PECO
An Exelon Company

Legal Department
2301 Market Street / S23-1
Philadelphia, PA 19103

Direct Dial: 215.841.4608
Email: Jack.Garfinkle@exeloncorp.com

May 28, 2019

VIA ELECTRONIC FILING

Rosemary Chiavetta, Secretary
Pennsylvania Public Utility Commission
Commonwealth Keystone Building
400 North Street
P.O. Box 3265
Harrisburg, PA 17105-3265

Re: Technical Reference Manual 2021 Update - Docket No. M-2019-3006867

Dear Secretary Chiavetta:

Pursuant to the Commission's April 11, 2019 Tentative Order in the above-referenced docket, enclosed please find the **Comments of PECO Energy Company on the Proposed Update to the Technical Reference Manual**.

As instructed, the Comments have been mailed electronically, in Word format, to Regi Sam (rsam@pa.gov) and Kriss Brown (kribrown@pa.gov).

Please do not hesitate to contact me if you have any questions.

Very truly yours,

Jack R. Garfinkle
Associate General Counsel

Enclosure

BEFORE THE
PENNSYLVANIA PUBLIC UTILITY COMMISSION

Implementation of the Alternative Energy Portfolio Standards Act of 2004: Standards for the Participation of Demand Side Management Resources – Technical Reference Manual 2021 Update	:	**Docket No. M-2019-3006867**

COMMENTS OF PECO ENERGY COMPANY ON THE
PROPOSED UPDATE TO THE TECHNICAL REFERENCE MANUAL

Pursuant to the April 11, 2019 Tentative Order entered by the Pennsylvania Public Utility Commission (the "Commission") in the above-referenced docket, PECO Energy Company ("PECO" or the "Company") hereby submits comments on the Commission's proposed 2021 update to its Technical Reference Manual ("TRM").

I. INTRODUCTION

PECO appreciates the Commission's efforts to complete an updated TRM that will serve as a more effective tool for validating savings and providing support for Act 129 goals. PECO strongly agrees that the scope of the TRM should be broadened to reflect new energy efficiency and conservation ("EE&C") measures being implemented by electric distribution companies ("EDCs") and that TRM protocols should appropriately balance savings accuracy and measurement and verification costs. PECO's general comments in response to the proposed TRM update and key issues identified in the Tentative Order are provided below. Specific, section-by-section comments are attached to this document as Appendix A.

II. GENERAL COMMENTS

A. Code Change Updates Should Be Implemented At The Beginning Of A Program Year And No Earlier Than Six Months After A Code Becomes Effective

PECO supports the Commission's proposal to implement a streamlined, predictable process to update the TRM to reflect changes to federal standards, ENERGY STAR specifications, and state-adopted building energy codes. The Company also agrees with the Commission's schedule for such updates, with code changes effective before July 1st of a program year being considered for inclusion in the TRM for the following program year. At the time a code change is adopted, the market will still have some stock (e.g., appliances) that predates the code change. For this reason, it is appropriate to require a code to be in effect for at least six months prior to its incorporation in the TRM. It is also important that code changes be integrated into the TRM at the beginning of a program year to avoid confusion and unnecessary complexity in the measurement and verification of energy savings within a program year.

B. The Commission Should Be Cognizant Of The Streamlined Process For Code Change Updates When Examining Phase IV Savings Potential

The savings potential of an EDC's EE&C plan may be reduced when code changes are reflected in the TRM after the plan is approved. As the Commission begins to consider savings potential for a possible Phase IV of the EE&C program, it should identify and consider any material code changes that are likely to occur during the Phase IV program period.

C. The TRM Should Codify Interim Measure Protocols Approved By The Statewide Evaluator During Phase III Absent Material Changes In Information Or Implementation Concerns

Over the course of the Phase III EE&C Program, the Statewide Evaluator ("SWE") has approved numerous Interim Measure Protocols ("IMPs") to address how savings should be determined for new measures that were not in place at the beginning of Phase III. Because IMPs have already been reviewed and approved by the SWE, and EDCs and evaluation, measurement and verification ("EM&V") providers have experience working with those IMPs, PECO believes it is appropriate to incorporate IMPs into this TRM update. Any changes to previously-approved IMPs should be based on material changes in information or implementation concerns.

D. The TRM Should Incorporate Default Values Where Appropriate

The Commission stated that a major goal of the TRM modifications is "to appropriately balance the integrity and accuracy of claimed energy savings estimates with costs incurred to measure and verify the claimed energy savings." Tentative Order, p. 5. Now that the Commission has over eight years of EE&C plan implementation data, PECO believes that reasonable and conservative default values can developed for a significant number of measures in the TRM. Permitting expanded use of data-based default values would significantly reduce the burden and cost associated with measuring and verifying savings while preserving the accuracy of claimed savings.

III. CONCLUSION

PECO appreciates the opportunity to comment on this important matter and believes that the Company's recommended revisions can improve the effectiveness of the Technical Reference Manual.

Respectfully Submitted

Jack R. Garfinkle (Pa. No. 81892)
PECO Energy Company
2301 Market Street
Philadelphia, PA 19103
Phone: 215.841.4608
Fax: 215.568.3389
jack.garfinkle@exeloncorp.com

May 28, 2019

For PECO Energy Company

APPENDIX A

<u>TRM Volume 1: Overview</u>

1. Refer to Table 1-6

    1.1 PECO climate zones are split with 99.8% for Region D and 0.2% for Region E. PECO recommends simplifying the climate zone to be 100% Region D.

2. Refer to the text above Table 1-6

    2.1 Please clearly state whether EDCs may rely on these values for relevant savings estimates. The current text includes statements such as: "…could be used…", "…may result in discrepancies…"

3. Refer to Appendix E

    3.1 The current text provides: "For Act 129 energy efficiency measure saving qualification, products must meet the minimum requirements of ENERGY STAR and/or the Design Lights Consortium." The TRM should utilize "and" or "or" because the use of "and/or" creates confusion. PECO recommends the use of "or" to maintain flexibility.

<u>TRM Volume 2: Residential (measure numbers as reflected in the 2021 TRM update documents)</u>

4. Refer to 2.2.2 High Efficiency Equipment: Ductless Heat Pumps with Midstream Delivery Option

    4.1 Certain composite EFLH values are not consistent with the values in approved IMPs. For example, Philadelphia values changed from 454 to 512 for cooling and from 884 to 906 for heating. PECO recommends that the TRM be updated to be consistent with the approved IMP with respect to these EFLH values.

    4.2 The TRM added additional evaluation protocols, such as verification of installation and pre/post metering or billing analysis, which were not part of the relevant IMP. These new protocols increase the time and expense required to measure and verify savings. PECO recommends that the evaluation protocols in the TRM be consistent with the IMP.

5. Refer to 2.2.3 Properly Sized Cooling

    5.1 To avoid confusion, PECO recommends simplifying this as a factor within Measures 2.2.1 and 2.2.2. In addition, PECO believes that properly sized baseline units should not be eligible. Attachment 1 includes a redline of Measures 2.2.1 and 2.2.2 displaying these proposed changes.

6. Refer to 2.2.12 ENERGY STAR Certified Connected Thermostats

    6.1 Baseboard heating, which is currently eligible under approved IMPs, is not eligible in the TRM update. PECO recommends that equipment eligibility in the TRM be consistent with the IMP.

7. Refer to 2.2.13 Furnace Maintenance

    7.1 PECO recommends that the TRM be revised to include the gas savings values that were part of the relevant IMP.

    7.2 It appears that the label on Table 2-46 should be changed from total kWh to kWh/input kBTU/h.

8. Refer to 2.3.1 Heat Pump Water Heaters

    8.1 Round UEFs to two digits in Table 2-49 to align with federal standards.

    8.2 A definition should be provided for "draw pattern" and guidance is needed regarding which "draw pattern" to select. Guidance regarding draw patterns is needed for other TRM measures as well (e.g., 2.3.2, 2.3.3).

    8.3 Specify where default system efficiencies come from in Table 2-48.

9. Refer to 2.3.5 Water Heater Temperature Setback

    9.1 Table 2-57 and 2-58 values for cycle washes should be aligned.

    9.2 The clarity of Table 2-58 should be improved (i.e., type should be "Electric Storage with Washer").

10. Refer to 2.3.7 Low Flow Faucet Aerators and 2.3.8 Low Flow Showerheads

    10.1 The ISRs are based on program year nine data from the FirstEnergy EDCs. PECO recommends that the Commission consider data from additional EDCs over the course of multiple years.

