
<50% Conditioned	33%	39%	39%	58%	50%	52%	36%	44%
50%-90% Conditioned	3%	12%	11%	12%	13%	7%	4%	10%
>90% Conditioned	64%	48%	50%	31%	37%	41%	61%	46%

* Totals may not equal sum of column or row due to rounding.

Table 195: Return Duct Location by EDC
(Base: Homes with ducts)

	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
n-value	*36*	*33*	*36*	*26*	*30*	*27*	*28*	*216*
<50% Conditioned	33%	39%	39%	58%	50%	52%	36%	44%
50%-90% Conditioned	3%	12%	11%	12%	13%	7%	4%	10%
>90% Conditioned	64%	48%	50%	31%	37%	41%	61%	46%

* Totals may not equal sum of column or row due to rounding.

Table 196: Unconditioned Supply Duct Locations by EDC

(Base: Homes with ducts in Unconditioned Space)

	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
n-value	*29*	*26*	*20*	*23*	*23*	*20*	*14*	*155*
Unconditioned basement	52%	50%	65%	81%	43%	55%	58%	54%
Attic, exposed	37%	41%	15%	5%	33%	10%	33%	32%
Crawl Space	7%	--	10%	5%	10%	10%	8%	6%
Garage	4%	5%	10%	--	10%	25%	--	5%
Exterior wall	--	5%	--	5%	5%	--	--	2%
Attic, under insulation	--	--	--	5%	--	--	--	<1%

* Totals may not equal sum of column or row due to rounding.

Table 197: Unconditioned Return Duct Locations by EDC

(Base: Homes with ducts in Unconditioned Space)

	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
n-value	*29*	*26*	*20*	*23*	*23*	*20*	*14*	*155*
Unconditioned basement	58%	48%	69%	81%	45%	65%	62%	58%
Attic, exposed	38%	43%	19%	10%	35%	12%	23%	33%
Garage	4%	5%	0%	0%	10%	18%	8%	4%
Crawl Space	0%	0%	12%	5%	5%	6%	8%	2%
Exterior wall	0%	5%	0%	0%	5%	0%	0%	2%
Attic, under insulation	0%	0%	0%	5%	0%	0%	0%	1%

* Totals may not equal sum of column or row due to rounding.

Table 198: Unconditioned Supply Duct R-values by EDC

(Base: Homes with ducts in Unconditioned Space)

	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
n-value	*29*	*24*	*20*	*22*	*23*	*20*	*13*	*151*
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Max	6.0	8.0	4.2	8.0	8.0	6.0	8.0	8.0
Mean	**2.4**	**3.0**	**0.8**	**3.2**	**3.4**	**0.9**	**1.8**	**2.6**
Median	4.0	4.0	0.0	4.0	4.0	0.0	0.0	0.0
Std. Dev.	2.5	2.8	1.7	2.5	3.0	2.2	3.1	2.7

Table 199: Unconditioned Return Duct R-values by EDC

(Base: Homes with ducts in Unconditioned Space)

	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
n-value	*27*	*25*	*20*	*23*	*22*	*20*	*13*	*150*
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Max	6.0	8.0	4.2	8.0	8.0	6.0	8.0	8.0
Mean	**2.1**	**2.8**	**0.8**	**3.0**	**3.2**	**0.9**	**1.6**	**2.4**
Median	0.0	4.0	0.0	4.0	4.0	0.0	0.0	0.0
Std. Dev.	2.4	2.7	1.7	2.5	3.0	2.2	2.8	2.6

Appendix G Mechanical Equipment by EDC

G.1 Efficiency Conversion Tables

Table 200: SEER to SEER2 Conversion Values

SEER	SEER2 Converted Value
8	9
9	9-10
10	10-11
11	11
12	12
13	12-13
14	13-14
15	14-15
16	15-16
17	16
18	16-17
19	18
20	18-19
* Values converted to SEER2 may vary due to rounding.	

Table 201: HSPF to HSPF2 Conversion Values

HSPF	HSPF2 Converted Value
6	5
7	6
8	7
9	8
10	8-9
11	9-10
12	10

* Values converted to HSPF2 may vary due to rounding.

G.2 Heating Equipment

Table 202: Primary Heating Fuel by EDC

(Base = Homes)

Fuel	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*44*	*40*	*43*	*41*	*39*	*32*	*40*	*279*
Natural Gas	68%	25%	93%	37%	44%	75%	62%	55%
Electric	18%	55%	7%	49%	36%	22%	35%	31%
Oil	14%	18%	--	2%	10%	--	2%	12%
Propane	--	2%	--	12%	8%	3%	0%	3%
Wood - logs	--	--	--	--	3%	--	--	<1%
Self-Audit Results Only								
n-value	*10*	*28*	*21*	*21*	*21*	*15*	*19*	*135*
Electric	40%	61%	19%	43%	29%	20%	63%	47%
Natural Gas	40%	21%	76%	48%	52%	73%	32%	39%
Oil	20%	18%	5%	10%	14%	--	5%	13%
Propane	--	--	--	--	5%	--	--	<1%
Wood - logs	--	--	--	--	--	7%	--	<1%
Total On-Site and Self-Audit								
n-value	*54*	*68*	*64*	*62*	*60*	*47*	*59*	*414*
Natural Gas	63%	24%	88%	40%	47%	74%	53%	50%
Electric	22%	56%	11%	47%	33%	21%	44%	36%
Oil	15%	18%	2%	5%	12%	--	3%	12%
Propane	--	1%	--	8%	7%	2%	--	2%
Wood - logs	--	--	--	--	2%	2%	--	<1%

* Totals may not equal sum of column or row due to rounding.

Table 203: Primary Heating Equipment by EDC

(Base = Homes)

Type	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*44*	*40*	*43*	*41*	*39*	*32*	*40*	*279*
Furnace	55%	18%	74%	46%	46%	78%	57%	49%
Boiler	27%	30%	16%	5%	21%	--	10%	22%
ASHP	16%	28%	5%	27%	10%	19%	12%	18%
Electric baseboard	--	18%	--	12%	18%	--	18%	8%
Mini-split	--	5%	--	5%	3%	--	2%	2%
GSHP	--	2%	--	5%	--	--	--	1%
PTHP	--	--	--	--	3%	3%	--	<1%
VRF Heat Pump	--	--	2%	--	--	--	--	<1%
Wall Furnace/Space Heater	--	--	2%	--	--	--	--	<1%
WSHP	2%	--	--	--	--	--	--	<1%
Self-Audit Results Only								
n-value	*10*	*28*	*21*	*21*	*21*	*15*	*19*	*135*
Furnace	50%	11%	81%	48%	52%	73%	37%	39%
ASHP	30%	18%	10%	19%	14%	13%	32%	22%
Boiler	10%	32%	--	14%	24%	7%	11%	17%
Electric baseboard	--	32%	--	10%	--	--	16%	13%
GSHP	10%	4%	--	10%	10%	7%	0%	7%
Mini-split	--	4%	10%	--	--	--	5%	3%
Total On-site and Self-Audit								
n-value	*54*	*68*	*64*	*62*	*60*	*47*	*59*	*414*
Furnace	54%	15%	77%	47%	48%	77%	51%	44%
Boiler	24%	31%	11%	8%	22%	2%	10%	21%
ASHP	19%	24%	6%	24%	12%	17%	19%	19%
Electric baseboard	--	24%	--	11%	12%	--	17%	10%
GSHP	2%	3%	--	6%	3%	2%	--	3%
Mini-split	--	4%	3%	3%	2%	--	3%	2%
PTHP	--	--	--	--	2%	2%	--	<1%
VRF Heat Pump	--	--	2%	--	--	--	--	<1%
Wall Furnace/Space Heater	--	--	2%	--	--	--	--	<1%
WSHP	2%	--	--	--	--	--	--	<1%

* Totals may not equal sum of column or row due to rounding.

Table 204: Primary System Location by EDC

(Base = Systems)

Location	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*45*	*55*	*39*	*44*	*48*	*35*	*68*	*334*
Conditioned Area/Conditioned Crawl Space	67%	69%	62%	64%	81%	60%	81%	68%
Unconditioned Basement/Enclosed Crawl Space	31%	22%	35%	36%	17%	40%	18%	28%
Attic	2%	4%	2%	--	2%	--	1%	3%
Garage or Open Crawl Space	--	5%	--	--	--	--	--	2%
Self-Audit Results Only								
n-value	*10*	*35*	*22*	*25*	*26*	*21*	*27*	*166*
Unconditioned Basement/Enclosed Crawl Space	57%	48%	59%	67%	59%	64%	40%	53%
Conditioned Area/Conditioned Crawl Space	43%	48%	41%	33%	41%	36%	50%	45%
Garage or Open Crawl Space	--	4%	--	--	--	--	--	3%
Total On-site and Self-Audit								
n-value	*55*	*90*	*61*	*69*	*74*	*56*	*95*	*500*
Conditioned Area/Conditioned Crawl Space	63%	63%	55%	55%	70%	53%	74%	64%
Unconditioned Basement/Enclosed Crawl Space	35%	29%	43%	45%	28%	47%	23%	32%
Attic	2%	3%	2%	--	--	--	1%	2%
Garage or Open Crawl Space	--	5%	--	--	--	--	2%	2%

* Totals may not equal sum of column or row due to rounding.

Table 205: Heating Equipment Vintages by EDC

(Base = Systems)

Vintage	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*46*	*36*	*39*	*44*	*34*	*41*	*35*	*275*
2019 to 2023	26%	28%	10%	32%	3%	20%	29%	22%
2016 to 2018	20%	14%	18%	7%	21%	15%	6%	16%
2011 to 2015	13%	14%	18%	25%	15%	29%	20%	16%
2006 to 2010	22%	17%	18%	11%	21%	17%	20%	19%
2001 to 2005	13%	8%	15%	11%	24%	5%	11%	13%
1991 to 2000	4%	17%	15%	11%	15%	15%	11%	11%
1981 to 1990	--	3%	3%	--	3%	--	3%	1%
1980 or earlier	2%	--	3%	2%	--	--	--	1%
Self-Audit Results Only								
n-value	*9*	*17*	*13*	*10*	*18*	*8*	*14*	*89*
2019 to 2023	44%	6%	31%	40%	6%	12%	36%	28%
2016 to 2018	--	24%	23%	10%	22%	--	14%	12%
2011 to 2015	11%	29%	23%	10%	11%	25%	7%	16%
2006 to 2010	--	12%	8%	20%	28%	--	7%	9%
2001 to 2005	33%	12%	15%	10%	17%	38%	7%	21%
1991 to 2000	11%	12%	--	10%	11%	12%	21%	11%
1981 to 1990	--	6%	--	--	6%	12%	7%	3%
Total On-Site and Self-Audit								
n-value	*55*	*53*	*52*	*54*	*52*	*49*	*49*	*364*

2019 to 2023	29%	21%	15%	33%	4%	18%	31%	24%
2016 to 2018	16%	17%	19%	7%	21%	12%	8%	16%
2011 to 2015	13%	19%	19%	22%	13%	29%	16%	16%
2006 to 2010	18%	15%	15%	13%	23%	14%	16%	17%
2001 to 2005	16%	9%	15%	11%	21%	10%	10%	14%
1991 to 2000	5%	15%	12%	11%	13%	14%	14%	10%
1981 to 1990	--	4%	2%	--	4%	2%	4%	2%
1980 or earlier	2%	--	2%	2%	--	--	--	1%

* Totals may not equal sum of column or row due to rounding.

Table 206: ENERGY STAR Status by EDC

(Base = Systems)

ENERGY STAR	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
Onsite Results Only								
n-value	*59*	*74*	*52*	*71*	*71*	*58*	*93*	*478*
Yes	44%	32%	48%	56%	30%	53%	24%	40%
No	56%	68%	52%	44%	70%	47%	76%	60%
Self-Audit Results Only								
n-value	*9*	*21*	*10*	*17*	*23*	*14*	*16*	*110*
Yes	78%	24%	80%	59%	43%	71%	50%	56%
No	22%	76%	20%	41%	57%	29%	50%	44%
Total On-site and Self-Audit								
n-value	*68*	*95*	*62*	*88*	*94*	*72*	*109*	*588*
Yes	49%	31%	53%	57%	33%	57%	28%	42%
No	51%	69%	47%	43%	67%	43%	72%	58%

* Totals may not equal sum of column or row due to rounding.

Table 207: Residential Heating System AFUE by Status by EDC
(Base = Systems)

AFUE	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*35*	*16*	*32*	*22*	*26*	*28*	*22*	*181*
Min	79.0	80.0	79.0	80.0	80.0	75.0	68.0	68.0
Max	97.7	97.0	96.7	97.0	98.0	96.7	96.0	98.0
Mean	**86.3**	**88.6**	**90.2**	**91.7**	**89.1**	**92.6**	**90.0**	**88.6**
Median	83.0	86.2	92.5	92.1	92.0	95.0	92.0	92.0
Std. Dev.	7.1	5.8	6.6	4.8	6.3	5.4	6.8	6.5
Self-Audit Results Only								
n-value	*5*	*6*	*7*	*9*	*12*	*7*	*7*	*53*
Min	80.0	80.0	80.0	80.0	71.0	81.4	64.0	64.0
Max	96.0	85.1	96.0	96.8	96.0	96.7	97.0	97.0
Mean	**87.0**	**82.5**	**92.6**	**89.5**	**86.0**	**92.7**	**87.7**	**87.0**
Median	86.1	82.5	95.0	92.0	83.0	95.0	92.1	92.0
Std. Dev.	6.9	1.9	5.7	6.0	7.9	5.3	11.6	7.5
Total On-site and Self-Audit								
n-value	*40*	*22*	*39*	*31*	*38*	*35*	*29*	*234*
Min	79.0	80.0	79.0	80.0	71.0	75.0	64.0	64.0
Max	97.7	97.0	96.7	97.0	98.0	96.7	97.0	98.0
Mean	**86.4**	**86.9**	**90.6**	**91.1**	**88.1**	**92.7**	**89.4**	**88.1**
Median	83.5	85.0	93.0	92.0	92.0	95.0	92.1	92.0
Std. Dev.	7.0	5.7	6.5	5.1	6.9	5.3	8.0	6.7

Table 208: Residential Grade Furnaces (Fossil Fueled) by EDC

(Base = Systems)

