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|  | **PENNSYLVANIA**  **PUBLIC UTILITY COMMISSION**  Harrisburg, PA. 17105-3265 |  |

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|  | Public Meeting held August 8, 2019 |
| Commissioners Present: |  |

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| Gladys Brown Dutrieuille, Chairman | | |  |
| David W. Sweet, Vice Chairman  Norman J. Kennard | | |  |
| Andrew G. Place | | |  |
| John F. Coleman, Jr. | | |  |
|  |  |
| 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 |

**2021 TRM UPDATE FINAL Order**

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**BY THE COMMISSION:**

As explained in our Order, entered June 1, 2009, at Docket No. M-00051865, in implementing the Alternative Energy Portfolio Standards Act (AEPS Act) as amended, 73 P.S. §§ 1648.1‑1648.8, 66 Pa. C.S. § 2814 and 71 P.S. § 714,this Commission had adopted an *Energy‑Efficiency and DSM Rules for Pennsylvania’s Alternative Energy Portfolio Standard, Technical Reference Manual* (TRM).[[1]](#footnote-2) In adopting the original version of the TRM, this Commission directed its Bureau of Conservation, Economics, and Energy Planning (CEEP)[[2]](#footnote-3) to oversee the implementation, maintenance, and periodic updating of the TRM.[[3]](#footnote-4) Additionally, in the *Energy Efficiency and Conservation Program* Implementation Order for Phase I of Act 129’s Energy Efficiency and Conservation (EE&C) Program,[[4]](#footnote-5) this Commission adopted the TRM as a component of the EE&C Program evaluation process.

On April 11, 2019, the Commission issued for Comment the proposed 2021 Technical Reference Manual that would be used for a potential Phase IV of the EE&C Program.[[5]](#footnote-6) With this Order, and in keeping with guidance from previous Implementation Orders, the Commission adopts the TRM as a component of the EE&C Program evaluation process. If the Commission adopts a Phase IV of the EE&C Program, the Commission will allow for optional updates to keep the TRM aligned with updates to codes and standards that occur during the phase.

With this Order, the Commission adopts several updates to climate‑related assumptions in the TRM, a revised taxonomy of commercial and industrial (C&I) building types, an adjustment to the definition of peak and off-peak periods, and other general changes described in greater detail in [Section B](#_General_Improvements), below. The Commission adopts 12 new residential and 25 new non-residential measures to include in the Phase IV TRM. See [Section C](#_Additional_Residential_EE&C) and [Section D](#_Additional_C&I_EE&C) of this Order for a listing of these measures. [Section E](#_Existing_Residential_EE&C) and [Section F](#_Existing_C&I_EE&C) of this Order describe the Commission’s adopted updates to residential and non-residential measures included from the Phase III TRM. Finally, the Commission has removed from the TRM six residential and three non‑residential measures that are listed in [Section G](#_Removed_Residential_EE&C) and [Section H](#_Removed_C&I_EE&C) of this Order.

# BACKGROUND

Act 129 of 2008, P.L. 1592, specifically directed this Commission to establish an evaluation process that monitors and verifies data collection, quality assurance, and the results of each electric distribution company’s (EDC) EE&C plan and the EE&C program as a whole. *See* 66 Pa. C.S. § 2806.1(a)(2). To assist in meeting this obligation, the Commission contracted with the NMR Group, Inc. in March 2016 to perform these duties as the Act 129 Statewide Evaluator (SWE). As part of its duties, the SWE is to review the TRM and the Total Resource Cost (TRC) Test and provide suggestions for possible revisions and additions to these guidance documents.