11. Refer to 2.4.5 ENERGY STAR Clothes Dryers

    11.1 Ventless Energy Star models should be included in this measure.

12. Refer to 2.4.10 Dehumidifier Retirement

    12.1 Please revise the text to clarify which value from source 5 should be used.

13. Refer to 2.4.11 ENERGY STAR Ceiling Fans

    13.1 PECO recommends adding 25 kWh/year and 0.002 kW as default values for units with diameters greater than 36 inches.

14. Refer to 2.4.12 ENERGY STAR Air Purifiers

    14.1 Regarding proof of eligibility, please revise the text to state clearly that an Energy Star label is sufficient and providing UL Safety Listing information is not required.

    14.2 The "CADR" variable should specify the appropriate units (e.g., cubic feet per minute).

15. Refer to 2.7.1 Residential New Construction

    15.1 Because residential new construction programs include single-family homes, the term "Residential" should not be replaced with "Multi-family" in the first paragraph under "Algorithms."

    15.2 The TRM should allow the use of other modeling platforms beyond REM/Rate, such as BEopt, so that EDCs can use a calibrated model based on actual consumption or customer billing data.

    15.3 In Table 2-136, water heaters should be "UEF" instead of "EF."

16. Refer to 2.7.3 Low-Rise Multifamily Construction

    16.1 The TRM should allow the use of other modeling platforms beyond REM/Rate, such as BEopt, so that EDCs can use a calibrated model based on actual consumption or customer billing data.

    16.2 Consider combining this measure with Residential New Construction (Measure 2.7.1) in order to streamline EM&V-related reporting.

17. Refer to 2.7.4 ENERGY STAR Manufactured Homes

    17.1 In Table 2-140, water heaters should be "UEF" instead of "EF."

    17.2 Correct the spelling error in the kWpeak equation (i.e., change "dmand" to "demand").

18. Refer to 2.7.5 Home Energy Reports

    18.1 Attachment 1 includes a redline of Measure 2.7.5 displaying PECO's recommended changes to improve clarity.

TRM Volume 3: Commercial and Industrial (measure numbers as reflected in the 2021 TRM update documents)

19. Refer to 3.1.5 LED Channel Signs

    19.1 Measure eligibility should not be limited to red-colored signs. The TRM statement that other colors do not save energy is not adequately supported. A color-agnostic criteria could be used instead, such as the 2016 TRM eligibility criteria: "Replacement signs cannot use more than 20% of the actual input power of the sign that is replaced."

20. Refer to 3.1.7 Lighting Improvements for Midstream Delivery Programs

    20.1 PECO recommends including LED exit signs as eligible for midstream implementation, consistent with a current approved IMP.

21. Refer to 3.2.5 Fuel Switching: Small Commercial Electric Heat to Natural Gas / Propane / Oil Heat

    21.1 PECO believes that billing analysis is an appropriate option, but should not be mandatory. If an EDC customer receives gas service from a different utility, compiling the information necessary for a billing analysis would be burdensome.

22. Refer to 3.2.6 Small C&I HVAC Refrigerant Charge Correction

    22.1 For Table 3-44, please clarify: (1) that "orifice" means a "non-TXV" unit; and (2) that the three columns of "% of nameplate charge added (removed)" are the independent variables.

23. Refer to 3.2.7 ENERGY STAR Room Air Conditioner

    23.1 PECO was unable to find justification for the proposed addition of a 31% ELFH multiplier in the source referenced in the TRM. Please provide any additional support for the multiplier.

24. Refer to 3.2.13 Circulation Fan: High-Volume Low-Speed

    24.1 "Efficient wattage source", "baseline definition", and "baseline source" are not defined terms. PECO recommends defining these terms by wattage required to move an equivalent amount of air, volume or size.

25. Refer to 3.3.2 Variable Frequency Drive (VFD) Improvements

    25.1 The savings cap of 250 MWh and the requirement to collect more detailed data once the cap is exceeded should be highlighted at the beginning of the section. The text should also be revised to explain the requirements for more detailed data collection.

26. Refer to 3.4.1 Heat Pump Water Heaters

26.1 It is unclear why the default midstream savings for tanks less than 55 gallons are fifteen times greater than 55 gallon tanks. The derivation of these values should be explained.

26.2 Define variable "Vr" in Table 3-86.

27. Refer to 3.4.2 Low Flow Pre-Rinse Sprayers for Retrofit Programs and Time of Sale Program

27.1 The text should be revised to clarify that "Retrofit: Groceries" and "Time of Sale: Other" can be used for the unknown installation case.

28. Refer to 3.5.9 Night Covers for Display Cases

28.1 PECO recommends that the TRM include conservative default HOU based on averages from previous project data or store schedule assumptions and a default of (0.01 kW/ft) for case type to allow for simplified implementation. The Company also recommends changing the metric "width of opening" to "quantity of night covers" given that there are standard sizes (e.g., 4, 6, 8 ft) in order to further simplify implementation.

29. Refer to 3.5.10 Auto Closers

29.1 PECO recommends that the TRM include conservative default savings for use when the type of installation in unknown. Such a value would likely be close to the more conservative cooler savings number (737 kWh) in the TRM .

30. Refer to 3.5.13 Suction Pipe Insulation for Walk-in Coolers and Freezers

30.1 PECO recommends that the TRM include a default value for length of insulation based on averages from previous project data in order to reduce data requirements.

31. Refer to 3.5.15 Adding Doors to Existing Refrigerated Display Cases

31.1 PECO recommends that the TRM include conservative default savings to reduce data requirements. Assume doors with anti-sweat heaters (i.e., 277.7 kWh/yr/ft) and change the algorithm to account for number of doors with assumed door width.

32. Refer to 3.5.18 Refrigeration Economizers

32.1 PECO recommends utilizing "Discus" type as an option for "kWh_cond" when the type of compressor is unknown.

33. Refer to 3.7.2 Controls: Beverage Machine Controls

33.1 PECO recommends using "Refrigerated beverage vending machine" as an option for unknown machine type

34. Deleted (previously 3.7.5) [Energy Star Refrigerated Beverage Machine]

34.1 PECO understands that new standards came into effect in January of 2019 and that replacing units meeting the new standards will not result in any savings. However, because the measure life for these machines is 14 years, it is reasonable to expect that some of the units replaced in the future will be older and less efficient. For that reason, PECO believes this measure should be retained in the TRM.

35. Refer to 3.7.8 ENERGY STAR Commercial Hot Food Holding Cabinet

35.1 The TRM requires the EDC to gather unit volume data. PECO recommends that the TRM include a default unit volume value as an option. This change would allow for the development of a default savings value and a midstream delivery option.

36. Refer to 3.7.9 ENERGY STAR Commercial Dishwasher

36.1 Define "low temperature" and "high temperature" in Tables 3-160 and 3-161 to facilitate implementation. Because potentially burdensome data collection is required under the current protocol (e.g., water heater fuel type, presence of booster heater, high or low temperature, machine type), PECO recommends a default based on lowest value shown in Table 3-161, or other values if typical/average installation type is known from previous project data.

37. Refer to 3.9.2 Office Equipment – Network Power Management

37.1 The TRM should define the baseline condition to be networks without management software. Otherwise, simple savings based on default algorithms will require knowledge of the desktop or laptop software.

38. Refer to 3.9.3 Advanced Power Strips

38.1 Please clarify whether this measure is limited to installations in office workstations.

39. Refer to 3.10.2 Compressed Air-entraining Air Nozzle

39.1 PECO recommends conservative default savings values within Tables 3-184 through 3-187 for unknown implementation specifics to allow for easier implementation.

40. Refer to 3.10.3 Compressed Air-no-loss Condensate Drains

40.1 PECO recommends use of conservative options within Tables 3-189 through 3-192 for unknown implementation specifics to allow for easier implementation for the Alternatively, other values if typical/average installation type is known from previous project data can inform defaults.

40.2 The operating hours in Tables 3-191 and 3-192 are different and should be aligned.

41. Refer to 3.10.8 Compressed Air Mist Eliminators

41.1 PECO recommends reducing the eligibility threshold from 50 HP to 40 HP to be consistent with the eligibility requirements of Compressed Air Controller (measure 3.10.6).