AFUE	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*25*	*7*	*28*	*21*	*18*	*28*	*20*	*147*
Min	80.0	80.0	79.0	80.0	80.0	75.0	68.0	68.0
Max	97.7	97.0	96.7	97.0	98.0	96.7	96.0	98.0
Mean	**86.6**	**91.9**	**91.6**	**92.1**	**89.9**	**92.6**	**90.6**	**89.6**
Median	80.0	96.0	93.0	92.1	92.0	95.0	92.1	92.1
Std. Dev.	7.7	6.5	5.8	4.5	6.3	5.4	6.8	6.4
Self-Audit Results Only								
n-value	*4*	*2*	*7*	*6*	*8*	*6*	*5*	*38*
Min	80.0	80.0	80.0	80.0	71.0	92.0	64.0	64.0
Max	96.0	83.0	96.0	96.8	95.0	96.7	97.0	97.0
Mean	**87.2**	**81.5**	**92.6**	**90.8**	**86.2**	**94.6**	**88.8**	**88.0**
Median	86.5	81.5	95.0	92.0	87.5	95.5	95.0	92.0
Std. Dev.	8.0	2.1	5.7	5.6	8.8	2.1	14.0	8.0
Total On-site and Self-Audit								
n-value	*29*	*9*	*35*	*27*	*26*	*34*	*25*	*185*
Min	80.0	80.0	79.0	80.0	71.0	75.0	64.0	64.0
Max	97.7	97.0	96.7	97.0	98.0	96.7	97.0	98.0
Mean	**86.7**	**89.6**	**91.8**	**91.8**	**88.8**	**93.0**	**90.2**	**89.1**
Median	81.0	92.1	94.0	92.0	92.0	95.0	92.1	92.1
Std. Dev.	7.6	7.3	5.7	4.7	7.2	5.0	8.4	6.7

Table 209: Residential Grade Natural Gas Furnace AFUE by EDC

(Base = Systems)

AFUE	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*22*	*5*	*28*	*13*	*13*	*26*	*20*	*127*
Min	80.0	80.0	79.0	90.0	80.0	75.0	68.0	68.0
Max	97.7	97.0	96.7	97.0	98.0	96.7	96.0	98.0
Mean	**87.1**	**92.2**	**91.6**	**93.5**	**91.8**	**92.7**	**90.6**	**90.2**
Median	80.0	96.0	93.0	92.2	92.1	95.0	92.1	93.0
Std. Dev.	8.0	7.1	5.8	2.2	5.5	5.6	6.8	6.3
Self-Audit Results Only								
n-value	*3*	*1*	*7*	*6*	*5*	*6*	*5*	*33*
Min	80.0	80.0	80.0	80.0	71.0	92.0	64.0	64.0
Max	96.0	80.0	96.0	96.8	95.0	96.7	97.0	97.0
Mean	**89.3**	**80.0**	**92.6**	**90.8**	**89.2**	**94.6**	**88.8**	**89.4**
Median	92.0	80.0	95.0	92.0	93.0	95.5	95.0	93.0
Std. Dev.	8.3	NA	5.7	5.6	10.3	2.1	14.0	7.9
Total On-site and Self-Audit								
n-value	*25*	*6*	*35*	*19*	*18*	*32*	*25*	*160*
Min	80.0	80.0	79.0	80.0	71.0	75.0	64.0	64.0
Max	97.7	97.0	96.7	97.0	98.0	96.7	97.0	98.0
Mean	**87.4**	**90.2**	**91.8**	**92.6**	**91.1**	**93.1**	**90.2**	**89.9**
Median	80.0	94.0	94.0	92.1	92.5	95.0	92.1	93.0
Std. Dev.	7.9	8.1	5.7	3.7	6.9	5.2	8.4	6.7

Table 210: Residential Grade Propane Furnace AFUE by EDC

(Base = Systems, Site Visits)

AFUE	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	Statewide
n-value		*1*	*--*	*6*	*3*	*2*	*12*
Min		96.0	--	80.0	80.0	92.0	80.0
Max		96.0	--	96.0	93.0	92.0	96.0
Mean		**96.0**	**--**	**91.8**	**88.0**	**92.0**	**91.3**
Median		96.0	--	93.5	91.0	92.0	92.0
Std. Dev.		NA	--	6.1	7.0	0.0	5.6

Table 211: Residential Grade Boilers (Fossil Fueled) by EDC

(Base = Systems)

AFUE	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*10*	*9*	*4*	*1*	*8*	*0*	*2*	*34*
Min	79.0	81.2	79.0	83.4	80.1	--	83.2	79.0
Max	95.0	95.0	82.0	83.4	95.0	--	85.3	95.0
Mean	**85.3**	**86.0**	**80.3**	**83.4**	**87.3**	**--**	**84.2**	**85.6**
Median	83.6	85.0	80.2	83.4	84.5	--	84.2	84.1
Std. Dev.	5.6	3.9	1.2	NA	6.2	--	1.5	5.0
Self-Audit Results Only								
n-value	*1*	*4*	*0*	*3*	*4*	*1*	*2*	*15*
Min	86.1	81.2	--	82.6	80.2	81.4	84.0	80.2
Max	86.1	85.1	--	95.0	96.0	81.4	85.5	96.0
Mean	**86.1**	**83.1**	**--**	**87.0**	**85.5**	**81.4**	**84.8**	**85.0**
Median	86.1	83.0	--	83.4	82.9	81.4	84.8	83.4
Std. Dev.	NA	1.8	--	6.9	7.1	NA	1.1	4.6
Total On-site and Self-Audit								
n-value	*11*	*13*	*4*	*4*	*12*	*1*	*4*	*49*
Min	79.0	81.2	79.0	82.6	80.1	81.4	83.2	79.0
Max	95.0	95.0	82.0	95.0	96.0	81.4	85.5	96.0
Mean	**85.4**	**85.1**	**80.3**	**86.1**	**86.7**	**81.4**	**84.5**	**85.4**
Median	84.3	84.6	80.2	83.4	84.0	81.4	84.6	84.0
Std. Dev.	5.4	3.6	1.2	5.9	6.2	NA	1.1	4.8

Table 212: Residential Grade Natural Gas Boiler AFUE by EDC

(Base = Systems)

AFUE	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*7*	*2*	*4*	*0*	*4*	*0*	*1*	*18*
Min	79.0	84.0	79.0	--	81.7	--	85.3	79.0
Max	95.0	95.0	82.0	--	95.0	--	85.3	95.0
Mean	**85.1**	**89.5**	**80.3**	**--**	**91.3**	**--**	**85.3**	**86.3**
Median	82.0	89.5	80.2	--	94.2	--	85.3	82.5
Std. Dev.	6.9	7.8	1.2	--	6.4	--	NA	6.6
Self-Audit Results Only								
n-value	*0*	*2*	*0*	*1*	*3*	*1*	*1*	*8*
Min	--	81.2	--	95.0	80.2	81.4	84.0	80.2
Max	--	82.0	--	95.0	83.0	81.4	84.0	95.0
Mean	**--**	**81.6**	**--**	**95.0**	**82.0**	**81.4**	**84.0**	**83.5**
Median	--	81.6	--	95.0	82.8	81.4	84.0	82.4
Std. Dev.	--	0.6	--	NA	1.6	NA	NA	4.7
Total On-site and Self-Audit								
n-value	*7*	*4*	*4*	*1*	*7*	*1*	*2*	*26*
Min	79.0	81.2	79.0	95.0	80.2	81.4	84.0	79.0
Max	95.0	95.0	82.0	95.0	95.0	81.4	85.3	95.0
Mean	**85.1**	**85.5**	**80.3**	**95.0**	**87.3**	**81.4**	**84.6**	**85.6**
Median	82.0	83.0	80.2	95.0	83.0	81.4	84.6	82.4
Std. Dev.	6.9	6.4	1.2	NA	6.8	NA	0.9	6.1

Table 213: ASHP and Ductless Mini Split HSPF by EDC

(Base = Systems)

HSPF	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*12*	*15*	*4*	*20*	*6*	*9*	*8*	*74*
Min	6.3	5.1	5.8	5.9	6.5	6.5	5.9	5.1
Max	8.5	8.9	7.3	9.6	8.9	10.2	9.3	10.2
Mean	**7.3**	**7.5**	**6.6**	**7.7**	**7.7**	**7.8**	**7.5**	**7.5**
Median	7.2	7.2	6.7	7.7	7.6	7.2	7.4	7.2
Std. Dev.	0.6	1.0	0.7	1.0	0.9	1.1	1.1	1.0
Self-Audit Results Only								
n-value	*2*	*4*	*2*	*4*	*5*	*2*	*4*	*23*
Min	7.6	6.9	8.5	6.9	6.9	6.8	5.9	5.9
Max	7.6	9.9	9.5	8.5	7.6	6.9	7.9	9.9
Mean	**7.6**	**8.4**	**9.0**	**7.4**	**7.1**	**6.9**	**7.2**	**7.7**
Median	7.6	8.3	9.0	7.1	6.9	6.9	7.4	7.2
Std. Dev.	0.0	1.5	0.7	0.7	0.3	0.1	0.9	1.0
Total On-site and Self-Audit								
n-value	*14*	*19*	*6*	*24*	*11*	*11*	*12*	*97*
Min	6.3	5.1	5.8	5.9	6.5	6.5	5.9	5.1
Max	8.5	9.9	9.5	9.6	8.9	10.2	9.3	10.2
Mean	**7.4**	**7.7**	**7.4**	**7.7**	**7.5**	**7.6**	**7.4**	**7.5**
Median	7.2	7.2	7.1	7.4	7.2	7.2	7.4	7.2
Std. Dev.	0.6	1.2	1.4	0.9	0.8	1.1	1.0	1.0

Table 214: ECM Motors in All Furnaces By EDC

(Base = Systems)

ECM	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*26*	*8*	*34*	*21*	*19*	*29*	*23*	*160*
Yes	64%	57%	58%	57%	44%	55%	35%	54%
No	36%	43%	42%	43%	56%	45%	65%	46%
Self-Audit Results Only								
n-value	*5*	*3*	*17*	*13*	*14*	*16*	*11*	*79*
Yes	40%	33%	38%	23%	27%	47%	50%	34%
No	60%	67%	62%	77%	73%	53%	50%	66%
Total On-site and Self-Audit								
n-value	*31*	*11*	*51*	*34*	*33*	*45*	*34*	*239*
Yes	60%	50%	51%	44%	38%	52%	39%	51%
No	40%	50%	49%	56%	62%	48%	61%	49%

Table 215: Heating Capacity per Square Foot of Conditioned Floor Area (BTUh /sq.ft.) by EDC

(Base = Homes, Site Visits)

BTUh/sq.ft.	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
n-value	*40*	*38*	*36*	*39*	*38*	*31*	*39*	*261*
Min	10.3	4.5	16.5	8.1	2.8	3.4	7.0	2.8
Max	111.9	115.7	96.9	108.7	104.0	83.7	100.5	115.7
Mean	**41.2**	**36.5**	**45.8**	**31.4**	**39.4**	**36.4**	**39.2**	**38.7**
Median	40.6	30.8	42.5	26.7	36.2	36.5	34.0	35.6
Std. Dev.	19.9	23.2	19.3	18.7	24.6	18.8	24.4	21.6

Table 216: Supplemental Heating Fuel by EDC

(Base = Systems, Site Visits)

Fuel	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
n-value	*16*	*24*	*16*	*32*	*28*	*29*	*28*	*173*
Electric	58%	48%	86%	65%	67%	46%	56%	56%
Natural Gas	8%	14%	7%	13%	4%	46%	30%	16%
Wood - logs	33%	14%	--	3%	7%	8%	4%	13%
Propane	--	14%	--	13%	19%	--	4%	9%
Wood - pellets	--	0%	7%	3%	4%	--	7%	3%
Oil	--	5%	--	3%	--	--	--	2%
Coal	--	5%	--	--	--	--	--	1%

* Totals may not equal sum of column or row due to rounding.

Table 217: Supplemental Heating Equipment by EDC

(Base = Systems)

Type	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
n-value	*16*	*24*	*16*	*32*	*28*	*29*	*28*	*173*
Fireplace insert/Wood stove	44%	38%	20%	19%	32%	34%	32%	35%
Electric baseboard	6%	17%	--	38%	25%	7%	11%	14%
Portable space heater	--	4%	60%	6%	21%	14%	36%	14%
Open hearth/fireplace	19%	17%	--	9%	--	21%	14%	13%
ASHP	19%	4%	--	12%	4%	3%	--	7%
Wall Furnace/Space Heater	--	8%	--	0%	7%	3%	7%	5%
Furnace	--	4%	--	12%	7%	7%	--	4%
Mini-split	6%	--	19%	3%	4%	7%	--	4%
Electric radiant surface	6%	4%	--	--	--	3%	--	2%
Boiler	--	4%	--	--	--	--	--	1%

* Totals may not equal sum of column or row due to rounding.

G.3 Cooling Equipment

Table 218: Cooling System Penetration by EDC

(Base: Home, Site Visits)

Type	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
n-value	*44*	*41*	*44*	*43*	*41*	*32*	*41*	*286*
Central Air-split	50%	22%	55%	40%	39%	69%	44%	44%
Room Air Conditioner	25%	29%	25%	14%	15%	6%	34%	23%
ASHP	23%	27%	2%	30%	12%	22%	15%	21%
Mini-split	--	5%	--	5%	2%	--	2%	2%
GSHP	--	2%	--	5%	--	--	--	1%

PTHP	--	2%	--	--	2%	3%	--	1%
Chiller	--	--	2%	--	--	--	--	<1%
Portable AC	--	--	--	--	2%	--	--	<1%
PTAC	--	--	2%	--	--	--	--	<1%
VRF Heat Pump	--	--	2%	--	--	--	--	<1%
WSHP	2%	--	--	--	--	--	--	<1%
None	--	12%	11%	7%	27%	--	5%	7%

* Totals may not equal sum of column or row due to rounding.

Table 219: Residential Permanent Cooling System Penetration by EDC

(Base: Homes, Site Visits)

System Type	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
n-value	*44*	*41*	*44*	*43*	*41*	*32*	*41*	*286*
Central Air-split	50%	20%	50%	37%	32%	66%	41%	42%[1]
ASHP	23%	27%	5%	30%	10%	22%	15%	21%
Mini-split	--	5%	--	5%	2%	--	2%	2%
GSHP	--	2%	--	5%	--	--	--	1%
PTHP	--	5%	--	--	2%	--	--	1%
PTAC	--	--	2%	--	--	--	--	<1%
None	27%	41%	43%	23%	54%	12%	41%	33%

[1]This table excludes commercial and shared equipment which explains the difference in central air-splits from the space cooling penetration.
* Totals may not equal sum of column or row due to rounding.