The SWE, in collaboration with the program evaluation group (PEG)[[6]](#footnote-7) and staff from the Commission’s Bureau of Technical Utility Services (TUS), reviewed the 2016 TRM and proposed several changes and additions for consideration for inclusion in the 2021 TRM. The Commission released these proposed changes for comment when we adopted the 2021 TRM Update Tentative Order at our April 11, 2019 Public Meeting. A  notice of the Tentative Order and proposed 2021 TRM update was published in the *Pennsylvania Bulletin* on April 27, 2019. Comments were due on May 28, 2019, and Reply Comments were due on June 17, 2019.

The following parties filed comments in response to the Tentative Order: Bradford White Corporation; Brian McGowan; Duquesne Light Company (Duquesne); Energy Association of Pennsylvania (EAP); Franklin Energy; Metropolitan Edison Company, Pennsylvania Electric Company, Pennsylvania Power Company and West Penn Power Company (collectively, FirstEnergy); Pennsylvania Department of Environmental Protection (DEP); Performance Systems Development; Oracle Utilities; PECO Energy Company (PECO); PPL Electric Utilities Corporation (PPL) and TrickleStar Inc. (TrickleStar). No parties filed reply comments.

# DISCUSSION

The changes and improvements to the TRM are based on more recent research, a review of TRMs from other states, and the needs and experiences of the EDCs. The EDCs provided, through the SWE evaluation, measurement, and verification (EM&V) process, much of the data that forms the basis of the changes and improvements being adopted in the 2021 version of the TRM. Specifically, the current changes and improvements were the result of SWE site inspections and comments from conservation service providers (CSPs) and EDC independent evaluators. Additionally, many of the issues raised during the 2016 TRM update process were referred to the SWE. The SWE then completed further research in order to provide recommendations during the 2021 TRM update. The adopted changes focus on improving assumptions for key parameters, algorithms, and deemed savings values, as well as accounting for new codes and standards for residential and commercial and industrial (C&I) EE&C measures. The Commission observes that the adopted changes will make the TRM a more effective and professional tool for validating energy savings and providing support for the Act 129 goals.

The major goals of the adopted modifications are as follows:

1. To add protocols for EE&C measures being implemented by the EDCs and to broaden the scope of the TRM;
2. To update the TRM baseline assumptions to reflect changes to building codes in the Commonwealth;
3. To split the TRM into three separate volumes – a general volume that describes the purpose of the TRM and how it should be used, a volume for residential measures, and a volume for non-residential measures;
4. To update TRM assumptions based on findings from the SWE’s residential and non-residential end-use saturation studies;
5. To appropriately balance the integrity and accuracy of claimed energy savings estimates with costs incurred to measure and verify the claimed energy savings;
6. To clarify existing calculation methods;
7. To allow more flexibility for the EDCs to use territory-specific or gathered data when calculating savings; and
8. To provide additional reasonable methods for measurement and verification of energy savings associated with EE&C measures without unduly burdening EE&C program and evaluation staff.

Below is a summary of the changes adopted in this 2021 TRM update.

1. Inclusion of 12 new residential EE&C measure protocols.
2. Clarification of the existing residential EE&C measure protocols.
3. Inclusion of 25 new C&I EE&C measure protocols.
4. Clarification of the existing C&I EE&C measure protocols.
5. Clarification of demand response protocols.
6. Updates to Appendix C – Lighting Audit and Design Tool.
7. Updates to Appendix D – Motor and Variable Frequency Drive (VFD) Audit and Design Tool.

Below, we will further discuss more significant TRM changes and updates that are being adopted. Minor administrative changes will not be discussed.

## Uncontested TRM Changes

The following TRM changes proposed in the Tentative TRM Update Order elicited no comments in opposition. Accordingly, the Commission adopts them as proposed.

1. Changes related to International Energy Conservation Code (IECC) 2015 building code updates.

2. Updated equivalent full load hours and coincidence factors for residential HVAC equipment.

3. Section 1.2.4 change to the definition of in‑service‑date for efficient equipment installed in spaces that are not currently occupied.