42. Refer to 3.11.3 High-frequency Battery Chargers

42.1 PECO recommends that the TRM include conservative default savings for unknown options to allow for midstream or instant discounts. An unknown default can be equivalent to the most conservative value shown in Table 3-214. Alternatively, other values may be appropriate if typical/average installation type is known from previous project data.

43. Refer to 3.12.1 Load Curtailment for Commercial and Industrial Programs

43.1 Attachment 1 includes a redline of Measure 3.12.1 displaying PECO's proposed changes concerning weather adjustments.

44. Refer to 4.1.3 High-efficiency Ventilation Fans with and without Thermostats

44.1 PECO recommends the most conservative values shown in Tables 4-5 and 4-6 as an option for unknown facility type to streamline.

Attachment 1

To Appendix A

2.2 HVAC

2.2.1 High Efficiency Equipment: ASHP, CAC, GSHP, PTAC, PTHP

Target Sector	Residential Establishments
Measure Unit	Central AC, ASHP, GSHP, PTAC or PTHP Unit
Measure Life	15 Source 1
Vintage	Early Replacement, Replace on Burnout, New Construction

The method for determining residential high-efficiency cooling and heating equipment energy impact savings is based on algorithms that determine a central air conditioner or heat pump's cooling/heating energy use and peak demand contribution. Input data is based both on fixed assumptions and data supplied from the high-efficiency equipment AEPS application form or EDC data gathering.

The algorithms applicable for this program measure the energy savings directly related to the more efficient hardware installation.

Larger commercial air conditioning and heat pump applications are dealt with in Section 3 of Volume 3: Commercial and Industrial Measures of this Manual, including GSHP systems over 65 $\frac{kBtu}{hr}$.

Quality installation of new units may also claim cooling savings for properly sized new units.

Eligibility

This measure requires the purchase of a high-efficiency Central Air Conditioner (CAC), Air Source Heat Pump (ASHP), Ground Source Heat Pump (GSHP), Packaged Terminal Air Conditioner (PTAC) or Packaged Terminal Heat Pump (PTHP). Cooling savings claimed from proper sizing requires Manual J calculations, following of ENERGY STAR HVAC Quality Installation procedures, or similar calculations.

Algorithms

This algorithm is used for the installation of new high efficiency air conditioners or heat pumps.

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat} + \Delta kWh_{PSF,cool}$$

$$\Delta kWh_{cool} = CAPY_{cool} \times \left(\frac{OF_{cool}}{SEER_{base}} - \frac{1}{SEER_{ee}}\right) \times EFLH_{cool}$$

$$\Delta kWh_{heat} = CAPY_{heat} \times \left(\frac{OF_{heat}}{HSPF_{base}} - \frac{1}{HSPF_{ee}}\right) \times EFLH_{heat}$$

$$\Delta kWh_{PSF,cool} = \frac{CAPY_{cool}}{SEER_{ee}} \times PSF \times EFLH_{cool}$$

$$\Delta kW = \Delta kW_{cool} + \Delta kW_{PSF}$$

$$\Delta kW_{cool} \Delta kW = CAPY_{cool} \times \left(\frac{OF_{cool}}{EER_{base}} - \frac{1}{EER_{ee}}\right) \times CF$$

$$\Delta kW_{PSF} = \frac{CAPY_{cool}}{EER_{ee}} \times PSF \times CF$$

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Baseline: Room Air Conditioner(s)

EDCs may collect information about the total capacity of the (kBTU/hr) of existing RACs ($CAPY_{RAC}$) in use in the home to determine the replaced capacity. An oversizing factor is calculated from the ratio of baseline to qualifying capacity:

$$OF_{cool} = \frac{\sum CAPY_{RAC}}{CAPY_{cool}}$$

Baseline: Spaceheater(s), Electric Baseboards

EDCs may collect information about the capacity of the existing space heaters, electric furnaces, or electric baseboards. Capacity is determined using the total wattage of electric heat in use, where OF_{heat} is the ratio of the existing electric capacity to the capacity of the new equipment:

$$OF_{heat} = \frac{\sum kW_{Spaceheat} \times 3.412\frac{\text{BTU}}{\text{W}\cdot\text{h}}}{CAPY_{Heat}}$$

Qualifying: Ground Source Heat Pump

GSHP efficiencies are typically calculated differently than air-source units, baseline and qualifying unit efficiencies should be converted as follows, but note that the HSPF derating as outlined above ***should not be applied:***

$$SEER = EER_g \times GSHPDF \times GSER$$

$$EER = EER_g \times GSPK$$

$$HSPF = COP_g \times GSHPDF \times 3.412\frac{\text{BTU}}{\text{W}\cdot\text{h}}$$

Qualifying: Package Terminal Heat Pumps, Package Terminal Air Conditioners

$$SEER = EER$$

$$HSPF = COP \times 3.412\frac{\text{BTU}}{\text{W}\cdot\text{h}}$$

Definition of Terms

Table 2-7: Terms, Values, and References for High Efficiency Equipment: ASHP, CAC, GSHP, PTAC, PTHP

Term	Unit	Value	Sources
$CAPY_{cool}$, The cooling capacity of the equipment being installed[9]	$kBTU/hr$	EDC Data Gathering	AEPS Application; EDC Data Gathering
$CAPY_{heat}$, The heating capacity of the heat pump being installed[10]	$kBTU/hr$	EDC Data Gathering	AEPS Application; EDC Data Gathering
$CAPY_{RAC}$, The cooling capacity of the room AC for the RAC cooling baseline	$kBTU/hr$	EDC Data Gathering	EDC Data Gathering
$kW_{spaceheat}$, The heating capacity of the space heaters in kilowatts.	kW	EDC Data Gathering	EDC Data Gathering
$SEER_{base}$, Seasonal Energy Efficiency Ratio of the Baseline Unit	$\frac{BTU}{W \cdot h}$	EDC Data Gathering, Default see Table 2-8	2; EDC Data Gathering
$SEER_{ee}$, Seasonal Energy Efficiency Ratio of the qualifying unit being installed[11]	$\frac{BTU}{W \cdot h}$	EDC Data Gathering	AEPS Application; EDC Data Gathering
EER_{base}, Energy Efficiency Ratio of the Baseline Unit	$\frac{BTU}{W \cdot h}$	EDC Data Gathering, Default see Table 2-8	3; EDC Data Gathering
EER_{ee}, Energy Efficiency Ratio of the unit being installed[12]	$\frac{BTU}{W \cdot h}$	EDC Data Gathering Default: $-0.0228 \times SEER^2 + 1.1522 \times SEER$	4; EDC Data Gathering; AEPS Application

[9] This data is obtained from the AEPS Application Form or EDC's data gathering based on the model number.
[10] Ibid. This refers to the capacity of the heat pump and not any auxiliary electric resistance heat.
[11] Ibid.
[12] Ibid.

Term	Unit	Value	Sources
EER_g , Energy Efficiency Ratio of a GSHP, this is measured differently than EER of an air source heat pump and must be converted	$\frac{BTU}{W \cdot h}$	EDC Data Gathering	
$HSPF_{base}$, Heating Seasonal Performance Factor of the Baseline Unit	$\frac{BTU}{W \cdot h}$	EDC Data Gathering, Default see Table 2-8	2; EDC Data Gathering
$HSPF_{ee}$, Heating Seasonal Performance Factor of the unit being installed	$\frac{BTU}{W \cdot h}$	EDC Data Gathering	AEPS Application; EDC Data Gathering
PSF , Proper Sizing Factor or the assumed cooling savings due to proper sizing and proper installation	*Proportion*	Not properly sized: 0 Properly sized: 0.05	10
COP_{ee} , Coefficient of Performance of the unit being installed. This is a measure of the efficiency of a heat pump	*Proportion*	EDC Data Gathering	AEPS Application; EDC Data Gathering
OF_{cool} , Oversize factor	*None*	EDC Data Gathering, Default see Table 2-9	5
OF_{heat} , Oversize factor	*None*	EDC Data Gathering, Default see Table 2-9	6
GSER , Factor used to determine the SEER of a GSHP based on its EER_g	$\frac{BTU}{W \cdot h}$	1.02	7
GSPK , Factor to convert EER_g to the equivalent EER of an air conditioner to enable comparisons to the baseline unit	*Proportion*	0.8416	7
GSHPDF , Ground Source Heat Pump De-rate Factor	*Proportion*	0.885	8
$EFLH_{cool}$, Equivalent Full Load Hours of operation during the cooling season for the average unit	$\frac{hours}{yr}$	See $EFLH_{cool}$ in Vol. 1, App. A	9
$EFLH_{heat}$, Equivalent Full Load Hours of operation during the heating season for the average unit	$\frac{hours}{yr}$	See $EFLH_{heat}$ in Vol. 1, App. A	9
CF , Demand Coincidence Factor	*Proportion*	See *CF* in Vol. 1, App. A	9