Table 220: Permanent Cooling Vintages by EDC

(Base: Systems)

Vintage	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*39*	*27*	*32*	*40*	*23*	*38*	*27*	*226*
2019 to 2023	38%	37%	22%	36%	20%	19%	31%	32%
2016 to 2018	19%	11%	9%	8%	30%	8%	8%	14%
2011 to 2015	16%	22%	22%	26%	15%	22%	27%	21%
2006 to 2010	19%	19%	19%	8%	10%	16%	8%	15%
2001 to 2005	5%	7%	16%	13%	10%	8%	12%	10%
1991 to 2000	--	--	12%	10%	15%	27%	15%	7%
1981 to 1990	3%	4%	--	--	--	--	--	2%
1980 or earlier	--	--	--	--	--	--	--	--
Self-Audit Results Only								
n-value	*9*	*17*	*16*	*21*	*12*	*12*	*12*	*99*
2019 to 2023	29%	29%	43%	38%	30%	8%	30%	34%
2016 to 2018	--	36%	21%	12%	50%	42%	30%	20%
2011 to 2015	43%	21%	7%	25%	10%	8%	10%	25%
2006 to 2010	14%	14%	7%	--	--	17%	20%	13%
2001 to 2005	14%	--	7%	25%	10%	8%	--	6%
1991 to 2000	--	--	14%	--	--	17%	10%	3%
1980 or earlier	--	--	--	--	--	--	--	--
Total On-Site and Self Audit								
n-value	*48*	*44*	*48*	*61*	*35*	*50*	*39*	*325*
2019 to 2023	36%	34%	28%	36%	23%	16%	31%	33%
2016 to 2018	16%	20%	13%	9%	37%	16%d	14%	17%
2011 to 2015	20%	22%	17%	25%	13%	18%	22%	21%
2006 to 2010	18%	17%	15%	5%	7%	16%	11%	14%
2001 to 2005	7%	5%	13%	16%	10%	8%	8%	9%
1991 to 2000	--	--	13%	7%	10%	24%	14%	5%
1981 to 1990	2%	2%	--	--	--	--	--	2%

1980 or earlier	--	--	--	--	--	--	--	--

* Totals may not equal sum of column or row due to rounding.

Table 221: Permanent Cooling ENERGY STAR Status by EDC

(Base: Systems)

ENERGY STAR	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
Onsite Results Only								
n-value	*39*	*27*	*31*	*39*	*19*	*37*	*26*	*218*
Yes	46%	67%	19%	59%	37%	32%	42%	50%
No	54%	33%	81%	41%	63%	68%	58%	50%
Self-Audit Results Only								
n-value	*7*	*14*	*14*	*19*	*12*	*11*	*12*	*89*
Yes	71%	50%	57%	32%	42%	27%	67%	57%
No	29%	50%	43%	68%	58%	73%	33%	43%
Total On-site and Self-Audit								
n-value	*46*	*41*	*45*	*58*	*31*	*48*	*38*	*307*
Yes	50%	61%	31%	50%	39%	31%	50%	51%
No	50%	39%	69%	50%	61%	69%	50%	49%

Table 222: Permanent Cooling System SEER2 Rating by EDC

(Base: Systems)

	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*39*	*23*	*30*	*36*	*18*	*36*	*26*	*208*
Min	10.0	9.0	9.0	10.0	10.0	10.0	10.0	9.0
Max	18.0	19.0	15.0	19.0	20.0	20.0	18.0	20.0
Mean	**13.8**	**14.7**	**12.7**	**14.2**	**14.1**	**13.0**	**13.2**	**13.8**
Median	14.0	14.0	13.0	14.0	13.5	13.0	13.0	14.0
Std. Dev.	1.6	2.1	1.4	2.7	2.5	2.5	2.1	2.3
Self-Audit Results Only								
n-value	*5*	*5*	*5*	*12*	*7*	*8*	*6*	*48*
Min	10.5	13.5	13.5	9.5	12.7	9.4	10.3	9.4
Max	15.9	19.9	19.0	16.7	15.5	16.3	15.3	19.9
Mean	**13.6**	**15.9**	**15.7**	**13.6**	**13.7**	**13.2**	**14.1**	**14.4**
Median	13.5	13.5	15.1	13.5	13.5	13.5	14.7	13.5
Std. Dev.	2.2	3.3	2.5	1.8	1.0	1.9	1.9	2.1
Total On-Site and Self-Audit								
n-value	*44*	*28*	*35*	*48*	*25*	*44*	*32*	*256*
Min	10.0	9.0	9.0	10.0	10.0	9.0	10.0	9.0
Max	18.0	20.0	19.0	19.0	20.0	20.0	18.0	20.0
Mean	**13.8**	**15.0**	**13.1**	**14.1**	**14.1**	**13.0**	**13.3**	**13.9**
Median	14.0	14.0	13.0	14.0	14.0	13.0	14.0	14.0
Std. Dev.	1.7	2.3	1.9	2.5	2.2	2.4	2.1	2.2

Table 223: Central Air Conditioner SEER Rating by EDC

(Base: Systems)

	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*27*	*8*	*24*	*16*	*12*	*27*	*18*	*132*
Min	10.3	12.7	10.3	9.5	9.7	9.5	9.7	9.5
Max	15.9	15.5	15.1	15.7	15.5	15.9	14.9	15.9
Mean	**13.5**	**14.0**	**12.7**	**12.5**	**13.1**	**12.2**	**12.5**	**13.1**
Median	13.5	13.9	12.7	12.7	12.9	12.6	12.7	12.7

Std. Dev.	1.5	1.1	1.0	1.8	1.5	1.8	1.6	1.6
Self-Audit Results Only								
n-value	*3*	*1*	*3*	*8*	*2*	*5*	*2*	*24*
Min	10.5	13.5	13.5	9.5	12.7	9.4	14.3	9.4
Max	13.5	13.5	15.1	15.1	12.7	13.9	15.1	15.1
Mean	**12.2**	**13.5**	**14.1**	**13.1**	**12.7**	**12.4**	**14.7**	**13.2**
Median	12.7	13.5	13.5	13.3	12.7	12.7	14.7	13.5
Std. Dev.	1.6	NA	0.9	1.8	0.0	1.8	0.6	1.6
Total On-site and Self-Audit								
n-value	*30*	*9*	*27*	*24*	*14*	*32*	*20*	*156*
Min	10.3	12.7	10.3	9.5	9.7	9.4	9.7	9.4
Max	15.9	15.5	15.1	15.7	15.5	15.9	15.1	15.9
Mean	**13.3**	**14.0**	**12.8**	**12.7**	**13.1**	**12.2**	**12.7**	**13.2**
Median	13.5	13.5	12.7	12.9	12.7	12.6	12.7	12.7
Std. Dev.	1.5	1.0	1.1	1.8	1.4	1.7	1.7	1.6

Table 224: ASHP/Ductless Mini Split SEER2 Rating by EDC

(Base: Systems)

	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*12*	*15*	*5*	*20*	*6*	*9*	*8*	*75*
Min	12.7	8.6	10.3	10.3	10.3	10.3	10.3	8.6
Max	18.3	19.1	13.9	19.1	20.3	19.9	18.5	20.3
Mean	**14.7**	**14.8**	**12.7**	**15.5**	**15.5**	**15.3**	**14.5**	**14.8**
Median	14.3	14.3	12.8	15.5	15.5	14.3	13.9	14.3
Std. Dev.	1.7	2.6	1.4	2.6	3.5	2.9	2.5	2.5
Self-Audit Results Only								
n-value	*2*	*4*	*2*	*4*	*5*	*2*	*4*	*23*
Min	15.3	13.5	17.5	13.5	13.5	13.5	10.3	10.3
Max	15.9	19.9	19.0	16.7	15.5	13.7	15.3	19.9
Mean	**15.6**	**16.5**	**18.3**	**14.7**	**14.1**	**13.6**	**13.8**	**15.5**
Median	15.6	16.3	18.3	14.3	13.5	13.6	14.7	14.3
Std. Dev.	0.4	3.5	1.0	1.4	0.9	0.1	2.3	2.2
Total On-site and Self-Audit								

n-value	*14*	*19*	*7*	*24*	*11*	*11*	*12*	*98*
Min	12.7	8.6	10.3	10.3	10.3	10.3	10.3	8.6
Max	18.3	19.9	19.0	19.1	20.3	19.9	18.5	20.3
Mean	**14.8**	**15.2**	**14.3**	**15.4**	**14.8**	**15.0**	**14.2**	**14.8**
Median	14.4	14.3	13.5	14.9	14.3	14.3	14.3	14.3
Std. Dev.	1.6	2.8	3.0	2.5	2.6	2.7	2.3	2.4

Table 225: Permanent Cooling System Capacity by EDC (BTUh/sq.ft.)

(Base: Permanent Cooling Systems, Site Visits)

	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
n-value	*32*	*24*	*25*	*33*	*19*	*28*	*24*	*185*
Min	6.4	8.3	9.7	6.6	6.9	3.2	7.5	3.2
Max	73.8	28.2	35.3	37.0	37.5	26.5	39.4	73.8
Mean	**19.2**	**16.3**	**16.1**	**14.8**	**15.8**	**15.5**	**16.3**	**15.8**
Median	17.4	16.6	15.9	13.6	12.7	15.0	13.8	14.5
Std. Dev.	13.9	4.8	5.5	5.9	8.9	6.6	7.5	8.3

Table 226: Room Air Conditioner Saturation by EDC

(Base: Homes, Site Visits)

Count	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
n	*44*	*41*	*44*	*43*	*41*	*32*	*41*	*286*
0	75%	71%	75%	86%	85%	94%	66%	77%
1	16%	12%	14%	5%	10%	6%	22%	12%
2	5%	5%	7%	9%	5%	--	7%	5%
3+	5%	12%	5%	--	--	--	5%	6%

* Totals may not equal sum of column or row due to rounding.

Table 227: Room Air Conditioner Vintages by EDC

(Base: Room Air Conditioners)

Vintage	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*20*	*27*	*18*	*10*	*8*	*2*	*21*	*106*
2019 to 2023	28%	17%	47%	60%	--	50%	31%	26%
2016 to 2018	22%	13%	33%	40%	--	50%	6%	16%
2011 to 2015	11%	17%	0%	--	71%	--	12%	16%
2006 to 2010	22%	22%	13%	--	14%	--	19%	20%
2001 to 2005	--	13%	7%	--	14%	--	25%	9%
1991 to 2000	17%	9%	--	--	--	--	6%	9%
1981 to 1990	--	4%	--	--	--	--	--	2%
1980 or earlier	--	4%	--	--	--	--	--	2%
Self-Audit Results Only								
n-value	*6*	*11*	*4*	*5*	*6*	*6*	*13*	*51*
2019 to 2023	--	62%	100%	100%	83%	80%	25%	43%
2016 to 2018	--	12%	--	--	--	--	25%	10%
2011 to 2015	50%	--	--	--	17%	20%	38%	16%
2006 to 2010	--	25%	--	--	--	--	12%	8%
2001 to 2005	25%	--	--	--	--	--	--	11%
1991 to 2000	25%	--	--	--	--	--	--	11%
1980 or earlier	--	--	--	--	--	--	--	--
Total On-Site and Self-Audit								
n-value	*26*	*38*	*22*	*15*	*14*	*8*	*34*	*157*
2019 to 2023	23%	29%	50%	71%	38%	71%	29%	33%
2016 to 2018	18%	13%	31%	29%	0%	14%	12%	14%
2011 to 2015	18%	13%	--	--	46%	14%	21%	16%
2006 to 2010	18%	23%	12%	--	8%	--	17%	18%
2001 to 2005	5%	10%	6%	--	8%	--	17%	8%
1991 to 2000	18%	6%	--	--	--	--	4%	10%
1981 to 1990	--	3%	--	--	--	--	--	1%
1980 or earlier	--	3%	--	--	--	--	--	1%

* Totals may not equal sum of column or row due to rounding.

Table 228: Room Air Conditioner ENERGY STAR Status by EDC

(Base: Room Air Conditioners)

ENERGY STAR	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
Onsite Results Only								
n-value	*19*	*25*	*16*	*6*	*8*	*1*	*19*	*94*
Yes	42%	28%	19%	17%	38%	100%	32%	32%
No	58%	72%	81%	83%	62%	0%	68%	68%
Self-Audit Results Only								
n-value	*5*	*8*	*2*	*5*	*6*	*6*	*13*	*45*
Yes	40%	25%	--	20%	50%	50%	31%	27%
No	60%	75%	100%	80%	50%	50%	69%	73%
Total On-site and Self-Audit								
n-value	*24*	*33*	*18*	*11*	*14*	*7*	*32*	*139*
Yes	42%	27%	17%	18%	43%	57%	31%	32%
No	58%	73%	83%	82%	57%	43%	69%	68%

Table 229: Room Air Conditioner CEER Rating by Home Type

(Base: Room Air Conditioners)

	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
Onsite Results Only								
n-value	*17*	*23*	*14*	*5*	*7*	*2*	*18*	*86*
Min	9.2	8.2	9.0	11.0	8.7	10.0	9.4	8.2
Max	15.0	12.0	12.0	11.3	11.0	15.0	12.1	15.0
Mean	**11.0**	**10.4**	**10.9**	**11.1**	**10.2**	**12.5**	**10.4**	**10.6**
Median	11.0	10.6	10.9	11.1	10.7	12.5	10.3	10.9
Std. Dev.	1.4	0.9	0.8	0.1	0.9	3.5	0.9	1.1
Self-Audit Results Only								
n-value	*6*	*8*	*4*	*5*	*6*	*5*	*13*	*47*
Min	9.5	10.6	8.1	9.7	10.6	8.4	9.4	8.1
Max	11.1	11.4	11.0	11.8	11.0	11.4	12.0	12.0
Mean	**10.2**	**11.0**	**9.9**	**10.9**	**10.9**	**10.6**	**10.5**	**10.6**
Median	10.2	11.0	10.2	11.0	11.0	11.0	10.6	11.0
Std. Dev.	0.7	0.3	1.3	0.8	0.2	1.2	0.8	0.8
Total On-site and Self-Audit								
n-value	*23*	*31*	*18*	*10*	*13*	*7*	*31*	*133*
Min	9.2	8.2	8.1	9.7	8.7	8.4	9.4	8.1
Max	15.0	12.0	12.0	11.8	11.0	15.0	12.1	15.0
Mean	**10.8**	**10.5**	**10.7**	**11.0**	**10.6**	**11.1**	**10.5**	**10.6**
Median	10.7	10.9	10.9	11.0	10.9	11.0	10.6	10.9
Std. Dev.	1.3	0.8	0.9	0.5	0.7	2.0	0.8	1.0

Table 230: Room Air Conditioner Capacity by EDC

(Base = Homes, Site Visits)

	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
n-value	*19*	*25*	*15*	*5*	*8*	*2*	*18*	*92*
Min	5,000	5,000	5,000	5,000	5,000	8,000	5,000	5,000
Max	14,000	18,000	12,000	6,000	10,150	8,000	10,150	18,000
Mean	**7,453**	**7,288**	**7,273**	**5,800**	**7,119**	**8,000**	**6,500**	**7,161**
Median	6,500	6,000	8,000	6,000	5,850	8,000	6,000	6,000
Std. Dev.	2,423	3,493	2,212	447	2,476	0	1,861	2,546

G.4 Water Heating Equipment

Table 231: DHW Fuel Mix by EDC

(Base = Homes)

Fuel	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
Onsite Results Only								
n-value	*43*	*37*	*41*	*38*	*38*	*32*	*41*	*270*
Natural Gas	60%	27%	83%	32%	35%	62%	44%	48%
Electric	35%	57%	17%	61%	59%	38%	56%	45%
Oil	5%	14%	--	--	3%	--	--	5%
Propane	--	3%	--	8%	3%	--	--	2%
Self-Audit Results Only								
n-value	*19*	*24*	*31*	*34*	*30*	*28*	*29*	*195*
Electric	47%	75%	23%	42%	47%	32%	52%	50%
Natural Gas	53%	17%	77%	48%	50%	64%	48%	47%
Propane	--	8%	--	6%	3%	4%	--	3%
Oil	--	--	--	3%	--	--	--	<1%
Total On-site and Self-Audit								
n-value	*62*	*61*	*72*	*72*	*68*	*60*	*70*	*465*
Natural Gas	58%	23%	81%	39%	42%	63%	46%	48%
Electric	39%	64%	19%	52%	54%	35%	54%	47%
Oil	3%	8%	--	1%	1%	--	--	3%
Propane	--	5%	--	7%	3%	2%	--	2%

* Totals may not equal sum of column or row due to rounding.