4. Table 1‑4 line loss factors.

5. Section 1.19 clarification.

## General Changes

### TRM Applicability

As discussed above, the TRM was developed to support the AEPS Act and later adopted to support the requirements of the Act 129 EE&C Program. The Commission has continued to develop and modify the TRM to support both as electric equipment and technology standards have evolved and changed.

#### Comments

Bradford White Corporation submits a general comment that suggests that the proposed TRM is biased towards electric fueled products. Bradford White suggests that “instead of the PA PUC choosing winners and losers on the adoption of appliances, we would recommend that energy efficiency choices be considerate of both available technology and fuel choices.” Bradford White at 3.

#### **Disposition**

The Commission agrees with Bradford White that the TRM is biased toward electrically fueled measures. The TRM is designed to support Act 129 EE&C programs and, to a lesser extent, the Alternative Energy Portfolio Standards. Act 129 programs are funded by electric ratepayers with established electric consumption and peak electric demand reduction targets for the large EDCs. While several of Pennsylvania’s natural gas distribution companies also have EE&C programs, the TRM is not currently designed to support natural gas energy efficiency programs. The Commission declines to adopt a TRM that supports the natural gas EE&C programs in this proceeding as the TRM is mandated by the AEPS Act and is designed to meet the requirements and the Act 129 EE&C Program, both of which only apply to electric utilities. *See* 73 P.S. § 1648.3(e)(10) & (11), and 66 Pa. C.S. § 2806.1(a)(2). Furthermore, we find that as the SWE costs for developing the TRM are born solely by the large EDCs and recovered from their customers on a full and current basis, it would be inappropriate to have the SWE develop TRM measures that are not applicable to either the AEPS Act or Act 129 EE&C Program.

### Process for Code Change Updates

For Phase IV, the Commission proposed a new process for incorporating codes, standards, and ENERGY STAR specifications that change during the phase without undertaking a full TRM update. Each year of the phase, the SWE will track code updates to federal standards, ENERGY STAR specifications, and state-adopted building energy codes. Based on the extent of code updates that occur, the SWE will recommend whether to open the TRM for a code refresh for the following program year. Code updates that are not finalized and in effect before July 1 of a program year will not be considered for inclusion in the TRM in that update cycle. Changes to the TRM proposed by the SWE through this process will be limited to updating values directly related to codes, standards, and ENERGY STAR specifications.

The Commission proposed the following schedule for this process:

| **Estimated Date** | **Action** |
| --- | --- |
| March 15 | SWE memo analyzing impact of code or standards changes will be delivered to TUS. |
| April 15 | TUS will determine if an update is warranted. |
| July 1 | Codes and standards must be in effect by this date. |
| July | Tentative TRM Order and Manual on Public Meeting Agenda. |
| August - September | Comment and review process. |
| November | Final TRM Order and Manual on Public Meeting Agenda. |

#### Comments

PECO expresses support for the Commission’s proposal to implement a streamlined, predictable process to update changes to codes and standards in the TRM. PECO supports the Commission’s proposed schedule because it requires codes to be in effect for at least six months prior to incorporation in the TRM and all changes are reflected at the beginning of a program year. PECO also recommends that the Commission remain cognizant that code changes may reduce energy efficiency savings when examining potential for Phase IV of Act 129. PECO Comments at 3. The Energy Association of Pennsylvania (EAP) also expresses general support for the proposed process to reflect changes to codes and standards in the Phase IV TRM. EAP requests that the Commission confirm that any TRM modifications take effect on June 1 of the following calendar year. EAP Comments at 5.

#### **Disposition**

The Commission adopts the proposed update process. The Commission affirms that any modification to the Phase IV TRM would become effective on June 1 of the calendar year following the comment and review process and we agree with EAP that it is important to time any changes with the beginning of a new Act 129 program year. In response to PECO’s comment regarding codes being in effect for six months, the Commission notes that the proposed schedule requires codes to be in effect for a minimum of eleven months prior to incorporation in the TRM. We acknowledge PECO’s comment about the impact of code changes on Phase IV potential and will work with the SWE to consider the impacts of likely code changes on estimates of market potential or the cost of acquiring energy efficiency potential.