Table 2-8: Default Baseline Equipment Efficiency for High Efficiency Equipment

	Early Replacement			Replace on Burnout / New Construction		
Baseline Equip.	$SEER_{base}$	EER_{base}	$HSPF_{base}$	$SEER_{base}$	EER_{base}	$HSPF_{base}$
ASHP	13.5	11.4	8.2	14	12.0	8.2
CAC	12.1	10.6[a]	–	13	11.3	8.2
GSHP	15.0	16.6[a]	10.9	14	12.0	8.2
Elec. Baseboard	–	–	3.412	–	–	–
Elec. Furnace[13]	–	–	3.241	–	–	–
Space Heaters	–	–	3.412	–	–	–
PTAC[14,15,16]	$EER_{base} = 10.9 - (0.213 \times CAPY_{cool})$		–	$EER_{base} = 14.0 - (0.3 \times CAPY_{cool})$		–
PTHP [15,16,17]	$EER_{base} = 10.8 - (0.213 \times CAPY_{cool})$		$3.412 \frac{Btu}{W \cdot h} \times (2.9 - 0.026 \times CAPY_{cool})$	$EER_{base} = 14.0 - (0.3 \times CAPY_{cool})$		$3.412 \frac{Btu}{W \cdot h} \times (3.7 - 0.052 \times CAPY_{cool})$

a. Calculated using the equation from Source 4

Table 2-9: Default Oversize Factors for High Efficiency Equipment

Qualifying	Oversize Factor	Existing						
		ASHP	CAC	Electric Baseboard	Electric Furnace	GSHP	RAC	Space Heaters
CAC	OF_{cool}	1	1	0	0	1	1	0
HP	OF_{heat}	1	1	1	1	1	0	0.6
	OF_{cool}	1	1	0	0	1	1	0

Evaluation Protocols

The most appropriate evaluation protocol for this measure is verification of installation coupled with assignment of stipulated energy savings.

Sources

1) California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx Accessed December 2018
2) For Early Replacement ASHP, CAC: Pennsylvania Act 129 2018 Residential Baseline Study [http://www.puc.state.pa.us/Electric/pdf/Act129/SWE-Phase3_Res_Baseline_Study_Rpt021219.pdf] For Early Replacement GSHP: the values represent the minimum efficiency values for GSHP in BEopt v2.8.0. For Replace on Burnout/New Construction ASHP, CAC, GSHP: Federal Code of Regulations 10 CFR 430. https://www.gpo.gov/fdsys/pkg/CFR-2017-title10-vol3/pdf/CFR-2017-title10-vol3-sec430-

Field Code Changed

Field Code Changed

Field Code Changed

13 Using the relation $HSPF=COP\times3.412$ where $HSPF = 3.412$ for electric resistance heating. Electric furnace efficiency typically varies from 0.95 to 1.00, therefore a COP of 0.95 equates to an $HSPF$ of 3.241.
14 If the unit's capacity is less than 7 kBTU/hr, use 7 kBTU/hr in the calculation. If the unit's capacity is greater than 15 kBTU/h, use 15 kBTU/hr in the calculation.
15 "Early Replacement" is for nonstandard size packaged terminal air conditioners and heat pumps with existing sleeves having an external wall opening of less than 16 in. high or less than 42 in. wide and having a cross-sectional area less than 670 sq. in. Shall be factory labeled as follows: "Manufactured for nonstandard size applications only: not to be installed in new construction projects."
16 "New Construction" is intended for applications with new, standard size exterior wall openings.

32.pdf. For PTAC and PTHP: standards are based on requirements of ASHRAE 90.1-2016, Energy Standard for Buildings Except Low-Rise Residential Buildings, Table 6.8.1-4, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards.

Field Code Changed

3) Average EER for SEER 13 units as calculated by EER = -0.02 × SEER² + 1.12 × SEER based on U.S. DOE Building America House Simulation Protocol, Revised 2010.
4) "Methodology for Calculating Cooling and Heating Energy Input-Ratio (EIR) from the Rated Seasonal Performance Eefficiency (SEER OR HSPF)" (Kim, Baltazar, Haberl). April 2013 Accessed December 2018. http://oaktrust.library.tamu.edu/bitstream/handle/1969.1/152118/ESL-TR-13-04-01.pdf

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5) Based on REM/Rate modeling using models from the PA 2012 Potential Study. EFLH calculated from kWh consumption for cooling and heating. Models assume 50% over-sizing of air conditioners[17] and 40% oversizing of heat pumps.[18]
6) Assumptions used to calculate a default value for de facto heating system OF: Four (4) 1500W portable electric space heaters in use in the home with capacity of $4 \times 1.5kW \times 3412 \frac{BTU}{kW{\cdot}h} = 20{,}472\ BTU$, replaced by DHP with combined heating capacity of 36kBTU. $OF = \frac{20{,}472}{36{,}000} \approx 0.6$
7) VEIC estimate. Extrapolation of manufacturer data.
8) McQuay Application Guide 31-008, Geothermal Heat Pump Design Manual, 2002. Engineering Estimate - See System Performance of Ground Source Heat Pumps
9) Based on the Phase III SWE team's analysis of regional HVAC runtime data collected from ecobee's Donate Your Data research service. https://www.ecobee.com/donateyourdata/

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10) Northeast Energy Efficiency Partnerships, Inc., "Strategies to Increase Residential HVAC Efficiency in the Northeast", (February 2006): Appendix C Benefits of HVAC Contractor Training: Field Research Results 03-STAC-01, p. 46.

[17] Neme, Proctor, Nadal, "National Energy Savings Potential From Addressing Residential HVAC Installation Problems". ACEEE, February 1, 1999. https://www.proctoreng.com/dnld/NationalEnergySavingsPotentialfromAddressingResidentialHVACInstallationProblems.pdf Confirmed also by *Central Air Conditioning in Wisconsin, a compilation of recent field research*. Energy Center of Wisconsin. May 2008, emended December 15, 2010. https://www.seventhwave.org/publications/central-air-conditioning-wisconsin-compilation-recent-field-research

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[18] ACCA, "Verifying ACCA Manual S Procedures," http://www.acca.org/wp-content/uploads/2014/01/Manual-S-Brochure-Final.pdf

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2.2.2 High Efficiency Equipment: Ductless Heat Pumps with Midstream Delivery Option

Target Sector	Residential Establishments
Measure Unit	Ductless Heat Pump Unit
Measure Life	15 years Source 1
Vintage	Early Replacement, Replace on Burnout, New Construction

ENERGY STAR Version 5.0 ductless "mini-split" heat pumps technology is typically used to convert an electric resistance heated home into an efficient single or multi-zonal ductless heat pump system.

Quality installation of new units may also claim cooling savings for properly sized new units.

Eligibility

This protocol documents the energy savings attributed to ductless heat pumps. Eligible equipment must meet ENERGY STAR Version 5.0 requirements. The baseline heating system could be:

1) Existing electric resistance heating
2) Electric space heaters used as the primary heating source when fossil fuel (other than natural gas) heating systems failed (referred to as de facto heating) [19]
3) A lower-efficiency ductless heat pump system
4) A ducted heat pump
5) Electric furnace
6) A non-electric fuel-based system.

The baseline cooling system can be:

1) A standard efficiency heat pump system
2) A central air conditioning system
3) A room air conditioner

For new construction or addition applications, the baseline assumption is a standard-efficiency ductless unit (Table 2-12). DHP systems may be installed as the primary heating or cooling system for the house or as a secondary heating or cooling system for a single room. Cooling savings claimed from proper sizing requires Manual J calculations, following of ENERGY STAR HVAC Quality Installation procedures, or similar calculations.

Midstream HVAC Overview

Residential ductless mini-split heat pumps midstream delivery programs will offer incentives on eligible products sold to trade allies and customers through residential sales channels such as distributors of HVAC products. This complements other delivery channels (such as downstream rebates to trade allies and customers) by providing incentives to encourage distributors to stock, promote, and sell more efficient systems.

[19] This baseline is for participants with broken-beyond-repair oil heating systems who are heating their homes with portable electric space heaters.