Table 232: DHW Type and Fuel by EDC

(Base = Systems)

Type and Fuel	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*43*	*37*	*41*	*38*	*38*	*32*	*41*	*270*
Storage, Stand-alone	**81%**	**78%**	**95%**	**87%**	**84%**	**88%**	**98%**	**85%**
Natural Gas	63%	28%	82%	33%	35%	64%	45%	50%
Electric	37%	69%	18%	58%	65%	36%	55%	49%
Propane	--	3%	--	9%	--	--	--	2%
Tankless Coil	**5%**	**14%**	**--**	**--**	**--**	**--**	**--**	**5%**
Oil	100%	100%	–	–	–	–	–	100%
Instantaneous	**5%**	**5%**	**5%**	**3%**	**--**	**6%**	**--**	**3%**

Natural Gas	50%	100%	100%	100%	–	100%	–	89%
Electric	50%	--	--	--	–	--	–	11%
Storage, Heat pump (Electric)	**2%**	**3%**	**--**	**8%**	**5%**	**6%**	**2%**	**3%**
Storage, Indirect heat	**5%**	**--**	**--**	**3%**	**8%**	**--**	**0%**	**3%**
Natural Gas	100%	–	–	--	33%	–	–	69%
Oil	--	–	–	--	33%	–	–	11%
Propane	--	–	–	--	33%	–	–	11%
Electric	--	–	–	100%	--	–	–	9%
Combi Boiler	**2%**	**--**	**--**	**--**	**3%**	**--**	**--**	**1%**
Natural Gas	100%	–	–	–	100%	–	–	100%
Self-Audit Results Only								
n-value	*19*	*24*	*31*	*34*	*30*	*28*	*29*	*195*
Storage, Stand-alone	**95%**	**88%**	**94%**	**82%**	**90%**	**93%**	**97%**	**92%**
Electric	50%	76%	21%	48%	52%	35%	54%	51%
Natural Gas	50%	14%	79%	44%	48%	65%	46%	47%
Propane	--	10%	--	7%	--	--	--	3%
Instantaneous	**5%**	**--**	**--**	**12%**	**3%**	**7%**	**3%**	**3%**
Natural Gas	100%	–	–	100%	100%	50%	100%	98%
Propane	--	–	–	--	--	50%	--	2%
Storage, Heat pump (Electric)	**--**	**4%**	**3%**	**3%**	**--**	**--**	**--**	**2%**
Storage, Indirect heat	**--**	**8%**	**--**	**3%**	**3%**	**--**	**--**	**2%**
Natural Gas	--	50%	–	--	100%	–	–	45%
Electric	--	50%	–	--	--	–	–	32%
Oil	--	--	–	100%	--	–	–	22%
Combi Boiler	**--**	**--**	**3%**	**--**	**3%**	**--**	**--**	**1%**
Natural Gas	–	–	100%	–	0%	–	–	50%
Propane	–	–	--	–	100%	–	–	50%
Total On-Site and Self-Audit								
n-value	*62*	*61*	*72*	*72*	*68*	*60*	*70*	*465*
Storage, Stand-alone	**85%**	**82%**	**94%**	**85%[c]**	**87%[c]**	**90%**	**97%**	**87%**
Electric	42%	72%	19%	53%	59%	35%	54%	50%
Natural Gas	58%	22%	81%	38%	41%	65%	46%	48%
Propane	--	6%	--	8%	--	--	--	2%
Instantaneous	**5%**	**3%**	**3%**	**7%**	**1%**	**7%**	**1%**	**3%**
Natural Gas	67%	100%	100%	100%	100%	75%	100%	91%
Electric	33%	--	--	--	--	--	--	8%
Propane	--	--	--	--	--	25%	--	1%

Storage, Indirect heat	**3%**	**3%**	**--**	**3%**	**6%**	**--**	**--**	**3%**
Natural Gas	100%	50%	–	--	50%	–	–	66%
Electric	--	50%	–	33%	--	–	–	15%
Oil	--	--	–	67%	25%	–	–	14%
Propane	--	--	–	--	25%	–	–	5%
Tankless Coil	**3%**	**8%**	**--**	**--**	**--**	**--**	**--**	**3%**
Oil	100%	100%	–	–	–	–	–	100%
Storage, Heat pump (Electric)	**2%**	**3%**	**1%**	**6%**	**3%**	**3%**	**1%**	**2%**
Combi Boiler	**2%**	**--**	**1%**	**--**	**3%**	**--**	**--**	**1%**
Natural Gas	100%	–	100%	–	50%	–	–	82%
Propane	--	–	--	–	50%	–	–	18%

* Totals may not equal sum of column or row due to rounding.

Table 233: Water Heater Vintages by EDC

(Base = Systems)

Vintage	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*43*	*34*	*35*	*37*	*37*	*33*	*38*	*257*
2019 to 2023	33%	18%	31%	26%	28%	38%	18%	25%
2016 to 2018	19%	24%	20%	31%	19%	12%	18%	22%
2011 to 2015	21%	24%	23%	9%	**14%**	**28%**	**37%**[d,f]	22%
2006 to 2010	23%	15%	14%	17%	17%	9%	8%	17%
2001 to 2005	5%	3%	9%	14%	22%	6%	8%	8%
1991 to 2000	--	15%	3%	3%	--	6%	8%	5%
1981 to 1990	--	--	--	--	--	--	3%	<1%
1980 or earlier	--	--	--	--	--	--	--	--
Self-Audit Results Only								
n-value	*19*	*24*	*31*	*35*	*30*	*28*	*29*	*196*

2019 to 2023	47%	33%	32%	41%	24%	23%	26%	33%
2016 to 2018	13%	11%	14%	10%	16%	8%	4%	13%
2011 to 2015	27%	39%	43%	24%	16%	23%	39%	33%
2006 to 2010	13%	11%[c]	7%	3%	36%	27%	17%	14%
2001 to 2005	--	6%	4%	10%	8%	4%	13%	5%
1991 to 2000	--	--	--	10%	--	12%	--	1%
1981 to 1990	--	--	--	--	--	4%	--	<1%
1980 or earlier	--	--	--	--	--	--	--	--
Total On-Site and Self-Audit								
n-value	*62*	*58*	*66*	*72*	*67*	*61*	*67*	*453*
2019 to 2023	36%	24%	32%	33%	26%	31%	21%	28%
2016 to 2018	17%	20%	17%	22%	18%	10%	13%	18%
2011 to 2015	22%	29%	32%	16%	15%	26%[c]	38%	26%
2006 to 2010	21%	14%	11%	11%	25%	17%	11%	18%
2001 to 2005	3%	4%	6%	12%	16%	5%	10%	7%
1991 to 2000	--	10%	2%	6%	--	9%	5%	4%
1981 to 1990	--	--	--	--	--	2%	2%	<1%
1980 or earlier	--	--	--	--	--	--	--	--

* Totals may not equal sum of column or row due to rounding.

Table 234: Water Heater UEF by EDC

(Base = Systems)

	PECO	PPL	Duquesne	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
Onsite Results Only								

n-value	*38*	*28*	*35*	*32*	*31*	*31*	*38*	*233*
Min	0.57	0.56	0.53	0.54	0.56	0.53	0.54	0.53
Max	3.34	2.48	0.93	3.42	3.71	3.55	0.95	3.71
Mean	**0.88**	**0.89**	**0.66**	**0.89**	**0.92**	**0.92**	**0.79**	**0.83**
Median	0.67	0.92	0.59	0.90	0.92	0.66	0.91	0.89
Std. Dev.	0.61	0.35	0.13	0.48	0.54	0.72	0.16	0.47
Self-Audit Results Only								
n-value	*19*	*20*	*30*	*32*	*28*	*27*	*29*	*185*
Min	0.57	0.57	0.54	0.58	0.55	0.54	0.55	0.54
Max	0.97	2.44	2.52	3.88	0.96	0.97	0.95	3.88
Mean	**0.77**	**0.92**	**0.74**	**0.90**	**0.78**	**0.73**	**0.78**	**0.81**
Median	0.91	0.92	0.66	0.91	0.92	0.63	0.86	0.72
Std. Dev.	0.17	0.38	0.36	0.56	0.16	0.17	0.16	0.33
Total On-site and Self-Audit								
n-value	*57*	*48*	*65*	*64*	*59*	*58*	*67*	*418*
Min	0.57	0.56	0.53	0.54	0.55	0.53	0.54	0.53
Max	3.34	2.48	2.52	3.88	3.71	3.55	0.95	3.88
Mean	**0.84**	**0.90**	**0.69**	**0.90**	**0.85**	**0.83**	**0.79**	**0.82**
Median	0.67	0.92	0.61	0.91	0.92	0.66	0.90	0.87
Std. Dev.	0.51	0.36	0.26	0.52	0.41	0.54	0.16	0.41

Table 235: Water Heater ENERGY STAR Status by EDC

(Base = Systems)

ENERGY STAR	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*38*	*29*	*35*	*37*	*34*	*33*	*38*	*244*
Yes	13%	10%	20%	31%	9%	31%	10%	15%
No	87%	90%	80%	69%	91%	69%	90%	85%
Self-Audit Results Only								
n-value	*19*	*22*	*30*	*33*	*28*	*28*	*29*	*189*
Yes	6%	10%	28%	37%	11%	11%	11%	12%
No	94%	90%[d]	72%	63%	89%	89%	89%	88%
Total On-Site and Self-Audit								
n-value	*57*	*51*	*65*	*70*	*62*	*61*	*67*	*433*
Yes	11%	10%	23%	34%	10%	22%	11%	13%

No	89%	90%	77%	66%	90%	78%	89%	87%

Table 236: Standalone Water Heater Capacity (Gallons) by EDC

(Base = Systems)

Storage Capacity	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
Onsite Results Only								
n-value	*34*	*28*	*33*	*32*	*32*	*28*	*38*	*225*
<40	12%	18%	27%	6%	19%	4%	8%	11%
40 to 55	71%	71%	70%	84%	81%	82%	87%	77%
55 to 75	6%	--	--	3%	--	4%	5%	4%
>75	12%	11%	3%	6%	--	11%	--	8%
Self-Audit Results								
n-value	*18*	*21*	*29*	*28*	*27*	*26*	*28*	*177*
<40	18%	--	28%	4%	4%	--	7%	6%
40 to 55	71%	100%	72%	80%	88%	88%	89%	85%
55 to 75	6%	--	--	12%	4%	4%	--	5%
>75	6%	--	--	4%	4%	8%	4%	4%
Total On-Site and Self-Audit								
n-value	*52*	*49*	*62*	*60*	*59*	*54*	*66*	*402*
<40	14%	10%	27%	5%	12%	2%	8%	10%
40 to 55	71%	84%	71%	82%	84%	85%	88%	79%
55 to 75	6%	--	--	7%	2%	4%	3%	4%
>75	10%	6%	2%	5%	2%	9%	2%	7%

* Totals may not equal sum of column or row due to rounding.

Appendix H Appliance ENERGY STAR Status by EDC

Table 237: Refrigerator ENERGY STAR Status by EDC

(Base = Refrigerators)

ENERGY STAR	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*48*	*44*	*47*	*45*	*53*	*48*	*56*	*341*
Yes	48%	48%	49%	58%	47%	52%	32%	48%
No	52%	52%	51%	42%	53%	48%	68%	52%
Self-Audit Results Only								
n-value	*15*	*28*	*35*	*42*	*37*	*26*	*36*	*219*
Yes	33%	68%	40%	67%	57%	50%	44%	52%
No	67%	32%	60%	33%	43%	50%	56%	48%
Total On-site and Self-Audit								
n-value	*63*	*72*	*82*	*87*	*90*	*74*	*92*	*560*
Yes	44%	56%	45%	62%	51%	51%	37%	49%
No	56%	44%	55%	38%	49%	49%	63%	51%

Table 238: Freezer ENERGY STAR Status by EDC

(Base = Freezers)

ENERGY STAR	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*12*	*11*	*11*	*14*	*17*	*18*	*17*	*100*
Yes	8%	18%	27%	21%	24%	22%	18%	19%
No	92%	82%	73%	79%	76%	78%	82%	81%
Self-Audit Results Only								
n-value	*5*	*9*	*4*	*8*	*12*	*10*	*7*	*55*
Yes	0%	44%	25%	25%	33%	40%	43%	27%
No	100%	56%	75%	75%	67%	60%	57%	73%
Total On-site and Self-Audit								
n-value	*17*	*20*	*15*	*22*	*29*	*28*	*24*	*155*
Yes	6%	30%	27%	23%	28%	29%	25%	22%
No	94%	70%	73%	77%	72%	71%	75%	78%

Table 239: Dishwasher ENERGY STAR Status by EDC

(Base = Dishwashers)

ENERGY STAR	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*36*	*29*	*28*	*30*	*26*	*30*	*28*	*207*
Yes	61%	59%	75%	87%	77%	83%	82%	70%
No	39%	41%	25%	13%	23%	17%	18%	30%
Self-Audit Results Only								
n-value	*13*	*16*	*14*	*27*	*19*	*12*	*18*	*119*
Yes	85%	81%	71%	81%	84%	92%	100%	89%
No	15%	19%	29%	19%	16%	8%	0%	11%
Total On-site and Self-Audit								
n-value	*49*	*45*	*42*	*57*	*45*	*42*	*46*	*326*
Yes	67%	67%	74%	84%	80%	86%	89%	75%
No	33%	33%	26%	16%	20%	14%	11%	25%

Table 240: Clothes Washer ENERGY STAR Status by EDC

(Base = In-home Clothes Washers)