### TRM Default Values

The TRM has incorporated default values for measures where collection of specific customer or equipment data is difficult or costly to collect. The use of default values must balance the costs with the impact they may have on the accuracy of claimed energy savings.

#### Comments

PECO states that the TRM should incorporate default values where appropriate. PECO suggests that expanded use of data-based default values would reduce the burden and cost of verifying savings while preserving the accuracy of claimed savings. PECO Comments at 4.

#### Disposition

The Commission agrees with PECO that default savings assumptions are an important component of TRM development to balance the integrity and accuracy of claimed savings with costs incurred to measure and verify the claimed savings. The proposed TRM included hundreds of default values where the Commission finds that measurement and verification would be cost-prohibitive. EDC data gathering requirements are limited to a relatively small subset of parameters. While we agree with PECO’s comment, in principle, we believe the 2021 TRM strikes the appropriate balance. We disagree with many of the specific instances where PECO proposes the addition of default values to the TRM. Collection of basic equipment properties such as type or capacity as part of program delivery is important to ensure Act 129 EE&C Program funds are being used responsibly. This is particularly true for non‑residential measures where equipment sizes can vary significantly. Without basic equipment characteristics, EDCs and their CSPs are unable to verify the eligibility requirements in the TRM or determine if incentive levels are commensurate with incremental measure costs and expected energy savings. While we decline to adopt most of PECO’s suggestions to add default savings assumptions, the Commission finds that, for certain measures, PECO’s suggestions are reasonable. Such changes have the benefit of limiting certain overhead and administrative costs. Additional detail is provided in the measure-specific dispositions of this order.

### Updated Climate Assumptions

The Commission proposed to update the climate-dependent values used in the TRM. Many TRM measures incorporate climate-dependent terms (CDD, HDD, cooling/heating equivalent full load hours, coincidence factors, etc.) to reflect the variations in climate across the state. In the 2016 TRM, the weather reference cities included seven reference zones, defined by the major cities in the zone: Allentown, Erie, Harrisburg, Philadelphia, Pittsburgh, Scranton, and Williamsport. The Commission’s proposed update includes the addition of two new reference cities: Binghamton, NY, and Bradford, PA. The Commission believes these nine cities better reflect the climate characteristics of the state and fulfill the need to incorporate other climate region systems from ASHRAE and IECC.

In cases where a climate-dependent value for one of the two new weather cities is unknown, the Commission proposed that the value be estimated via regression modeling. The regression models were to be based on the seven established weather reference cities, and the models would use CDD and HDD as explanatory variables. For Residential HVAC equipment, the Commission proposed a different approach, which is discussed in the next section. Regarding CDD and HDD, there is a Class 1 weather station in each of the nine weather reference cities that provides typical meteorological year (TMY) weather data for the city.[[7]](#footnote-8) Weather data from these stations were used to calculate CDD and HDD for the relevant weather reference cities.

Additional weather regionalization results in a better representation of climate variations in Pennsylvania. New measures affected by this update include Weather Stripping, Caulking and Outlet Gaskets, Basement Wall Insulation, and Residential Window Repair. Existing TRM Protocols affected by this update include the following:

* 2.4.3 – Refrigerator / Freezer Recycling with and without Replacement;
* 2.6.1 – Ceiling / Attic and Wall Insulation;
* 2.6.7 – Crawl Space Wall Insulation;
* 3.2.1 – HVAC Systems;
* 3.2.2 – Electric Chillers;
* 3.2.4 – Ductless Mini-split Heat Pumps – Commercial < 5.4 Tons;
* 3.2.5 – Fuel Switching: Small Commercial Electric Heat to Natural Gas / Propane / Oil Heat;
* 3.2.6 – Small C/I HVAC Refrigerant Charge Correction;
* 3.2.7 – ENERGY STAR Room Air Conditioners;
* 3.2.9 – Controls: Economizer;
* 3.3.1 – Premium Efficiency Motors;
* 3.3.3 – ECM Circulating Fan;
* 3.5.5 – Controls: Floating Head Pressure Controls;
* 3.8.1 – Wall and Ceiling Insulation;
* 4.1.3 – High-efficiency Ventilation Fans with and without Thermostats;
* 4.1.5 – High-volume Low-speed Fans; and
* 4.1.6 – Livestock Waterer.

#### Comments

PECO requests clarity regarding the use of values presented in Table 1-6 of the proposed TRM. Table 1-6 shows the distribution of population, according to the 2010 Census, within each EDC service territory associated to one of the nine weather regions. PECO also recommends simplifying the climate assumptions for its service territory to 100% climate region D (Philadelphia) instead of 99.8% climate region D and 0.2% climate region E (Harrisburg). PECO Comments at 7. The Pennsylvania DEP expresses support for the updated climate assumptions and agrees that the nine proposed cities will better reflect the climate characteristics of Pennsylvania. DEP Comments at 1.

#### Disposition

The Commission recognizes that the proposed language introduced in Table 1-6 was confusing. The intent of the climate region weights table is to allow EDCs to calculate a single blended set of weather assumptions for its service territory rather than associating individual participants with a weather region and calculating savings using different weather assumptions. The underlying assumption of this approach is that program participation will generally mimic population, so the population-weighted average weather characteristics should produce an unbiased estimate of weather‑dependent energy savings and reduce the administrative burden on EDCs, CSPs, and EM&V contractors.

The Commission, in response to PECO’s request, has clarified in the TRM that the use of the climate region weights in Table 1-6 is appropriate for deemed and partially deemed measure protocols. However, custom projects are less common and may not follow population averages, therefore, these projects should rely on location-specific weather assumptions. We reject PECO’s recommendation to map PECO service territory entirely to climate region D. Although the population PECO serves in York county is small, we find it important to reflect the diversity in TRM climate assumptions as it appropriately accounts for the weather diversity in PECO’s service territory. Calculating weighted average weather assumptions across two climate regions should be a straightforward exercise for PECO, its CSPs, and its EM&V contractor.

### Updated C&I Building Types

The Commission proposed adopting a common set of C&I building types across all C&I measures for which one or more of the inputs is a function of building type. In the 2016 TRM, the list of possible building types changes from measure to measure. The adoption of a common set of building types across measures should improve TRM usability. The table below maps the proposed adjustments and consolidations to the building types listed in the 2016 TRM. The proposed standardization is largely drawn from the building types used in 3.1.1 Lighting Improvements. Simple averaging will be used to make the proposed consolidations. For example, the default CFs for the “Office – Large” and “Office – Small” building types will be averaged to produce the default CF for the Office building type.

| **2016 TRM Building Types** | **Proposed Building Type** |
| --- | --- |
| Assembly | Institutional / Public Service |
| Education – Community College | Education – College / University |
| Education – University |
| Education – Primary School | Education – Other |
| Education – Relocatable Classroom |
| Education – Secondary School |
| Grocery | Grocery |
| Health / Medical – Hospital | Health – Hospital |
| Health / Medical – Nursing Home | Health – Other |
| Lodging – Hotel | Lodging |
| Manufacturing – Bio Tech / High Tech | Industrial Manufacturing |
| Manufacturing – 1 Shift / Light Industrial |
| Multifamily (Common Areas) | Multifamily (Common Areas) |
| Office – Large | Office |
| Office – Small |
| Restaurant – Fast-Food | Restaurant |
| Restaurant – Sit-Down |
| Retail – Multi-story Large | Retail |
| Retail – Single-story Large |
| Retail – Small |
| Storage – Conditioned | Warehouse – Other |
| Warehouse – Refrigerated | Warehouse – Refrigerated |