Midstream savings calculations rely on composite baseline information formulated by blending historical participant data from PECO's downstream programs for PY8 to PY9 and PPL's programs from PY8 to PY10Q1 with the existing PA TRM deemed values for the downstream incentive program. See "Midstream Composite Baseline Calculations" below. Cooling savings from proper sizing cannot be claimed in addition to the midstream savings calculations.

ALGORITHMS

The savings depend on three main factors: baseline condition, usage (primary or secondary heating system), and the capacity of the indoor unit. This algorithm is used for the installation of new high efficiency air conditioners or heat pumps. For non-midstream delivery methods, if there are multiple zones, each zone should be calculated separately. For midstream delivery, composite values are provided.

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat} + \Delta kWh_{PSF,cool}$$

$$\Delta kWh_{cool} = CAPY_{cool} \times \left(\frac{OF_{cool} \times DLF}{SEER_{base}} - \frac{1}{SEER_{ee}}\right) \times EFLH_{cool,zone} \times n_{MS\ zones}$$

Note: Be sure to use $EFLH_{cool}$ of Room ACs for secondary cooling zones, see Table 2-11.

$$\Delta kWh_{heat} = CAPY_{heat} \times \left(\frac{OF_{heat} \times DLF}{HSPF_{base}} - \frac{1}{HSPF_{ee}}\right) \times EFLH_{heat,HP,zone} \times n_{MS\ zones}$$

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$$\Delta kWh_{PSF,cool} = \frac{CAPY_{cool}}{SEER_{ee}} \times PSF \times EFLH_{cool,zone}$$

$$\Delta kW = \Delta kW_{peak} + \Delta kW_{PSF}$$

$$\Delta kW_{peak} = CAPY_{cool} \times \left(\frac{OF_{cool} \times DLF}{EER_{base}} - \frac{1}{EER_{ee}}\right) \times CF \times n_{MS\ zones}$$

$$\Delta kW_{PSF} = \frac{CAPY_{cool}}{EER_{ee}} \times PSF \times CF ~~\times n_{MS\ zones}~~$$

Note: Be sure to use $EFLH_{heat}$ of Secondary HP for secondary heating zones, see Table 2-11.

Baseline: Room Air Conditioner(s)

EDCs may collect information about the capacity of existing RACs (W_{RAC}) in use in the home to determine the replaced capacity. An oversizing factor is calculated from the ratio of baseline to qualifying capacity:

$$OF_{cool} = \frac{\sum CAPY_{RAC}}{CAPY_{cool}}$$

Baseline: Spaceheater(s), Electric Baseboards

EDCs may collect information about the capacity of the existing space heaters, electric furnaces, or electric baseboards. Capacity is determined using the total wattage of wattage of electric heat in use, where OF_{heat} is the ratio of the existing electric capacity to the capacity of the new equipment:

$$OF_{heat} = \frac{\sum kW_{Spaceheat} \times 3.412\frac{BTU}{W \cdot h}}{CAPY_{Heat}}$$

DEFINITION OF TERMS

Table 2-10: Terms, Values, and References for High Efficiency Equipment: Ductless Heat Pump

Term	Unit	Value	Sources
$CAPY_{cool}$, The cooling capacity of the central air conditioner or heat pump being installed[20]	$kBTU/hr$	EDC Data Gathering	AEPS Application; EDC Data Gathering
$CAPY_{heat}$, The heating capacity of the heat pump being installed[21]	$kBTU/hr$	EDC Data Gathering	AEPS Application; EDC Data Gathering
$CAPY_{RAC}$, The cooling capacity of the room AC. Used only for the RAC cooling baseline	$kBTU/hr$	EDC Data Gathering	EDC Data Gathering
$kW_{spaceheat}$, The heating capacity of the space heaters in watts.	kW	EDC Data Gathering	EDC Data Gathering
$SEER_{base}$, Seasonal Energy Efficiency Ratio of the Baseline Unit	$\frac{BTU}{W \cdot h}$	EDC Data Gathering Default: Table 2-12 ~~Table 2-12~~ or Table 2-8 in Sec. 2.2.1 Midstream: 12.1	EDC Data Gathering; 2; 10
$SEER_{ee}$, Seasonal Energy Efficiency Ratio of the qualifying unit being installed[22]	$\frac{BTU}{W \cdot h}$	EDC Data Gathering	AEPS Application; EDC Data Gathering
EER_{base}, Energy Efficiency Ratio of the Baseline Unit	$\frac{BTU}{W \cdot h}$	EDC Data Gathering Default: Table 2-12 ~~Table 2-12~~	EDC Data Gathering; 3
EER_{ee}, Energy Efficiency Ratio of the unit being installed[23]	$\frac{BTU}{W \cdot h}$	EDC Data Gathering Default: $-0.0228 \times SEER_{ee}^2 + 1.1522 \times SEER_{ee}$	EDC Data Gathering; AEPS Application; 4
$HSPF_{base}$, Heating Seasonal Performance Factor of the Baseline Unit	$\frac{BTU}{W \cdot h}$	EDC Data Gathering Default: Table 2-12 ~~Table 2-12~~ or Table 2-8 in 2.2.1 Midstream: 6.7	EDC Data Gathering; 2; 10
$HSPF_{ee}$, Heating Seasonal Performance Factor of the unit being installed[24]	$\frac{BTU}{W \cdot h}$	EDC Data Gathering	AEPS Application; EDC Data Gathering

[20] This data is obtained from the AEPS Application Form or EDC's data gathering based on the model number.
[21] Ibid.
[22] Ibid.
[23] Ibid.
[24] This data is obtained from the AEPS Application Form or EDC's data gathering.

Term	Unit	Value	Sources
PSF , Proper Sizing Factor or the assumed cooling savings due to proper sizing and proper installation	*Proportion*	Midstream: 0 Not properly sized: 0 Properly sized: 0.05	11
OF_{cool} , Oversize factor	None	EDC Data Gathering Default: Table 2-9 Midstream: 1.1	EDC Data Gathering; 5
OF_{heat} , Oversize factor	None	EDC Data Gathering Default: Table 2-9 Midstream: 1.3	EDC Data Gathering ;6
DLF, "Duct Leakage Factor" accounts for the fact that a % of the energy is lost to duct leakage and conduction for ducted systems, but not ductless ones	None	Depends on baseline & efficient conditions: Table 2-13 Midstream, cooling: 1.02 Midstream, heating: 1.01	7; 10
zone, Primary or secondary usage level of a space, this affects $EFLH_{cool}$ and $EFLH_{heat}$. For midstream delivery, use provided composite *EFLH* values.	None	See Table 2-11	
$n_{MS\ zones}$, Average number of heating and cooling zones per site. Note: this factor applies to mid-stream delivery only.	None	1.18	10
$EFLH_{cool}$, Equivalent Full Load Hours of operation during the cooling season for the average unit	$\frac{hours}{yr}$	See $EFLH_{cool}$ in Vol. 1, App. A Use Room AC hours for secondary zones. Midstream: Table 2-18	8
$EFLH_{heat,HP}$, Equivalent Full Load Hours of operation during the heating season for the average unit	$\frac{hours}{yr}$	See $EFLH_{heat}$ in Vol. 1, App. A Use Secondary HP for secondary zones. Midstream: Table 2-18	8
CF , Demand Coincidence Factor	*Proportion*	See *CF* in Vol. 1, App. A	8

Table 2-11: Ductless Heat Pump Usage Zones

Usage Zone	Definition
Primary	Dining room Family room House hallway Living room Kitchen areas Recreation room
Secondary	Basement Bathroom Bedroom Laundry/Mudroom Office/Study Storage room Sunroom/Seasonal room

Table 2-12: Default Ductless Heat Pump Efficiencies

Baseline Equip.	Early Replacement			Replace on Burnout/New Construction		
	$SEER_{base}$	EER_{base}	$HSPF_{base}$	$SEER_{base}$	EER_{base}	$HSPF_{base}$
Ductless	13	11.3	8.2	14	12	8.2

Table 2-13: Oversize and Duct Leakage Factors for High Efficiency Equipment

	ASHP	CAC	Ductless	Electric Baseboard	Electric Furnace	New Construction	RAC	Space Heaters
DLF	1.15	1.15	1	1	1.15	1	1	1
OF_{heat}	1.4	0	1	1.4	1.4	1	0	0.6
OF_{coo}	1.4	1.5	1	0	0	1	1	0

Midstream Composite Baseline Calculations

The Midstream Delivery Program estimates the baseline system using composite values calculated from historical participant data. The composite values of the baseline inputs (SEER, EER, OF, DLF, and HSPF) are based on the PA TRM values and baseline heating and cooling system splits from historical PECO PY8 to PY9 and PPL PY8 to PY10Q1 data. The composite EFLH values assume a 50/50 split between primary and secondary installations and are a weighted average of EFLH values in Appendix A: Climate Dependent Values. Table 2-14 through Table 2-18 show the inputs for the calculation of each composite baseline value.