ENERGY STAR	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*38*	*32*	*34*	*33*	*29*	*28*	*31*	*225*
Yes	61%	47%	38%	48%	66%	50%	39%	52%
No	39%	53%	62%	52%	34%	50%	61%	48%
Self-Audit Results Only								
n-value	*12*	*11*	*12*	*20*	*17*	*13*	*14*	*99*
Yes	50%	73%	67%	65%	53%	69%	64%	63%
No	50%	27%	33%	35%	47%	31%	36%	37%
Total On-site and Self-Audit								
n-value	*50*	*43*	*46*	*53*	*46*	*41*	*45*	*324*
Yes	58%	53%	46%	55%	61%	56%	47%	56%
No	42%	47%	54%	45%	39%	44%	53%	44%

Table 241: Clothes Dryer ENERGY STAR Status by EDC

(Base = Clothes Dryers)

ENERGY STAR	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*37*	*31*	*33*	*34*	*31*	*29*	*29*	*224*
Yes	27%	23%	18%	18%	39%	24%	24%	27%
No	73%	77%	82%	82%	61%	76%	76%	73%
Self-Audit Results Only								
n-value	*8*	*12*	*9*	*18*	*18*	*10*	*13*	*88*
Yes	75%	42%	11%	44%	17%	70%	46%	49%
No	25%	58%	89%	56%	83%	30%	54%	51%
Total On-site and Self-Audit								
n-value	45	43	42	52	49	39	42	312
Yes	36%	28%	17%	27%	31%	36%	31%	32%
No	64%	72%	83%	73%	69%	64%	69%	68%

Table 242: Dehumidifier ENERGY STAR Status by EDC

(Base = Dehumidifiers)

ENERGY STAR	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn	Statewide
On-Site Results Only								
n-value	*14*	*10*	*10*	*13*	*19*	*7*	*10*	*83*
Yes	93%	90%	80%	85%	95%	100%	90%	90%
No	7%	10%	20%	15%	5%	0%	10%	10%
Self-Audit Results Only								
n-value	*1*	*4*	*5*	*7*	*7*	*4*	*5*	*33*
Yes	--	100%	80%	100%	86%	75%	60%	70%
No	100%	--	20%	--	14%	25%	40%	30%
Total On-site and Self-Audit								
n-value	*15*	*14*	*15*	*20*	*26*	*11*	*15*	*116*
Yes	87%	93%	80%	90%	92%	91%	80%	87%
No	13%	7%	20%	10%	8%	9%	20%	13%

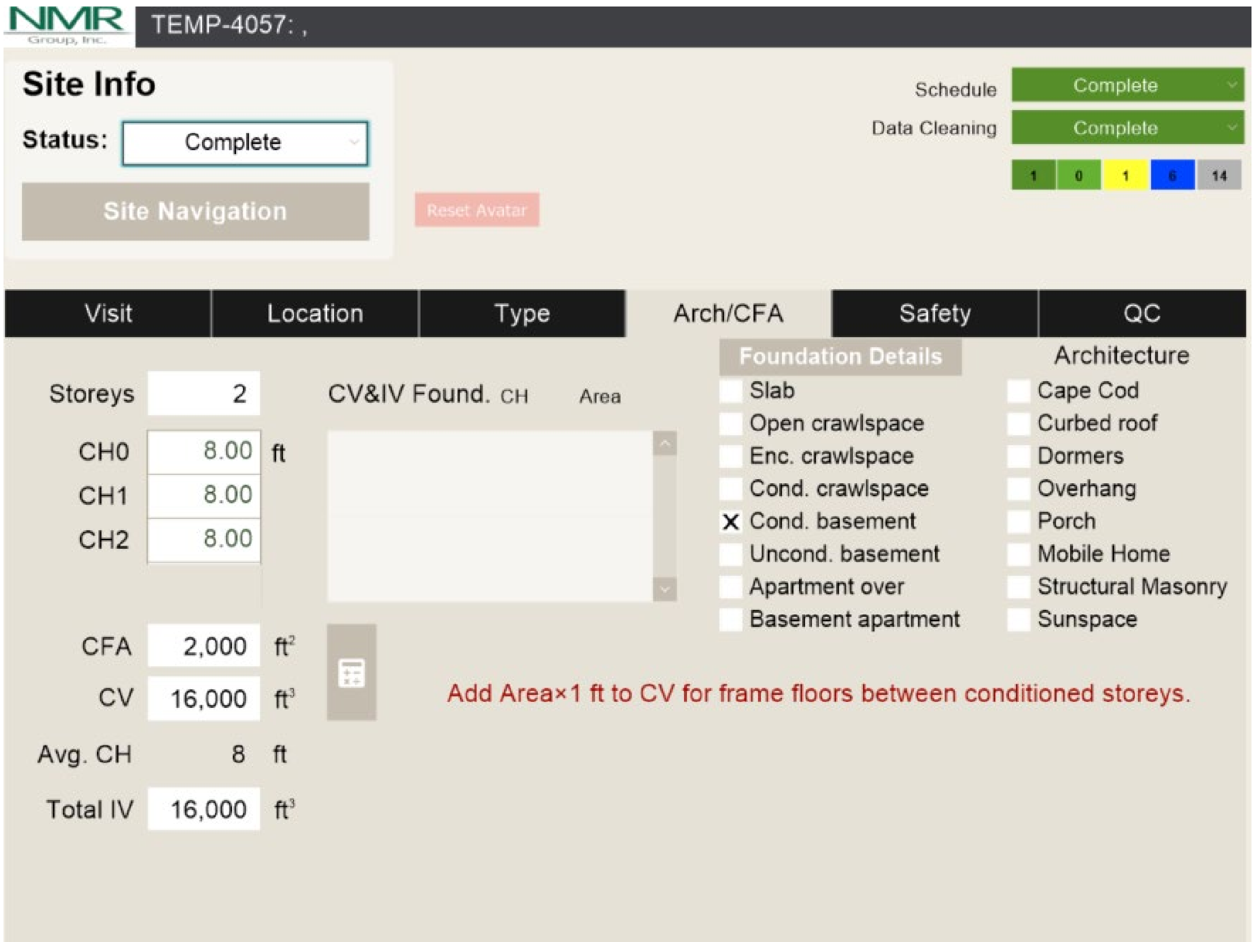
Appendix I Example Screen Shot of Electronic Data Collection Form

This Appendix provides examples of the on-site electronic data collection form and the self-audit tool used in the web-survey.

I.1 On-site Data Collection Form Example

Figure 41 is an example of one of the data collection input pages used to collect data during onsite visits. The screen shown below is the page where the auditor will enter general site information from the visit, including size and foundation type. For more complex homes, inputs such as CFA and CV are calculated after the visit is concluded based on measurements taken onsite. The information shown in the data entry fields is not actual customer data, it is purely for demonstration purposes.

Figure 41: Data Collection Form Example – General Site Information



I.2 Self-Audit Web-Survey Data Collection Example

The self-audit tool makes it easy for anyone to provide useful photos of equipment in their home, including model numbers, by guiding users through the photo-taking process and helping them identify the systems of interest and locate their nameplates. The photos provide a much higher quality of data than a typical telephone or web survey. With photos, certified HERS raters and other technicians verified the accuracy of occupant-reported information and determined other characteristics that would be too technical to ask of occupants, such as detailed system specifications. Sample screen captures of the self-audit tool are provided in Figure 42 and Figure 43.

Figure 42: Self-audit Tool Equipment Selection Prompt

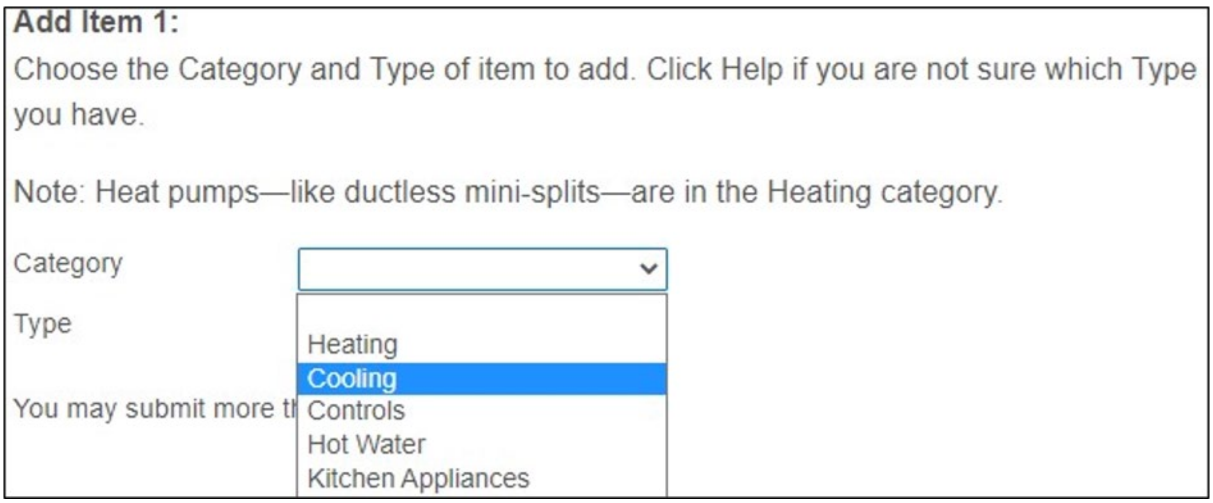


Figure 43:Self-audit Tool Equipment Identification Assistance (Cooling)

Note: Heat pumps—like ductless mini-splits—are in the Heating category.

Click an image to enlarge.

Central air conditioners are ducted, forced-air cooling systems for an entire home.

Conventional **room air conditioners** can be installed in a window or through-the-wall. **Portable** room air conditioners which connect to a window with one or two hoses can also be entered here.

Mini-split air conditioners are ductless cooling systems that have an indoor unit and an outdoor compressor. The indoor unit only produces cold air, and is usually mounted on the wall. Mini-split heat pumps, which also provide heat, should be entered under Heating.

Appendix J Willingness to Pay Results by EDC

Table 243: Adjusted Averages by EDC

(PECO)

Payback Period	CAC	Heat Pump	Clothes Washer	Refrigerator	Insulation	Water Heater	Dehumidifier
Energy Savings Covers the Premium							
8 years	5.5	6.0	5.4	5.7	4.4	5.6	4.1
6 years	6.7	6.9	6.7	6.5	4.1	5.8	4.7
4 years	7.4	7.6	7.1	7.0	5.1	6.2	5.9
2 years	8.2	7.9	8.4	7.3	5.1	7.2	6.8
1 year	8.7	8.5	8.8	8.9	6.6	7.3	7.9
Full utility incentive	8.7	8.9	9.2	8.8	8.1	7.8	7.9
Utility covers 50% of the Premium							
4 years	7.6	7.1	7.2	7.5	4.3	6.7	5.4
2 years	8.3	7.6	7.9	8.0	4.8	7.1	6.5
1 year	8.7	8.4	8.7	8.1	5.9	7.7	7.1
6 months	8.8	8.6	8.9	8.6	6.1	8.0	7.8
Utility Covers 25% of the Premium							
6 years	6.6	6.6	6.0	6.7	4.1	6.6	5.1
3 years	7.0	6.9	7.1	7.7	4.6	7	5.6
1.5 years	7.5	8.1	8.1	8.1	5.4	7.8	6.5
9 months	8.0	7.6	8.6	8.3	5.8	7.8	7.5

Table 244: Adjusted Averages by EDC

(PPL)

Payback Period	CAC	Heat Pump	Clothes Washer	Refrigerator	Insulation	Water Heater	Dehumidifier
Energy Savings Covers the Premium							
8 years	6.3	7.6	6.3	5.4	5.0	6.0	4.6
6 years	7.1	8.0	6.9	7.0	5.4	6.7	5.5
4 years	7.5	8.0	6.8	6.2	6.3	6.9	5.6
2 years	8.6	8.6	7.8	7.8	6.1	7.2	7.0
1 year	8.6	8.8	7.9	8.7	7.0	7.7	6.9
Full utility incentive	9.4	9.0	9.1	9.6	8.4	8.6	8.8
Utility covers 50% of the Premium							
4 years	8.1	8.5	7.9	7.8	6.3	7.1	6.3
2 years	8.2	8.9	8.2	8.1	6.6	7.4	7.3
1 year	8.6	9.0	8.4	9.1	7.4	7.8	7.9
6 months	8.9	9.1	8.8	9.6	7.1	8.1	8.0
Utility covers 25% of the Premium							
6 years	7.0	7.6	7.2	7.4	5.7	7.0	5.6
3 years	7.3	8.1	7.7	7.4	6.3	7.1	6.2
1.5 years	7.9	8.3	7.6	8.4	6.3	7.5	6.8
9 months	8.3	8.7	7.8	8.8	6.6	7.9	7.2

Table 245: Adjusted Averages by EDC

(Duquesne Light)

Payback Period	CAC	Heat Pump	Clothes Washer	Refrigerator	Insulation	Water Heater	Dehumidifier
Energy Savings Covers the Premium							
8 years	5.4	6.9	5.7	6.0	4.1	5.9	4.1
6 years	6.3	7.1	6.0	6.7	4.6	6.6	4.4
4 years	6.9	8.4	6.7	7.3	4.9	6.7	5.4
2 years	7.7	7	7	7.7	5.7	7.9	5.8
1 year	8	8.3	7.7	8.3	7.4	7.9	6.0
Full utility incentive	8.9	10	8.7	9.7	7.9	8.9	7.6
Utility covers 50% of the Premium							
4 years	7.3	8.3	6.9	7.6	5.8	7.0	5.7
2 years	7.8	8.7	7.4	8.1	6.7	7.8	6.2
1 year	8.1	9.1	7.5	9.1	7.4	8.4	7.0
6 months	8.3	9.6	7.9	9.6	7.6	8.5	7.0
Utility Covers 25% of the Premium							
6 years	6.7	7.4	6.5	7.3	4.6	6.2	5.1
3 years	7.0	7.6	7	7.7	5.5	6.6	5.5
1.5 years	7.5	8.1	7.5	8.5	6.1	7.5	6.1
9 months	7.9	8.3	7.6	9.1	6.7	8.6	6.6

Table 243: Adjusted Averages by EDC
(FE: Met-Ed)