The measures affected by this change include the following:

* 3.2.1 – HVAC Systems;
* 3.2.2 – Electric Chillers;
* 3.2.4 – Ductless Mini-split Heat Pumps – Commercial < 5.4 Tons;
* 3.2.5 – Fuel Switching: Small Commercial Electric Heat to Natural Gas / Propane / Oil Heat;
* 3.2.6 – Small C/I HVAC Refrigerant Charge Correction;
* 3.2.7 – ENERGY STAR Room Air Conditioners;
* 3.3.1 – Premium Efficiency Motors; and
* 3.4.1 – Heat Pump Water Heaters.

#### Comments

Duquesne recommends maintaining the distinction between “Restaurant – Fast Food” and “Restaurant – Sit-Down” and the associated hours of use. Duquesne Comments at 3.

#### Disposition

The Commission rejects the suggestion that the recommended hours of use values cited in Duquesne’s comments for the “Restaurant – Fast Food” and “Restaurant – Sit-Down” are from the DOE’s Uniform Methods Project[[8]](#footnote-9) (UMP), which, in turn, references values from the New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs. These values are explicitly provided in the UMP as an example, not a recommendation of specific values. In fact, the UMP recommends multiple methods for determining the hours of use, including using “Tables of HOU values by building type provided by the program implementer. HOU values have been developed from impact evaluation and M&V studies for many commercial and nonresidential buildings.” This is exactly what was done in the Pennsylvania Statewide Act 129 2014 Commercial & Residential Light Meter Study, the current primary source for C&I lighting hours of use. This study does not support the level of building type specificity proposed by Duquesne, as such, the Commission declines to adopt Duquesne’s suggestion.

### Definition of Peak and Off-peak Energy Periods

The monetary benefits of electric energy savings for Act 129 programs are time‑differentiated by season and on/off peak periods to account for differences in marginal costs in these periods. The Commission proposed updating the definition of the peak and off-peak hours to align with the definition used by PJM. The proposed peak hours are 7:00 am to 11:00 pm Monday through Friday. The proposed off-peak hours are 11:00 pm to 7:00 am Monday through Friday and all weekend and holiday hours.

#### Comments

The Commission did not receive comments on the proposed change to the definition of peak and off-peak hours.

#### Disposition

Although no comments were received regarding this proposed change; based on further review of historic energy prices by the SWE in preparation of the 2021 Tentative TRC Order, the Commission finds that the proposed definition of the winter period was too broad. Accordingly, the winter period has been divided into “winter” and “shoulder” periods to reflect the differences in wholesale energy prices between the coldest winter months and the milder spring and fall months.

## Additional Residential EE&C Measure Protocols

The Commission recognizes that the expansion of the residential section of the TRM is essential for the accurate and timely measurement and verification (M&V) of the EDCs’ Act 129 EE&C programs and proposed to include 15 new residential EE&C measure protocols. The EDCs’ independent evaluators, in collaboration with the SWE, produced, reviewed, and edited these residential EE&C measure protocols. The Commission subsequently combined three of the 15 measure protocols proposed in our Tentative Order into two existing measure protocols, leaving 12 new residential EE&C measure protocols.

The 12 new residential EE&C measure protocols are as follows:

* Section 2.2.3 – ECM Circulation Fans;
* Section 2.2.4 – GSHP Desuperheaters;
* Section 2.2.5 – Air Conditioner & Heat Pump Maintenance;
* Section 2.2.11 – ENERGY STAR Connected Thermostats;
* Section 2.2.12 – Furnace Maintenance;
* Section 2.3.10 – Drain Water Heat Recovery
* Section 2.4.6 – Heat Pump Clothes Dryers;
* Section 2.4.10 – Dehumidifier Retirement;
* Section 2.4.12 – ENERGY STAR Air Purifiers;
* Section 2.6.2 – Weather Stripping, Caulking, and Outlet Gaskets;
* Section 2.6.6 – Residential Window Repair; and
* Section 2.7.3 – Home Energy Reports.