Table 2-14: Midstream DHP – SEER and EER Baseline Splits

Cooling Type	$SEER_{base}$	EER_{base}	Split[25]
Central AC	13.0	11.3	4%
DHP or ASHP	14.0	12.0	8%
No existing cooling for primary space	13.0	11.3	29%
No existing cooling for secondary space	11.3	9.8	30%

[25] The split represents the approximate percentage of projects in the PECO and PPL territory that have the indicated Cooling Type. The split is calculated by dividing the number of projects with the indicated Cooling Type by the total number of projects in PECO PY8 to PY9 and PPL PY8 to PY10Q1 historical data set. The split is rounded to the nearest percent.

Room AC	11.3	9.8	30%
Composite[26]	12.1	10.5	100%

Table 2-15: Midstream DHP – HSPF Baseline Splits

Heating Type	$HSPF_{base}$	Split
ASHP	8.2	3%
Electric furnace	3.2	1%
Electric resistance or de facto space heaters	3.4	32%
No existing or non-electric heating	8.2	57%
Standard DHP	8.2	8%
Composite	6.7	100%

Table 2-16: Midstream DHP – DLF_{cool} and OF_{cool} Baseline Splits

Cooling Type	DLF_{cool}	OF_{cool}	Split
Central AC	1.15	1.5	8%
Central ASHP	1.15	1.4	5%
Ductless Heat Pump	1.00	1.0	19%
Room AC	1.00	1.0	69%
Composite	1.02	1.1	100%

Table 2-17: Midstream DHP – DLF_{heat} and OF_{heat} Baseline Splits

Heating Type	DLF_{heat}	OF_{heat}	Split
Central ASHP	1.15	1.4	6%
De facto Space Heaters	1.00	0.6	5%
Ductless Heat Pump	1.00	1.0	26%
Electric Baseboard	1.00	1.4	62%
Electric Furnace	1.15	1.4	1%
Composite	1.01	1.3	100%

Table 2-18: Midstream DHP – Composite EFLH Values

Reference City	Zone	Composite $EFLH_{cool}$	Composite $EFLH_{heat}$
Allentown	C	377	1040
Binghamton, NY	A	218	1277
Bradford	G	135	1445
Erie	I	307	1213
Harrisburg	E	479	1129
Philadelphia	D	512	906

[26] The composite value represents the weighted average of the system type based on the relative system splits. The computed average is rounded to the nearest tenth.

Pittsburgh	H	356	1073
Scranton	B	310	1143
Williamsport	F	366	1085

Evaluation Protocols

The most appropriate evaluation protocol for this measure is verification of installation coupled with assignment of stipulated energy savings. A sample of pre- and post-metering is recommended to verify heating and cooling savings but billing analysis will be accepted as a proper form of savings verification and evaluation.
The composite baseline values will be updated as needed from the downstream program participation data set.

Sources

1) California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx. Accessed December 2018.

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2) Federal Code of Regulations 10 CFR 430. https://www.gpo.gov/fdsys/pkg/CFR-2017-title10-vol3/pdf/CFR-2017-title10-vol3-sec430-32.pdf

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3) Average EER for SEER 13 units as calculated by EER = -0.02 × SEER² + 1.12 × SEER based on U.S. DOE Building America House Simulation Protocol, Revised 2010.
4) "Methodology for Calculating Cooling and Heating Energy Input-Ratio (EIR) from the Rated Seasonal Performance Eefficiency (SEER OR HSPF)" (Kim, Baltazar, Haberl). April 2013 Accessed December 2018. http://oaktrust.library.tamu.edu/bitstream/handle/1969.1/152118/ESL-TR-13-04-01.pdf

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5) Based on REM/Rate modeling using models from the PA 2012 Potential Study. Models assume 50% over-sizing of air conditioners[27] and 40% oversizing of heat pumps.[28]
6) Assumptions used to calculate a default value for de facto heating system OF: Four (4) 1500W portable electric space heaters in use in the home with capacity of $4 \times 1.5kW \times 3412 \frac{BTU}{kW{\cdot}h} = 20{,}472\ BTU$, replaced by DHP with combined heating capacity of 36kBTU. $OF = \frac{20{,}472}{36{,}000} \approx 0.6$
7) Assumption used in Illinois 2014 TRM, Ductless Heat Pumps Measure, p. 531, footnote 877. Reasonable assumption when compared to http://www.energystar.gov/index.cfm?c=home_improvement.hm_improvement_ducts and Residential HVAC and Distribution Research Implementation,. Berkeley Labs. May, 2002, p. 6. http://epb.lbl.gov/publications/pdf/lbnl-47214.pdf

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8) Based on the Phase III SWE team's analysis of regional HVAC runtime data collected from ecobee's Donate Your Data research service. https://www.ecobee.com/donateyourdata/

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9) Assumptions used to calculate a default value for de facto heating system OF: Four (4) 1500 W portable electric space heaters in use in the home with capacity of 1500 × 3.412 × 4 = 20,472 BTU, replaced by DHP with combined heating capacity of 36,000 BTU. OF = 20,472 / 36,000 = 0.6.

[27] Neme, Proctor, Nadal, "National Energy Savings Potential From Addressing Residential HVAC Installation Problems. ACEEE, February 1, 1999. Confirmed also by *Central Air Conditioning in Wisconsin, a compilation of recent field research.* Energy Center of Wisconsin. May 2008, emended December 15, 2010, http://ecw.org/sites/default/files/241-1_0.pdf

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[28] ACCA, "Verifying ACCA Manual S Procedures," http://www.acca.org/wp-content/uploads/2014/01/Manual-S-Brochure-Final.pdf

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10) PECO PY8 to PY9 Program Participation Data and PPL PY8 to PY10Q1 Program Participation Data

11) Northeast Energy Efficiency Partnerships, Inc., "Strategies to Increase Residential HVAC Efficiency in the Northeast", (February 2006): Appendix C Benefits of HVAC Contractor Training: Field Research Results 03-STAC-01, p. 46.

2.7.5 Home Energy Reports

Target Sector	Residential Establishments
Measure Unit	Household
Measure Life	1 year for cohorts with 1 year of exposure Source 1 3 years for cohorts with 2 years or more of exposure Source 1Specified in protocol
Vintage	Retrofit

Home Energy Report (HER) programs encourage conservation through greater awareness of consumption patterns and engagement with EDC resources to help reduce usage and lower bills. HER program vendors provide participants with account-specific information that allows customers to view various aspects of their energy use over time. Behavioral reports compare energy use of recipient homes with clusters of similar homes and businesses and provide comparisons with other efficient and average homes. This so-called "neighbor" comparison is believed to create cognitive dissonance in participants and spur them to modify their behavior to be more efficient. Reports also include a variety of seasonally appropriate energy-saving tips that are tailored for the home and are often used to promote other EDC program offerings. Historically, HERs have been largely issued on paper via the USPS, but EDCs and their vendors are increasingly moving toward email reports and digital portals to promote increased engagement and conserve resources. This protocol applies to residential HER programs regardless of delivery mode (e.g., paper, email, digital portals)..

A growing list of evaluation studies,[82] including analyses of HER persistence by the Phase II and Phase III Pennsylvania Statewide Evaluation team, have observed energy savings among HER recipient households for two years after HER exposure was discontinued. The persistence of HER savings has implications for calculation of first-year energy savings and cost-effectiveness. This protocol provides guidance to EDCs and their evaluation contractors for calculating first-year incremental savings and lifetime savings from HER programs using a multi-year measure life with "decay" perspective. This multi-year persistence perspective is a departure from prior phases of Act 129, which assumed a 1-year measure life for HER programs.

Because Act 129 goals are based on first-year incremental savings, accounting for persistence will yield reduced first-year compliance savings from EDC programs that continue to expose the same homes to HER messaging year after year. However, the multi-year perspective will improve the cost-effectiveness of new cohorts of HER recipients compared to a 1-year measure life assumption.