Payback Period	CAC	Heat Pump	Clothes Washer	Refrigerator	Insulation	Water Heater	Dehumidifier
Energy Savings Covers the Premium							
8 years	5.8	5.3	6.7	6.3	4.9	6.9	6.0
6 years	7.1	6.0	6.7	7.0	5.5	7.0	5.9
4 years	7.6	6.8	7.1	7.8	5.6	7.4	5.7
2 years	8.1	7.0	8.2	8.3	7.1	8.1	6.5
1 year	8.2	6.7	8.4	8.0	7.0	7.7	6.6
Full utility incentive	9.0	9.0	9.3	8.8	9.1	9.1	9.2
Utility covers 50% of the Premium							
4 years	8.0	6.5	7.4	7.9	6.5	8.0	6.4
2 years	8.4	7.7	7.9	8.2	7.5	8.5	7.1
1 year	8.7	8.0	8.3	8.8	8.2	8.7	7.4
6 months	8.8	8.5	8.8	9.0	8.5	9.3	8.4
Utility Covers 25% of the Premium							
6 years	7.3	5.9	6.8	7.7	5.9	7.7	6.4
3 years	7.9	6.7	7.3	7.8	6.7	7.9	6.7
1.5 years	8.2	7.3	7.8	8.4	7.5	8.3	7.1
9 months	8.5	8.0	8.3	8.7	8.2	8.7	7.9

Table 244: Adjusted Averages by EDC

(FE: Penelec)

Payback Period	CAC	Heat Pump	Clothes Washer	Refrigerator	Insulation	Water Heater	Dehumidifier
Energy Savings Covers the Premium							
8 years	5.5	7.3	5.7	5.5	5.4	6.3	4.7
6 years	6.3	8.1	5.9	6.1	6.1	7.0	5.2
4 years	7.2	8.4	6.4	7.2	6.7	7.1	6.2
2 years	8.0	8.8	7.0	7.2	7.0	7.7	6.7
1 year	8.8	9.1	7.4	7.6	6.9	7.0	7.6
Full utility incentive	9.7	9.4	9.0	9.2	8.4	8.9	9.1
Utility covers 50% of the Premium							
4 years	8.0	8.5	7.0	7.4	7.1	7.3	6.4
2 years	8.7	8.8	7.5	7.4	7.5	8.1	7.4
1 year	9.1	9.2	8.1	7.9	8.1	8.2	8.6
6 months	9.2	9.2	8.4	8.5	8.3	8.6	9.4
Utility Covers 25% of the Premium							
6 years	7.4	8.0	6.2	6.3	6.8	7.2	5.2
3 years	7.8	8.2	6.5	6.9	6.8	7.8	6.4
1.5 years	8.5	8.6	7.4	7.5	7.8	8.2	7.6
9 months	8.8	8.8	7.7	7.8	7.8	8.4	8.6

Table 245: Adjusted Averages by EDC
(FE: Penn Power)

Payback Period	CAC	Heat Pump	Clothes Washer	Refrigerator	Insulation	Water Heater	Dehumidifier
Energy Savings Covers the Premium							
8 years	5.6	6.0	5.5	5.8	4.1	5.8	5.1
6 years	6.3	6.2	5.8	6.8	4.7	6.5	4.9
4 years	6.8	7.4	6.3	7.3	5.4	6.8	6.0
2 years	7.3	8.4	7.0	7.5	6.3	7.5	6.6
1 year	8.0	8.0	7.0	8.1	6.3	8.1	7.2
Full utility incentive	9.0	9.4	8.4	9.1	8.1	9.6	8.2
Utility covers 50% of the Premium							
4 years	7.3	7.6	6.1	6.7	5.3	7.4	6.6
2 years	7.7	8.2	6.7	7.1	5.6	8.1	7.3
1 year	8.4	8.6	7.2	7.7	6.3	8.9	7.8
6 months	9.0	9.1	7.7	8.8	7.0	9.5	8.3
Utility Covers 25% of the Premium							
6 years	6.5	7.0	5.7	6.0	4.5	6.9	5.6
3 years	7.1	7.3	5.9	6.5	5.0	7.5	6.2
1.5 years	7.6	8.0	6.5	7.4	5.5	8.3	7.1
9 months	8.3	8.6	6.8	7.9	6.3	9.3	7.7

Table 246: Adjusted Averages by EDC
(FE: West Penn Power)

Payback Period	CAC	Heat Pump	Clothes Washer	Refrigerator	Insulation	Water Heater	Dehumidifier
Energy Savings Covers the Premium							
8 years	5.8	5.8	6.0	5.6	5.4	6.7	5.2
6 years	6.7	6.0	6.6	6.4	5.2	7.3	5.9
4 years	7.4	6.7	6.7	6.7	5.8	7.5	6.9
2 years	7.8	7.1	7.7	7.6	6.3	8.0	7.4
1 year	8.4	8.3	8.1	8.7	7.2	8.5	7.9
Full utility incentive	9.0	9.4	8.8	9.1	8.6	9.3	9.4
Utility covers 50% of the Premium							
4 years	7.4	7.3	6.7	7.1	6.4	8.1	7.0
2 years	7.9	8.1	7.5	7.7	6.5	8.3	8.2
1 year	8.5	8.5	8.1	8.4	8.4	8.8	8.9
6 months	8.8	8.8	8.6	9.0	8.5	9.1	8.7
Utility Covers 25% of the Premium							
6 years	6.8	6.1	6.3	6.6	5.6	7.5	6.7
3 years	7.5	6.7	6.8	7.4	5.7	7.9	7.4
1.5 years	7.9	7.4	7.7	8.5	7.2	8.4	8.4
9 months	8.2	7.8	8.4	8.0	7.6	8.8	8.8

Appendix K Additional Information on Income Status by EDC

The following tables are provided for informational purposes only. The results presented in Appendix K are by EDC and income status, for participants that divulged this information, and covers ENERGY STAR status for appliances, mechanical equipment efficiencies, lighting, and willingness-to-pay. The results for appliances and mechanical equipment are only presented for the full sample (both on-site and self-audit data), while the lighting only covers data collected on-site. The willingness-to-pay results cover the primary question asked to survey respondents for a select set of measures. It should be noted that sample sizes for certain measures and EDCs are small so caution should be used when interpreting these results.

K.1 ENERGY STAR Status by Income Level and EDC

Table 246: Low-income Refrigerator ENERGY STAR Status by EDC

(Base = Refrigerators)

EnergyStar	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn
n-value	*11*	*8*	*25*	*15*	*27*	*15*	*20*
Yes	55%	75%	32%	53%	48%	67%	30%
No	45%	25%	68%	47%	52%	33%	70%

Table 247: Non-low-income Refrigerator ENERGY STAR Status by EDC

(Base = Refrigerators)

EnergyStar	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn
n-value	*51*	*62*	*50*	*67*	*60*	*57*	*66*
Yes	43%	53%	50%	66%	52%	47%	38%
No	57%	47%	50%	34%	48%	53%	62%

Table 248: Low-income Freezer ENERGY STAR Status by EDC

(Base = Freezers)

EnergyStar	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn
n-value	*2*	*4*	*4*	*5*	*10*	*5*	*8*
Yes	--	--	25%	20%	20%	40%	--
No	100%	100%	75%	80%	80%	60%	100%

Table 249: Non-low-income Freezer ENERGY STAR Status by EDC

(Base = Freezers)

EnergyStar	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn
n-value	*15*	*16*	*8*	*17*	*19*	*23*	*16*
Yes	7%	38%	25%	24%	32%	26%	38%
No	93%	62%	75%	76%	68%	74%	62%

Table 250: Low-income Dishwasher ENERGY STAR Status by EDC

(Base = Dishwashers)

EnergyStar	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn
n-value	*7*	*7*	*6*	*10*	*13*	*7*	*10*
Yes	29%	71%	83%	80%	62%	71%	90%
No	71%	29%	17%	20%	38%	29%	10%

Table 251: Non-low-income Dishwasher ENERGY STAR Status by EDC

(Base = Dishwashers)

EnergyStar	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn
n-value	*41*	*37*	*32*	*46*	*30*	*34*	*31*
Yes	73%	65%	75%	85%	87%	88%	90%
No	27%	35%	25%	15%	13%	12%	10%

Table 252: Low-income Clothes Washer ENERGY STAR Status by EDC

(Base = In-home Clothes Washers)

EnergyStar	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn
n-value	*10*	*9*	*16*	*9*	*13*	*10*	*15*
Yes	70%	44%	31%	44%	54%	30%	53%
No	30%	56%	69%	56%	46%	70%	47%

Table 253: Non-low-income Clothes Washer ENERGY STAR Status by EDC

(Base = In-home Clothes Washers)

EnergyStar	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn
n-value	*42*	*39*	*35*	*44*	*36*	*34*	*30*
Yes	55%	56%	54%	57%	61%	62%	47%
No	45%	44%	46%	43%	39%	38%	53%

Table 254: Low-income Clothes Dryer ENERGY STAR Status by EDC

(Base = Clothes Dryers)

EnergyStar	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn
n-value	*9*	*9*	*18*	*9*	*14*	*9*	*15*
Yes	11%	44%	0%	33%	21%	33%	20%
No	89%	56%	100%	67%	79%	67%	80%

Table 255: Non-low-income Clothes Dryer ENERGY STAR Status by EDC

(Base = Clothes Dryers)

EnergyStar	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn
n-value	*37*	*37*	*32*	*45*	*39*	*32*	*28*
Yes	41%	22%	19%	29%	33%	34%	32%
No	59%	78%	81%	71%	67%	66%	68%

Table 256: Low-income Dehumidifier ENERGY STAR Status by EDC

(Base = Dehumidifiers)

EnergyStar	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn
n-value	*0*	*2*	*3*	*4*	*4*	*2*	*1*
Yes	–	100%	100%	100%	100%	100%	100%
No	--	--	--	--	--	--	--

Table 257: Non-low-income Dehumidifier ENERGY STAR Status by EDC

(Base = Dehumidifiers)

EnergyStar	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn
n-value	*15*	*11*	*11*	*14*	*22*	*9*	*14*
Yes	87%	91%	73%	86%	91%	89%	79%
No	13%	9%	27%	14%	9%	11%	21%

K.2 Heating Efficiency by Income Status and EDC

Table 258: Low-income Residential Heating System AFUE by Status by EDC

(Base = Systems)

AFUE	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn
n-value	*7*	*1*	*8*	*6*	*11*	*7*	*6*
Min	79.0	85.0	79.0	80.0	71.0	75.0	64.0
Max	95.0	85.0	96.1	97.0	95.0	96.1	96.0
Mean	**82.4**	**85.0**	**91.1**	**92.0**	**86.8**	**89.1**	**86.0**
Median	80.0	85.0	95.0	93.5	92.0	92.0	92.0
Std. Dev.	5.6	NA	7.3	6.2	7.4	7.8	12.1

Table 259: Non-low-income Residential Heating System AFUE by Status by EDC

(Base = Systems)

AFUE	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn
n-value	*33*	*21*	*27*	*24*	*27*	*26*	*20*
Min	80.0	80.0	79.0	80.0	80.0	80.0	68.0
Max	97.7	97.0	96.0	96.8	98.0	96.7	97.0
Mean	**87.2**	**87.0**	**89.9**	**91.1**	**88.7**	**93.5**	**89.9**
Median	85.0	85.1	93.0	92.0	92.0	95.0	92.0
Std. Dev.	7.0	5.8	6.6	4.9	6.8	4.3	7.0

K.3 Cooling Efficiency by Income Status and EDC

Table 260: Low-income Permanent Cooling System SEER2 Rating by EDC

(Base: Systems)

SEER2	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn
n-value	*6*	*3*	*4*	*8*	*7*	*7*	*5*
Min	12.7	14.3	9.1	10.3	12.7	9.4	11.4
Max	17.5	15.5	13.9	18.1	20.3	15.1	15.5
Mean	**14.1**	**15.0**	**12.1**	**13.2**	**14.4**	**11.1**	**13.6**
Median	13.5	15.1	12.7	12.9	13.5	10.3	14.3
Std. Dev.	1.9	0.6	2.1	2.5	2.8	2.1	1.6

Table 261: Non-low-income Permanent Cooling System SEER2 Rating by EDC

(Base: Systems)

SEER2	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn
n-value	*38*	*24*	*28*	*39*	*16*	*37*	*25*
Min	10.3	8.6	10.3	9.5	9.7	9.5	9.7
Max	18.3	19.9	19.0	29.4	17.5	19.9	18.5
Mean	**13.8**	**14.8**	**13.2**	**14.7**	**13.4**	**13.3**	**13.3**
Median	14.1	14.3	12.8	13.9	13.4	13.5	13.5

Std. Dev.	1.6	2.6	1.8	3.5	1.9	2.2	2.2

Table 262: Low-income Room Air Conditioner ENERGY STAR Status by EDC

(Base: Room Air Conditioners)

EnergyStar	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn
n-value	*6*	*8*	*6*	*7*	*10*	*3*	*15*
No	33%	88%	67%	86%	60%	33%	73%
Yes	67%	12%	33%	14%	40%	67%	27%

Table 263: Non-low-income Room Air Conditioner ENERGY STAR Status by EDC

(Base: Room Air Conditioners)

EnergyStar	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn
n-value	*17*	*24*	*9*	*3*	*4*	*2*	*11*
No	65%	71%	100%	100%	50%	50%	55%
Yes	35%	29%	--	--	50%	50%	45%

K.4 Water Heating Efficiency by Income Status and EDC

Table 264: Low-income Water Heater UEF by EDC

(Base = Systems)

UEF	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn
n-value	*13*	*10*	*15*	*13*	*19*	*13*	*16*
Min	0.57	0.57	0.54	0.54	0.55	0.56	0.54
Max	3.34	0.95	0.93	0.93	0.96	0.95	0.95
Mean	**1.11**	**0.86**	**0.62**	**0.81**	**0.75**	**0.70**	**0.76**
Median	0.62	0.92	0.58	0.91	0.65	0.61	0.80
Std. Dev.	1.00	0.15	0.12	0.14	0.16	0.16	0.18

Table 265: Non-low-income Water Heater UEF by EDC

(Base = Systems)

	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn
n-value	*42*	*38*	*46*	*48*	*38*	*43*	*47*
Min	0.57	0.56	0.53	0.56	0.57	0.53	0.55
Max	0.97	2.48	2.52	3.88	3.71	3.55	0.95
Mean	**0.76**	**0.91**	**0.71**	**0.92**	**0.90**	**0.88**	**0.79**
Median	0.68	0.91	0.64	0.91	0.92	0.67	0.90
Std. Dev.	0.16	0.40	0.30	0.59	0.49	0.62	0.15

K.5 Lighting Technology by Income Status and EDC

Table 266: Low-income Efficient Lighting Saturation by EDC

Lighting	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn
n-value (bulbs)	*215*	*235*	*326*	*325*	*533*	*331*	*379*
Efficient	81%	87%	59%	88%	64%	63%	85%
LED	67%	57%	37%	81%	44%	42%	63%
CFL	8%	--	10%	6%	9%	12%	15%

Table 267: Non-low-income Efficient Lighting Saturation by EDC

Lighting	PECO	PPL	Duquesne Light	FE: Met-Ed	FE: Penelec	FE: Penn Power	FE: West Penn
n-value (bulbs)	*2,055*	*1,636*	*1,526*	*1,736*	*2,085*	*2,354*	*1,770*
Efficient	66%	74%	67%	78%	75%	81%	67%
LED	57%	60%	48%	69%	66%	55%	57%
CFL	5%	6%	10%	6%	5%	11%	4%