The three proposed measure protocols the Commission combined with existing measure protocols are:

* Properly Sized Cooling;
* Basement Wall Insulation; and
* Low-rise Multifamily New Construction.

No comments were received on Section 2.4.6 – Heat Pump Clothes Dryers. This proposed change is hereby adopted by the Commission for use in Phase IV.

Comments received on the remaining new residential EE&C measure protocols are addressed below.

### Inclusion of Interim Measure Protocols in the TRM

Several of the proposed new measure protocols were initially developed in Phase III and adopted by the SWE as interim measure protocols. Such interim measure protocols had not been vetted or adopted by the Commission in the TRM. With this TRM update the Commission proposed additional residential measure protocols and sought comment on them.

#### Comments

PECO identifies several instances where measure protocols, which had been approved during Phase III as Interim Measure Protocols (IMPs), were modified for inclusion in the 2021 TRM. PECO recommends that these IMPs should be included in the TRM, as approved, absent material changes in information or implementation concerns. PECO Comments at 4.

#### Disposition

The Commission rejects PECO’s suggestion that the Commission should not modify values included in Phase III IMPs when incorporating these IMPs into the 2021 TRM merely because the values were present in the IMPs. We emphasize that the purpose of the TRM Update process is to review and update all measures with the best available information at the time of the update. This process applies equally to measures present in the 2016 TRM and to IMPs approved by the SWE during Phase III. Additionally, several of the modifications identified by PECO were implemented to maintain consistency with updated climate assumptions or residential HVAC EFLH research. It is important that these assumptions be handled consistently throughout the TRM to limit the burden and cost of tracking and reporting savings. Other modifications to Phase III IMPs were based on material changes in information or implementation concerns.

### Section 2.2.3 – ECM Circulation Fans

#### Comments

Franklin Energy comments that brushless permanent magnet motors are now the federal standard baseline for new air handlers. Franklin Energy Comments at 37.

* + 1. **Disposition**

The Commission, in response to Franklin Energy’s comments, clarifies that this is a retrofit measure that is exclusively for older air handlers without ECM fans, so no baseline for new equipment is needed.

### Section 2.2.4 – GSHP Desuperheaters

#### Comments

FirstEnergy points out an inconsistency in default values between the source documentation and the TRM for the baseline UEF value. FirstEnergy Comments at 5. Franklin Energy requests clarification on whether the type of electric water heater is included as a variable in this savings algorithm. They recommend providing a table for different baseline electric water heater default values by type. Franklin Energy Comments at 39.

#### Disposition

The Commission agrees with FirstEnergy and corrected the baseline UEF value and resulting default savings. In response to Franklin Energy’s request for clarification, the Commission specifies that electric water heater values are based on the 2018 Pennsylvania Residential Baseline Study and adds “any type” to the eligibility requirements. Limited sample sizes for heat pump water heaters prevent the Commission from segmenting the baseline efficiency values by type. EDCs may gather data on efficiency ratings of existing heat pump water heaters if they wish to use those values when calculating savings.

### Section 2.2.5 – Air Conditioner & Heat Pump Maintenance

#### Comments

FirstEnergy requests removing “room air conditioner” and “electric resistance” from the table of default equipment efficiency values, as these types of systems are not eligible for maintenance. FirstEnergy Comments at 5. Franklin Energy recommends adding a separate set of hours for the EFLH variable for secondary units. Franklin Energy Comments at 42.