The core assumption in this protocol is an annual decay rate of 3331.3%[83] beginning after two consecutive years of treatment.[84] To illustrate the concept of decay consider a hypothetical cohort of 20,000 treatment group homes that have been receiving HERs for two years. Table 2-141 shows the average kWh savings per treatment group home by year as measured through a billing analysis of the randomized control trial design.

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[82] Refer to Source 1 which includes a list of secondary source information.
[83] One-third (1/3) of savings decay per year.
[84] The decay from only one year of treatment is assumed to be 100%.

Table 2-141: Home Energy Report Persistence Example

Year	Avg. kWh Savings per Home
1	150
2	200

For Year 3, the EDC can choose to either continue issuing HERs to the treatment group homes or stop treating them. If the EDC stops issuing HERs to the treatment group in Year 3, little or no cost will be incurred. If the EDC continues issuing HERs to the treatment group in Year 3, a full year of program delivery costs will be incurred. The key question is "what are the incremental energy savings associated with the decision to mail HERs in Year 3?" Table 2-142 shows the components of this calculation.

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Table 2-142: Calculation of Avoided Decay and Incremental Annual Compliance Savings

Year	Avg. kWh Savings per Home	Avg. kWh Savings Absent Year 3 Treatment	Avg. kWh Savings with Year 3 Treatment
1	150		
2	200		
3		200×(1-0.313/2) = 168.7	210

In this hypothetical example the incremental first-year savings achieved by the HER program in Year 3 is 41.3 kWh (210 – 168.7). This is the sum of two separate factors.

- **Avoided Decay** = 31.3 kWh. The avoided decay is the difference between the Year 2 savings and the assumed annual rate of decay. Because the decay rate is assumed to be linear the average amount of decay over the year is equal to half of the decay at the end of the year. The 168.7 kWh value in Table 2-142 is an estimate of what would have happened absent any further program effort. Some kWh savings persist, but at a lower rate than observed in Year 2, when households were actively receiving HER messaging. By continuing to issue HERs in Year 3, the EDC avoids this savings decay.

- **Change in the Average Treatment Effect** = 10 kWh. The "Avg. kWh Savings with Year 3 Treatment" column of Table 2-142 shows an average kWh savings value of 210 kWh per household. This is an increase of 10 kWh over the Year 2 measurement of 200 kWh per household. Many HER programs show growth in the average rate of savings over time as participants continue to respond to the messaging. This component of the calculation of the calculation could also be negative if the Year 3 savings measurement was smaller than the Year 2 measurement. HER savings can fluctuate based on weather and the measurement is inherently noisy because of the small effect size.

The following algorithms and default assumptions provide guidance on calculating and reporting compliance savings from HER programs in Phase IV of Act 129. Several assumptions that straddle technical and policy considerations are listed below.

1) The change in perspective from a 1-year EUL to a multi-year with decay approach creates an issue of unaccounted for lifetime savings from Phase III HER programs. Specifically, HER cohorts that were active in PY12 will be assumed to have persistent savings in PY13 even though persistent savings were not accounted for in Phase III TRC calculations. This is unavoidable with a change in accounting methods and best handled at the beginning of a Phase IV. It has no bearing on Phase III compliance savings.

2) New HER cohorts willThe assumed annual rate of decay for Act 129 HER programs is based on an analysis of mature programs where treatment group homes received HER messaging for multiple years. Studies have also consistently shown that it takes time for HER savings to mature. For Phase IV of Act 129, new HER cohorts will continue to assume a 1-year EUL during the first year of HER exposure. The persistence and decay assumptions outlined in this protocol will take effect for Year 2 of exposure. Years of exposure are mapped to Act 129 program years. If a cohort begins receiving HER messaging in December (halfway through the program year), that program year is still Year 1, and the following program year is Year 2 with regard to application of persistence assumptions.

3) The Phase IV HER accounting methodology may lead EDCs to modify their historic HER delivery approach of treating the same homes year after year. Doing so would lead to diminished cost-effectiveness in Year 3 and beyond. EDCs may instead organize their EE&C plans to 'rotate' through eligible households. Act 129 HER programs should always be delivered as a randomized control trial (RCT).), but EDCs have significant flexilbility in designing new HER cohorts. New cohorts can be composed of a mix of past HER recipients and control group homes or non-recipients. RTC validation must be performed for each new cohort.Randomization should ensure a balanced mix across the new treatment and control group and the billing analysis will capture the savings associated with exposing the new treatment group to HERs, but not the control group. When a new cohort is created, accounting always begins at Year 1, even if some of the treatment and control group homes have received HER messaging previously.

4) Over time, households close their EDC accounts. The most common reason is because the occupant is moving, but other possibilities exist. This account "churn" happens at a fairly predictable rate for an EDC service territory and can be forecasted with some degree of certainty. Calculating persistent HER savings in future program years requires both an assumption of the savings decay rate and an assumption of the churn rate.

ALGORITHMS

The equations for incremental first-year savings from HER programs are:

Annual Treatment Effect = ATE

The average savings per treated participant per day, within a given year, as reflected in billing analyses and before any adjustments for persistence considerations.

Aggregate Annual Treatment Effect = AATE

The average savings per treated participant per day, after accounting for persistence from previous years.

Year 1 and 2 of HER Exposure:

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Table 2-141142: Annual Incremental Savings Calculations

Consecutive Years of HER Exposure	Y (year subscript)	Aggregate Annual Treatment Effect ($AATE_y$)(kWh)	Treatment Accounts (TAy)	$Days_y$
1 Year	1	ATE_1	TA_1	$Days_1$
2 Years	2	ATE_2	TA_2	$Days_2$
3 Years	3	$ATE_3 - ATE_2 * 0.67 - ATE_1 * 0.33$	TA_3	$Days_3$
4 Years	4	$ATE_4 - ATE_3 * 0.67 - ATE_2 * 0.33$	TA_4	$Days_4$
5 Years	5	$ATE_5 - ATE_4 * 0.67 - ATE_3 * 0.33$	TA_5	$Days_5$
n Years	n	$ATE_n - ATE_{n-1} * 0.67 - ATE_{n-2} * 0.33$	TA_n	$Days_n$

Annual Incremental Savings:

$$\Delta kWh_Y = AATE_y * TA_y * Days_y = ATE * Treatment\ Accounts * Days$$

Lifetime Savings:If an EDC elects to treat an HER cohort for a 3rd year or beyond the equation for incremental first-year savings is:

Year 3 and Beyond of HER Exposure:

$$\Delta kWh_Y = \left(ATE - ATE_{Y-1} * \left(1 - \frac{Decay}{2}\right)\right) * Treatment\ Accounts * Days$$

The equations for calculating lifetime savings from a program year of HER exposure are given below.

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Table 2-142144: Lifetime Savings Calculations

Consecutive Years of HER Exposure	Lifetime Savings (kWh) (sume of columns to right)	Lifetime Savings: Current Year (kWh)	Lifetime Savings: Second Year (kWh)	Lifetime Savings: Third Year (kWh)
1 Year	kWh_1	kWh_1	0	0
2 Years	$kWh_2 * 1.92$	$kWh_2 * 1.00$	$kWh_2 * 0.63$	$kWh_2 * 0.29$
3 Years	$kWh_3 * 1.92$	$kWh_3 * 1.00$	$kWh_3 * 0.63$	$kWh_3 * 0.29$
4 Years	$kWh_4 * 1.92$	$kWh_4 * 1.00$	$kWh_4 * 0.63$	$kWh_4 * 0.29$
5 Years	$kWh_5 * 1.92$	$kWh_5 * 1.00$	$kWh_5 * 0.63$	$kWh_5 * 0.29$
n Years	$kWh_n * 1.92$	$kWh_n * 1.00$	$kWh_n * 0.63$	$kWh_n * 0.29$

The 1.92 factor is the sum of persisted savings considering both the 33.3% decay rate and a 6% churn rate. For example, 67.7% of savings persist into the second year and 33.3% of savings persist into the third year; 94% of participants remain in the treated group into the second year and 88% of participants remain in the treated group into the third year. No lifetime savings are assumed beyond a third year.

- First year: 1.00 (no decay or churn)

- Second year: 67% * 94% = 0.63
- Third year: 33% * 88% = 0.29
- Sum of three years: 1.92

For Year 1, the lifetime savings are equal to the first-year savings. For the Year 2 and beyond of HER exposure the lifetime savings include both the savings measured at the meter via billing analysis and persistent savings from future program years. The equations below do not include the discount rate, but EDC evaluation contractors should use an approved discount rate to calculate the net present value of future savings when performing the TRC test.