Table 268: Single-family and Multifamily Efficient Lighting Saturation by Income Status

Lighting	Single-family Low Income	Single-family Non-low Income	Multifamily Low-income	Multifamily Non-low-income
n-value (bulbs)	*2,046*	*12,195*	*298*	*967*
Efficient	73%	72%	80%	79%
LED	54%	58%	59%	69%
CFL	10%	7%	6%	5%

K.6 Willingness to Pay by Income Status and EDC

Table 269: Adjusted Averages by EDC and Income Status
(PECO)

Payback Period	CAC (low income)	CAC (non-low income)	Heat Pump (low income)	Heat Pump (non-low income)	Refrigerator (low income)	Refrigerator (non-low income)	Water Heater (low income)	Water Heater (non-low income)
n-value	*14*	*74*	*0*	*24*	*7*	*37*	*8*	*24*
Energy Savings Covers the Premium								
8 years	4.8	5.7	--	6	5.1	5.9	4.1	6.1
6 years	3.3	7.1	--	6.9	6.7	6.4	4	6.3
4 years	4	7.7	--	7.6	6.3	7.3	4	6.7
2 years	7	8.2	--	7.9	5.7	7.9	4.2	7.9
1 year	8	8.8	--	8.5	8.1	9.2	4.2	8.1
Full utility incentive	6.3	8.9	--	8.9	7.5	9.1	4.4	8.7

Table 270: Adjusted Averages by EDC and Income Status
(PPL)

Payback Period	CAC (low income)	CAC (non-low income)	Heat Pump (low income)	Heat Pump (non-low income)	Refrigerator (low income)	Refrigerator (non-low income)	Water Heater (low income)	Water Heater (non-low income)
n-value	*4*	*58*	*1*	*36*	*10*	*52*	*10*	*50*
Energy Savings Covers the Premium								
8 years	8	6.2	10	7.5	3.9	5.8	4.3	6.4
6 years	7	7.1	10	7.9	7.8	6.8	4.9	7.0
4 years	7	7.5	10	7.9	4.3	6.5	4.8	7.2
2 years	8.5	8.7	10	8.5	5.0	8.3	4.0	7.8
1 year	5.3	8.8	10	8.8	6.7	8.9	5.0	8.2
Full utility incentive	9	9.5	10	9.0	9.8	9.6	6.7	8.9

Table 271: Adjusted Averages by EDC and Income Status

(DLC)

Payback Period	CAC (low income)	CAC (non-low income)	Heat Pump (low income)	Heat Pump (non-low income)	Refrigerator (low income)	Refrigerator (non-low income)	Water Heater (low income)	Water Heater (non-low income)
n-value	*23*	*119*	*0*	*10*	*12*	*37*	*16*	*31*
Energy Savings Covers the Premium								
8 years	4.5	5.7	--	6.9	6.1	6.0	7.9	5.2
6 years	5.2	6.6	--	7.1	6.9	6.5	8.3	6.1
4 years	5.9	7.2	--	8.4	6.5	7.4	7.5	6.4
2 years	5.1	8.3	--	7.0	5.8	8.3	7.7	8.1
1 year	5.6	8.5	--	8.3	7.3	8.4	7.5	8.2
Full utility incentive	8.3	9.1	--	10.0	9.7	9.8	8.8	9.3

Table 272: Adjusted Averages by EDC and Income Status

(Met-Ed)

Payback Period	CAC (low income)	CAC (non-low income)	Heat Pump (low income)	Heat Pump (non-low income)	Refrigerator (low income)	Refrigerator (non-low income)	Water Heater (low income)	Water Heater (non-low income)
n-value	*18*	*149*	*1*	*31*	*7*	*37*	*7*	*44*
Energy Savings Covers the Premium								
8 years	3.5	6.2	10	5.1	6.2	6.2	3.0	7.4
6 years	3.6	7.6	10	5.8	6.7	6.9	2.0	7.7
4 years	4.6	7.9	10	6.7	6.7	7.9	2.0	8.5
2 years	6	8.4	10	6.9	6.0	8.5	2.3	8.7
1 year	4.5	8.7	10	6.6	5.8	8.3	5.0	7.8
Full utility incentive	5.3	9.4	10	8.9	7.5	8.9	6.7	9.3

Table 273: Adjusted Averages by EDC and Income Status
(Penelec)

Payback Period	CAC (low income)	CAC (non-low income)	Heat Pump (low income)	Heat Pump (non-low income)	Refrigerator (low income)	Refrigerator (non-low income)	Water Heater (low income)	Water Heater (non-low income)
n-value	*14*	*76*	*4*	*33*	*17*	*51*	*17*	*40*
Energy Savings Covers the Premium								
8 years	5.6	5.5	8.3	7.2	4.7	5.9	5.0	6.8
6 years	5.7	6.4	7.5	8.2	5.6	6.3	6.3	7.2
4 years	6.3	7.3	7.8	8.5	6.3	7.4	5.6	7.5
2 years	7.1	8.2	8.3	8.9	6.1	7.6	6.0	8.3
1 year	8.6	8.9	9.5	9.0	6.2	8.3	5.5	7.5
Full utility incentive	9.8	9.7	9.3	9.4	9.2	9.2	8.6	9.0

Table 274: Adjusted Averages by EDC and Income Status
(Penn Power)

Payback Period	CAC (low income)	CAC (non-low income)	Heat Pump (low income)	Heat Pump (non-low income)	Refrigerator (low income)	Refrigerator (non-low income)	Water Heater (low income)	Water Heater (non-low income)
n-value	*17*	*121*	*3*	*34*	*15*	*40*	*10*	*44*
Energy Savings Covers the Premium								
8 years	4.6	5.9	2.0	6.4	6.0	6.1	5.5	5.7
6 years	5.3	6.7	1.0	6.9	6.5	7.0	6.4	6.4
4 years	5.9	7.1	3.5	7.9	6.1	7.8	5.9	6.9
2 years	6.6	7.6	5.0	8.8	6.9	8.0	5.8	7.7
1 year	8.0	8.2	4.7	8.5	6.3	8.7	6.7	8.3
Full utility incentive	9.0	9.2	7.0	9.8	7.1	9.7	10.0	9.5

Table 275: Adjusted Averages by EDC and Income Status

(West Penn Power)

Payback Period	CAC (low income)	CAC (non-low income)	Heat Pump (low income)	Heat Pump (non-low income)	Refrigerator (low income)	Refrigerator (non-low income)	Water Heater (low income)	Water Heater (non-low income)
n-value	*23*	*114*	*3*	*30*	*8*	*55*	*20*	*41*
Energy Savings Covers the Premium								
8 years	4.2	6.0	9.3	5.3	7.8	5.3	6.6	6.7
6 years	6.0	6.7	10.0	5.7	6.1	6.4	7.5	7.2
4 years	6.7	7.5	10.0	6.4	7.3	6.6	7.1	7.7
2 years	7.4	7.8	10.0	6.9	6.7	7.7	6.8	8.6
1 year	7.6	8.4	10.0	8.2	7.8	8.8	7.4	9.1
Full utility incentive	8.3	9.1	10.0	9.3	8.2	9.2	8.8	9.5

Appendix L Recruiting Screening Survey and Optional Self-Audit Survey

Thank you for your interest in participating in a research project to assess the energy features of Pennsylvania homes. [EDC NAME] is participating in an important research project sponsored by the Pennsylvania Public Utility Commission (PUC). Recently, you should have received a postcard or an email from [EDC NAME] inviting you to participate in this research project. This survey should take less than ten minutes, and the information you provide will help Pennsylvania improve its energy-efficiency programs and services for residents like you. Your responses will be kept strictly confidential.

There is an option to extend the survey and receive up to a $40 dollar gift card as a participation incentive. This will require you to submit photos of key energy consuming equipment from your home. In addition, there is an opportunity to be included in the next phase of the research project which includes another $150 incentive.

If you have questions about the validity of this study, please contact the Pennsylvania Public Utility Commission at (717) 425-7584 or via email ra-act129@pa.gov and reference the “Pennsylvania Home Energy Efficiency Study”

You may also contact [EDC NAME] at [EDC Contact]

SCREENERS

IS1. Are you the owner or person who is most knowledgeable about the home at [ADDRESS]’s characteristics and equipment?

1. Yes [Continue to IS2]
2. No [Skip to IS5]
96. Don’t know [Skip to IS5]

IS2. Which of the following best describes your home?

1. Manufactured home, mobile home or trailer
2. Detached single-family home
3. Townhouse or row home with shared adjacent walls (i.e., side-by-side units)
4. Apartment or condo in a two-unit building with units above and below one another
5. Apartment or condo in a three- or four-unit building with some units above and below one another
6. Apartment or condo in a building with five or more units
7. Or something else? [Custom Text]
96. Don't know [THANK AND TERMINATE]
97. Refused [THANK AND TERMINATE]

IS3. [IF IS2=4,5,6, or 7] Do you have access to all of the basement and attic spaces in the building?

1. Yes
2. No
96. Don't know

[IF IS3 = 1 (YES) and IS1 = 1 (YES), RESPONDENT QUALIFIES; SKIP TO DEM1 (OWN OR RENT), FIRST QUESTION AFTER "IS' SERIES']

IS4. [IF IS3=2 or 96] Could we have the name and phone number of the building owner or manager? We are conducting a separate study of multifamily buildings and we will contact the building owner or manager about participating in the study.

1. Name [Custom Text]
2. Phone[Custom Text]
3. Email[Custom Text]
4. Don't know
5. Refused

[IF IS3 = 2 (NO) AND IS1 = 1 (YES), RESPONDENT QUALIFIES; SKIP TO DEM1 (OWN OR RENT), FIRST QUESTION AFTER "IS' SERIES']

IS5. [IF IS1 = 2 or 96] Please provide email or contact information for the person who is most knowledgeable about [ADDRESS]'s characteristics and equipment.

1. Email [Custom text entry]
2. Phone [Custom text entry]
3. No thanks

IS6 Unfortunately you do not qualify for the survey. Thank you for taking the time to respond.

HOME CHARACTERISTICS

HC1. How many bedrooms are in your home? Count bedrooms as those rooms you would list if your home was for sale or rent.

1. 1
2. 2
3. 3
4. 4
5. 5
6. Other: [Please specify]
7. Studio Apartment
96. Don't know
97. Refused

HC2. How many total rooms are in your home, not counting bathrooms, halls, garages, porches, and unheated or unfinished rooms?

1. 1
2. 2

3. 3
4. 4
5. 5
6. Other: [Please specify]
7. Studio Apartment

98. Don't know
99. Refused

HC3. Approximately how large is the interior living space of your home in square feet? Please only include the heated areas of your home and exclude unfinished basements from your estimate.

1. Less than 500 square feet
2. 500 to less than 1,000 square feet
3. 1,000 to less than 1,500 square feet
4. 1,500 to less than 2,000 square feet
5. 2,000 to less than 2,500 square feet
6. 2,500 to less than 3,000 square feet
7. 3,000 to less than 4,000 square feet
8. 4,000 to less than 5,000 square feet
9. 5,000 square feet or more
10. Exact square footage [Allow for custom value response]

96. Don't know
97. Refused

HC4. When was your home built?

1. 1930s or earlier
2. 1940s
3. 1950s
4. 1960s
5. 1970s
6. 1980s
7. 1990s
8. 2000s
9. 2010s
10. 2020 or later

96. Don't know
97. Refused

HC5. Which type of fuel supplies most of the heating for your home? [Single Response]

1. Natural Gas
2. Oil (fuel oil/heating oil/#2 oil)
3. Propane or other bottled or tank gas (LP, butane)
4. Electricity
5. Wood Pellets
6. Wood (firewood or cordwood)

7. Kerosene
8. Coal
9. Solar Thermal
10. Or something else [Specify]
11. No heating
96. Don't know
97. Refused

HC6. [IF HC5≠11] What type of [HC5 FUEL] heating system supplies most of the heating for your home?

1. Hot water or steam boiler
2. Warm air furnace
3. Wood or pellet stove
4. Electric baseboard
5. Heat pump (includes air source or water source (geothermal) heat pumps and ductless heat pumps)
6. Coal stove
7. Or something else? (Specify)
8. (None)
96. Don't know
97. Refused

HC7. Do you have a central air conditioning system or any other type of cooling system in your home? Please indicate what type of cooling system, if any, is installed in your home.

1. Central air conditioner
2. Central heat pump
3. Window air conditioner(s) [Programming Note: Include quantity if selected]
4. Ductless heat pumps, whole home
5. Ductless heat pumps, only certain rooms of the home
6. No cooling
96. Don't know

HC8. Do you have ducts and registers in your home? They are typically used by a warm air furnace or a central air conditioning system to deliver warm or cool air to the entire home.

1. Yes
2. No
96. Don't know

DEMOGRAPHICS

DEM1. Do you own or rent this home?

1. Own or buying
2. Rent or lease
3. Other [CUSTOM TEXT ENTRY]

DEM2. About how many months out of the year do you usually occupy this home?

1. The entire year (12 months)
2. Less than 12 months [ENTER MONTHS]
96. Don't know
97. Refused

DEM3. How long have you lived in your home?

1. 1 year or less
2. 2 to 5 years
3. 6 to 10 years
4. 11 to 20 years
5. Over 20 years
96. Don't know

DEM4. What is the highest level of education that you have completed?

1. Less than high school
2. High school graduate
3. Technical or trade school graduate
4. Some college
5. College graduate
6. Some graduate school
7. Graduate degree
97. Refused

DEM5. What is your age?

1. 18 to 24
2. 25 to 34
3. 35 to 44
4. 45 to 54
5. 55 to 64
6. 65 or over
97. Refused

DEM6. Counting yourself, how many people live in your home for most of the year?

1. 1
2. 2
3. 3
4. 4
5. 5
6. 6
7. 7
8. 8
9. 9
10. 10 or more
11. None – seasonally occupied
12. Don't know [GO TO DEM8]

13. Refused [GO TO DEM8]

DEM7_1. [IF DEM6=1] Which of these categories best describes your total household income in 2022 before taxes – counting everyone living in your home?

1. Less than $20,385 [GO TO DEM8]
2. $20,385 or more[GO TO DEM8]
96. Don't know [GO TO DEM8]
97. Refused [GO TO DEM8]

DEM7_2. [IF DEM6=2] Which of these categories best describes your total household income in 2022 before taxes – counting everyone living in your home?

1. Less than $27,465 [GO TO DEM8]
2. $27,465 or more[GO TO DEM8]
96. Don't know [GO TO DEM8]
97. Refused [GO TO DEM8]

DEM7_3. [IF DEM6=3] Which of these categories best describes your total household income in 2022 before taxes – counting everyone living in your home?