Year 1 of HER Exposure:

$$\Delta kWh_{lifetime} = ATE * Treatment\ Accounts * Days$$

Year 2 and Beyond of HER Exposure:

$$\Delta kWh_{lifetime} = \Delta kWh_Y + \sum_{X=1}^{X=3} \Delta kWh_Y * \left(\left(1 - Decay * (x - 0.5)\right) * (1 - Churn)^x\right)$$

DEFINITION OF TERMS

Table 2-143: Terms, Values, and References for HER Persistence Protocol

Parameter	Unit	Value	Source
ΔkWh_Y, kWh savings per home in the program year being evaluated	*Total Incremental Annual kWh Savings of an HER cohort*	EDC Data Gathering	EDC Data Gathering
ATE, Average Treatment Effect	*kWh/day per household*	EDC Data Gathering	EDC Data Gathering
$AATE$, Aggregate Average Treatment Effect	*kWh/day per household*	Calculation, EDC Data Gathering	EDC Data Gathering, 1
$Treatment\ Accounts$, number of active homes in the treatment group	*Households (EDC account number)*	EDC Data Gathering	EDC Data Gathering
$Days$, average number of post-treatment days in the analysis period per household	*Days*	EDC Data Gathering	EDC Data Gathering
$Decay$, Annual rate of decay of the HER effect when exposure is discontinued	-	331.3%	1
$Churn$, Average annual reduction in participating households due to account closures, move-out etc.	-	Default: 6% EDC Data Gathering	2

EVALUATION PROTOCOLS

This protocol deals with the measure life and persistence aspects of HER programs. Chapter 6.1 of the Pennsylvania Evaluation Framework provides detailed guidance on other aspects of HER evaluation protocols.

SOURCES

1) Pennsylvania Statewide Evaluation Team. Residential Behavioral Program Persistence Study. http://www.puc.state.pa.us/Electric/pdf/Act129/SWE_Res_Behavioral_Program-Persistence_Study_Addendum2018.pdf

Field Code Changed

2) SWE Analysis of average annual churn rate among Phase III EDC cohorts.

3.12 Demand Response

3.12.1 Load Curtailment for Commercial and Industrial Programs

Target Sector	Commercial and Industrial Establishments
Measure Unit	N/A
Measure Life	1 year
Measure Vintage	Demand Response

In a C&I Load Curtailment (LC) program, end-use customers are provided a financial incentive to reduce the amount of electricity they take from the EDC during Demand Response events. This temporary reduction in electricity consumption can be achieved in a number of ways. The specific load curtailment actions taken by program participants are outside of the scope of this protocol. Load curtailment is a dispatchable, event-based resource because the load impacts are only expected to occur on days when DR events are called. This is fundamentally different from non-dispatchable DR options such as dynamic pricing or permanent load shifting. This protocol only applies to dispatchable resources.

Peak demand reductions associated with DR resources are defined as the difference between a customer's actual (measured) electricity demand and the amount of electricity the customer would have demanded in the absence of the DR program incentive. The latter is inherently counterfactual because it never occurred and therefore cannot be measured and must be estimated. This estimate of how much electricity would have been consumed absent the DR program is analogous to the baseline condition for an energy efficiency measure. In this protocol, this estimate is referred to as the reference load.

The reference load used to determine impacts from a LC program participant during a DR event shall be estimated using one of the following methods.[60] The methods are in hierarchical order of preference based on expected accuracy. The EDCs are strongly encouraged to utilize the first three methodologies to verify achievement of demand reductions targets for the phase. In scenarios where an EDC determines a Customer Baseline (CBL) approach is more appropriate, the EDC should provide sound reasoning for the choice of the CBL approach as opposed to the first three methodologies.

1) A comparison group analysis where the loads of a group of non-participating customers that are similar to participating customers with respect to observable characteristics (e.g. non-event weekday consumption) are used to estimate the reference load. A variety of matching techniques are available and the EDC evaluation contractor can choose the technique used to select the comparison group based on their professional judgment. The primary objective of statistical matching is to eliminate bias in the reference load during the most relevant load hours. The most relevant hours are those during the event, but hours immediately prior to and immediately following the event period are also important. As such, matching methods should focus on finding customers with loads during these critical hours that are as close as possible to the loads of participating customers for days that have weather and perhaps other conditions very similar to event days. If events are most likely to be called on hot days, hot non-event days should be used for statistical matching (and very cool days should be excluded). If need be, difference-in-differences techniques can be utilized to eliminate any pre-existing differences in consumption between the treatment and matched control group during estimation.

[60] Detailed technical guidance for matching techniques is provided in the Evaluation Framework.

2) A 'within-subjects' regression analysis where the loads of participating customers on non-event days are used to estimate the reference load. The regression equation should include temperature and other variables that influence usage as explanatory variables. This method is superior to the baseline methods discussed in (4).

3) A hybrid Regression-Matching method where matching is used for most customers and regression methods are used to predict reference loads for any large customers who are too unique to have a good matching candidate. This approach allows for matching methods to be used when good matches are available without dropping unique customers who do not have valid matches from the analysis. The hybrid approach is also superior to the baseline methods discussed in (4).

4) A CBL approach 1) with a weather adjustment to account for the more extreme conditions in place on event days or 2) without a weather adjustment in cases where loads are associated with non-weather-sensitive end-uses. In this approach, the reference load is estimated by calculating the average usage in the corresponding hours for selected days leading up to or following an event day. Multiplicative or additive same-day adjustments for the CBL are prohibited because of the day-ahead event notification. A variety of CBL methods are available to be used and the EDC contractor should provide justification for the specific method that is selected. Reference loads should generally be calculated separately for each participant, but aggregation of accounts or meters is permissible at the discretion of the EDC evaluation contractor. CBL methods are the least preferred of the four approaches, but may produce valid results in situations where customer loads are fairly constant and are not highly sensitive or insensitive to weather conditions.

The weather conditions in place at the time of the event are always used to claim savings. Weather-normalized or extrapolation of impacts to other weather conditions is not permitted.

Other curtailment event days – either Act 129 or PJM – should be removed when estimating the reference load for an Act 129 event day.

Where feasible, matching-based methods are capable of effectively removing selection bias and providing accurate impact estimates that are comparable to results from a randomized experiment and are generally superior to within-subjects approaches.[61] Because of this, in situations where large and representative control pools are available, it is suggested that the comparison group approach be used.

Eligibility

In order to be eligible for an EDC Load Curtailment program, a customer must have an hourly or sub-hourly revenue meter. Interval demand readings are necessary to calculate the reference load and estimate load impacts from DR events. Sub-metered loads may be used for accounts which do not have interval meters at the discretion of the SWE.

Algorithms

Annual peak demand savings must be estimated using individual customer data (e.g. account, meter, or site as defined by program rules) regardless of which evaluation method is used. Program savings are the sum of the load impacts across all participants. The equations below provide mathematical definitions of the average peak period load impact estimate that would be calculated using an approved method.

[61] See the Evaluation Framework for a discussion of the advantages of matching over within-subjects methods.

$$\Delta kW_{peak} = \frac{\sum_{i=1}^{n} \Delta kW_i}{n}$$

$$\Delta kW_i = kW\_Reference_i - kW\_Metered_i$$

Definition of Terms

Table 3-215: Terms, Values, and References for C&I Load Curtailment

Term	Unit	Values	Source
n, Number of DR hours during a program year for the EDC	Hours	EDC Data Gathering	EDC Data Gathering
ΔkW_i, Estimated load impact achieved by an LC participant in hour i. This term can be positive (a load reduction) or negative (a load increase).	kW	EDC Data Gathering	EDC Data Gathering
$kW\_Reference_i$, Estimated customer load absent DR during hour i	kW	EDC Data Gathering	EDC Data Gathering
$kW\_Metered_i$, Measured customer load during hour i	kW	EDC Data Gathering	EDC Data Gathering

Default Savings

There are no default savings for this measure.

Evaluation Protocols

The evaluation protocols for the Load Curtailment measure follow the calculation methodologies described in this document. Evaluation of the measure should rely on a census of program participants unless a sampling approach (either of days or participants) is approved by the SWE. Detailed protocols for implementing the methodologies described above and the outputs that must be produced are provided in the Evaluation Framework.