1. Less than $34,545 [GO TO DEM8]
2. $34,545 or more[GO TO DEM8]
96. Don't know [GO TO DEM8]
97. Refused [GO TO DEM8]

DEM7_4. [IF DEM6=4] Which of these categories best describes your total household income in 2022 before taxes – counting everyone living in your home?

1. Less than $41,625 [GO TO DEM8]
2. $41,625 or more[GO TO DEM8]
96. Don't know [GO TO DEM8]
97. Refused [GO TO DEM8]

DEM7_5. [IF DEM6=5] Which of these categories best describes your total household income in 2022 before taxes – counting everyone living in your home?

1. Less than $48,705 [GO TO DEM8]
2. $48,705 or more[GO TO DEM8]
96. Don't know [GO TO DEM8]
97. Refused [GO TO DEM8]

DEM7_6. [IF DEM6=6] Which of these categories best describes your total household income in 2022 before taxes – counting everyone living in your home?

1. Less than $55,785 [GO TO DEM8]
2. $55,785 or more[GO TO DEM8]
96. Don't know [GO TO DEM8]
97. Refused [GO TO DEM8]

DEM7_7. [IF DEM6=7] Which of these categories best describes your total household income in 2022 before taxes – counting everyone living in your home?

3. Less than $62,865 [GO TO DEM8]
4. $62,865 or more[GO TO DEM8]
98. Don't know [GO TO DEM8]
99. Refused [GO TO DEM8]

DEM7_8. [IF DEM6=8] Which of these categories best describes your total household income in 2022 before taxes – counting everyone living in your home?

5. Less than $69,945 [GO TO DEM8]
6. $69,945 or more[GO TO DEM8]
100. Don't know [GO TO DEM8]
101. Refused [GO TO DEM8]

DEM7_9. [IF DEM6=9] Which of these categories best describes your total household income in 2022 before taxes – counting everyone living in your home?

7. Less than $77,025 [GO TO DEM8]
8. $77,025 or more[GO TO DEM8]
102. Don't know [GO TO DEM8]
103. Refused [GO TO DEM8]

DEM7_10. [IF DEM6=10] Which of these categories best describes your total household income in 2022 before taxes – counting everyone living in your home?

9. Less than $84,105 [GO TO DEM8]
10. $84,105 or more[GO TO DEM8]
104. Don't know [GO TO DEM8]
105. Refused [GO TO DEM8]

DEM8. Does anyone in your household receive assistance from any of the following sources?

1. Assistance with energy costs through the low-income Home Energy Assistance Program or LIHEAP
2. TANF cash assistance program (Temporary Assistance for Needy Families)
3. WIC food assistance program (Women, infants, and children program)
4. Child Care assistance program
5. Medicaid
6. Food Stamps
7. Medicare Part D subsidy
8. Weatherization assistance from a Community Action Agency
9. Assistance with energy costs through a Low Income Assistance Plan from your electric or natural gas utility
10. Free or reduced cost meals in a school breakfast or lunch program
11. No one in our household receives assistance from any of these sources
96. Don't know
97. Refused

Onsite Recruitment

OSR1. The Pennsylvania Public Utility Commission (PUC) is interested in conducting home visits to assess the insulation, heating equipment, appliances, and lighting installed in homes. The Pennsylvania PUC would use this information to learn more about opportunities to save energy in Pennsylvania homes.

A participation incentive of $150 dollars, in the form of a gift card, is provided for your time. If you are interested and selected, one of our staff will reach out to you to schedule a visit. These visits take approximately 3-4 hours and will be conducted from March through August of 2023. These visits are strictly for data collection purposes only, so you will not be asked for any additional services or products.

Could we include you in our list of volunteers?

1. Yes, I am interested [GO TO OSR2]
2. Maybe, I would need more information [GO TO OSR2]
3. No I am not interested [GO TO SELF AUDIT PROMPT]

OSR2. Please provide contact information so we can reach out to schedule an energy audit at your home. Participants receive a $150 gift card as a thank you. Our schedulers will provide more information on the study and answer any questions you may have.

1. Name[CUSTOM ENTRY]
2. Phone[CUSTOM ENTRY]
3. Email [CUSTOM ENTRY]

Optional Self-Audit Survey

SAS1: Would you be interested in taking pictures of key energy consuming equipment around your home for a gift card up to $40 dollars in value? You will earn more for each piece of equipment that you submit, up to a maximum of $40 dollars reached. This may take an additional 15 to 30 minutes of your time to complete.

1. Yes
2. No [Terminate Survey]

Appendix M Willingness to Pay Survey

Introduction

When considering the installation of new heating or cooling equipment, appliances, or other equipment for your home, you can choose between standard and higher efficiency options. The higher efficiency options save energy and reduce electricity bills but cost more to purchase than the standard option. We are interested in learning the importance of different factors when making the choice between purchasing the standard or higher efficiency options.

[PROGRAMMING INSTRUCTIONS: IF RESPONDENT HAS INDICATED THAT THE HOME HAS A HEAT PUMP OR CENTRAL AIR CONDITIONG (IF HC6 = 5 or HC7 = 1, 2, 4 or 5), ASK HVAC MEASURE PLUS ONE OTHER MEASURE (RANDOMLY SELECTED). IF HOME DOES NOT HAVE A HEAT PUMP OR CENTRAL AIR CONDITIONING, ASK 2 NON-HVAC MEASURES (RANDOMLY SELECTED).]

HVAC Measure

[ASK IF HC6 = 5 or HC7 = 1, 2, 4 or 5]

HVAC1. If your [if HC6 = 5 or HC7 = 2, 4, 5: “heat pump”; if HC7 = 1: “central air conditioner”] broke and needed to be replaced, please indicate how likely you are to purchase a higher efficiency [if HC6 = 5 or HC7 = 2, 4, 5: “heat pump”; if HC7 = 1: “central air conditioner”] using a scale of 0 to 10, where 0 = not at all likely and 10 = extremely likely:

a. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 8 years. [IF HVAC1.A = 10, SKIP TO NEXT TECHNOLOGY]
b. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 6 years.
c. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 4 years.
d. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 2 years.
e. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 1 year.
f. If your electric utility covered the entire additional purchase cost of the higher efficiency option. [IF HVAC1.F=0, SKIP TO NEXT TECHNOLOGY]

HVAC2. Considering the same [MEASURE from HVAC1], what if your electric utility covered 50% of the extra cost of the higher efficiency option? Please indicate how likely you are to purchase the higher efficiency [MEASURE] using a scale of 0 to 10, where 0 = not at all likely and 10 = extremely likely:

a. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 4 years instead of 8 years?
b. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 2 years instead of 4 years?
c. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 1 year instead of 2 years?
d. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within six months instead of 1 year?

HVAC3. Considering the same [MEASURE from HVAC1], what if your electric utility covered 25% of the extra cost of the higher efficiency option? Please indicate how likely you are to purchase the higher efficiency [MEASURE] using a scale of 0 to 10, where 0 = not at all likely and 10 = extremely likely:

a. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 6 years instead of 8 years?
b. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 3 years instead of 4 years?
c. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 1.5 years instead of 2 years?
d. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 9 months instead of 1 year?

[IF RESPONDENT ASKED HVAC MEASURE, RANDOMLY SELECT 1 REMAINING MEASURE. OTHERWISE, RANDOMLY SELECT 2 REMAINING MEASURES]]

Insulation Measure

INSUL1. Please indicate how likely you are to install insulation to your home using a scale of 0 to 10, where 0 = not at all likely and 10 = extremely likely:

a. If the cost of the insulation pays for itself through electricity bill savings within 8 years. [IF INSUL1.A = 10, SKIP TO NEXT TECHNOLOGY]
b. If the cost of the insulation pays for itself through electricity bill savings within 6 years.
c. If the cost of the insulation pays for itself through electricity bill savings within 4 years.
d. If the cost of the insulation pays for itself through electricity bill savings within 2 years.
e. If the cost of the insulation pays for itself through electricity bill savings within 1 year.
f. If your electric utility covered the entire cost of the insulation [IF INSUL1.F = 0, SKIP TO NEXT TECHNOLOGY]

INSUL2. What if your electric utility covered 50% of the cost of the insulation? Please indicate how likely you are to install the insulation, using a scale of 0 to 10, where 0 = not at all likely and 10 = extremely likely:

a. If the cost of the insulation would now pay for itself through electricity bill savings within 4 years instead of 8 years?
b. If the cost of the insulation would now pay for itself through electricity bill savings within 2 years instead of 4 years?
c. If the cost of the insulation would now pay for itself through electricity bill savings within 1 year instead of 2 years?
d. If the cost of the insulation would now pay for itself through electricity bill savings within six months instead of 1 year?

INSUL3. What if your electric utility covered 25% of the cost of the insulation? Please indicate how likely you are to install the insulation, using a scale of 0 to 10, where 0 = not at all likely and 10 = extremely likely:

a. If the cost of the insulation would now pay for itself through electricity bill savings within 6 years instead of 8 years?

b. If the cost of the insulation would now pay for itself through electricity bill savings within 3 years instead of 4 years?
c. If the cost of the insulation would now pay for itself through electricity bill savings within 1.5 years instead of 2 years?
d. If the cost of the insulation would now pay for itself through electricity bill savings within 9 months instead of 1 year?

Water Heater Measure

WATER1. If your water was still working but you decided to replace it, please indicate how likely you are to purchase a higher efficiency water heater using a scale of 0 to 10, where 0 = not at all likely and 10 = extremely likely:

a. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 8 years. [IF WATER1.A = 10, SKIP TO NEXT TECHNOLOGY]
b. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 6 years.
c. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 4 years.
d. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 2 years.
e. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 1 year.
f. If your electric utility covered the entire additional purchase cost of the higher efficiency option. [IF WATER1.F=0, SKIP TO NEXT TECHNOLOGY]

WATER2. What if your electric utility covered 50% of the extra cost of the higher efficiency water heater? Please indicate how likely you are to purchase the higher efficiency water heater using a scale of 0 to 10, where 0 = not at all likely and 10 = extremely likely:

a. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 4 years instead of 8 years?
b. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 2 years instead of 4 years?
c. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 1 year instead of 2 years?
d. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within six months instead of 1 year?

WATER3. What if your electric utility covered 25% of the extra cost of the higher efficiency option? Please indicate how likely you are to purchase the higher efficiency water heater] using a scale of 0 to 10, where 0 = not at all likely and 10 = extremely likely:

a. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 6 years instead of 8 years?
b. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 3 years instead of 4 years?
c. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 1.5 years instead of 2 years?
d. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 9 months instead of 1 year?

Refrigerator

REFRIG1. If your refrigerator broke and needed to be replaced, please indicate how likely you are to purchase a higher efficiency refrigerator using a scale of 0 to 10, where 0 = not at all likely and 10 = extremely likely:

a. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 8 years. [IF REFRIG1.A = 10, SKIP TO NEXT TECHNOLOGY]
b. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 6 years.
c. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 4 years.
d. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 2 years.
e. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 1 year.
f. If your electric utility covered the entire additional purchase cost of the higher efficiency option. [IF REFRIG1.F=0, SKIP TO NEXT TECHNOLOGY]

REFRIG 2. What if your electric utility covered 50% of the extra cost of the higher efficiency option? Please indicate how likely you are to purchase the higher efficiency refrigerator using a scale of 0 to 10, where 0 = not at all likely and 10 = extremely likely:

a. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 4 years instead of 8 years?
b. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 2 years instead of 4 years?
c. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 1 year instead of 2 years?
d. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within six months instead of 1 year?

REFRIG 3. What if your electric utility covered 25% of the extra cost of the higher efficiency option? Please indicate how likely you are to purchase the higher efficiency refrigerator using a scale of 0 to 10, where 0 = not at all likely and 10 = extremely likely:

a. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 6 years instead of 8 years?
b. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 3 years instead of 4 years?
c. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 1.5 years instead of 2 years?
d. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 9 months instead of 1 year?

Clothes Washer

WASHER1. If your clothes washer broke and needed to be replaced, please indicate how likely you are to purchase a higher efficiency clothes washer using a scale of 0 to 10, where 0 = not at all likely and 10 = extremely likely:

a. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 8 years. [IF WASHER1.A = 10, SKIP TO NEXT TECHNOLOGY]

b. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 6 years.
c. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 4 years.
d. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 2 years.
e. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 1 year.
f. If your electric utility covered the entire additional purchase cost of the higher efficiency option. [IF WASHER1.F=0, SKIP TO NEXT TECHNOLOGY]

WASHER 2. What if your electric utility covered 50% of the extra cost of the higher efficiency option? Please indicate how likely you are to purchase the higher efficiency clothes washer using a scale of 0 to 10, where 0 = not at all likely and 10 = extremely likely:

a. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 4 years instead of 8 years?
b. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 2 years instead of 4 years?
c. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 1 year instead of 2 years?
d. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within six months instead of 1 year?

WASHER 3. What if your electric utility covered 25% of the extra cost of the higher efficiency option? Please indicate how likely you are to purchase the higher efficiency clothes washer using a scale of 0 to 10, where 0 = not at all likely and 10 = extremely likely:

a. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 6 years instead of 8 years?
b. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 3 years instead of 4 years?
c. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 1.5 years instead of 2 years?
d. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 9 months instead of 1 year?

Dehumidifier

DEHUMID1. If you needed a new dehumidifier, please indicate how likely you are to purchase a higher efficiency dehumidifier using a scale of 0 to 10, where 0 = not at all likely and 10 = extremely likely:

a. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 8 years. [IF DEHUMI1.A = 10, SKIP TO NEXT TECHNOLOGY]
b. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 6 years.
c. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 4 years.
d. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 2 years.
e. If the additional purchase cost of the higher efficiency option pays for itself through electricity bill savings within 1 year.

f. If your electric utility covered the entire additional purchase cost of the higher efficiency option. [IF DEHUMID1.F=0, SKIP TO NEXT TECHNOLOGY]

DEHUMID2. What if your electric utility covered 50% of the extra cost of the higher efficiency option? Please indicate how likely you are to purchase the higher efficiency dehumidifier using a scale of 0 to 10, where 0 = not at all likely and 10 = extremely likely:

a. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 4 years instead of 8 years?
b. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 2 years instead of 4 years?
c. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 1 year instead of 2 years?
d. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within six months instead of 1 year?

DEHUMID3. What if your electric utility covered 25% of the extra cost of the higher efficiency option? Please indicate how likely you are to purchase the higher efficiency dehumidifier using a scale of 0 to 10, where 0 = not at all likely and 10 = extremely likely:

a. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 6 years instead of 8 years?
b. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 3 years instead of 4 years?
c. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 1.5 years instead of 2 years?
d. If the additional purchase cost of the higher efficiency option would now pay for itself through electricity bill savings within 9 months instead of 1 year?