#### Disposition

The Commission agrees with FirstEnergy’s request and has replaced the table of default heating and cooling system efficiency values in this measure with a reference to Table 2-8: Default Baseline Equipment Efficiency for High Efficiency Equipment in Section 2.2.1 - High Efficiency Equipment: ASHP, CAC, GSHP, PTAC, PTHP. The Commission notes, regarding Franklin Energy’s recommendation to add a separate set of hours for the EFLH variable for secondary units, that EFLH values for secondary units are provided in Appendix A.

### Section 2.2.11 – ENERGY STAR Connected Thermostats

#### Comments

Franklin Energy recommends better quantification of “receiving education” in Table 2-35. Franklin Energy Comments at 61. PECO recommends ensuring consistency between the IMP and the TRM and notes that baseboard heating is currently eligible under approved IMPs but is not eligible in the TRM measure. PECO suggests that baseboard heating systems be included in the TRM but does not address the technical discussion provided in the proposed Manual regarding the exclusion of baseboard heating systems. PECO Comments at 2. FirstEnergy requests additional detail and guidance regarding default upstream EFLH values. FirstEnergy requests statewide default values to either be clearly identified in Vol. 1, Appendix A or included by EDC. FirstEnergy Comments at 2.

#### Disposition

The Commission provides discussion of the distinction between self-installation with and without education above Table 2-35. The EDCs can further define specific education requirements in their own program planning design. Baseboard heating is not included as an eligible system for the ENERGY STAR Connected Thermostat measure based on discussions between the SWE team and the two leading smart thermostat vendors. These manufacturers stated that their products are not compatible with baseboard heating units because of input voltage; therefore, the Commission rejects PECO’s suggestion to include baseboard heating systems in the Connected Thermostat measure.

The Commission agrees with FirstEnergy’s suggestion and has added detail to assist with the calculation of blended EFLH values for use in upstream program delivery where the service address of the participant is unknown. We do not provide all EDC specific EFLH values, but these can be calculated using a simple weighted average of the EDC Climate Region Weights (Table 1-6) and the EFLH cooling and heating values provided in the Residential HVAC Equivalent Full Load Hour and Coincidence Factor Assumptions table (Table 1-8). We have added text to describe this methodology into the TRM. For further explanation, we provide an example here. To obtain Penn Power’s cooling EFLH for central air conditioner and heat pump, utilize the following equation.

Although no stakeholders commented on the error, the Commission noted during the review of the proposed TRM that the unit values for the capacity terms in Table 2-36 were incorrect. Table 2-36 of the proposed TRM incorrectly indicated that the HVAC system capacity values were in units of kBTU/hour. The default values in Table 2-36 are in BTU/hour and the algorithms require capacity values in BTU/hour to return valid savings estimates. We have corrected this error in the final TRM.

### Section 2.2.12 – Furnace Maintenance

#### Comments

FirstEnergy, Franklin Energy, and PECO comment that the title of Table 2-42 does not use the correct units for the content of the table. FirstEnergy Comments at 2. Franklin Energy Comments at 68. PECO Comments at 8. PECO recommends that the TRM be revised to include the gas savings values that were part of the relevant IMP. PECO Comments at 8.

#### Disposition

The Commission agrees with commentators and corrected the units in Table 2-42. However, we decline to adopt PECO’s recommendation to add natural gas savings to this measure. The Act 129 2021 TRM is a guide for quantifying electricity savings.

### Section 2.3.10 **– Drain Water Heat Recovery**

#### Comments

Brian McGowan recommends the addition of a residential drain water heat recovery measure. Brian McGowan Comments at 2.

#### Disposition

The Commission agrees with Brian McGowan’s recommendation and has developed a drain water heat recovery measure for residential applications and added it to the 2021 TRM. Drain water heat recovery units capture waste heat from shower grey water and use it to preheat cold water that is delivered to the shower mixing valve, the water heater, or both. Savings are calculated per drain water heat recovery unit.

### Section 2.4.10 – Dehumidifier Retirement

#### Comments

PECO requests revising the text to clarify which values from Source 5 should be used. PECO Comments at 8.

#### Disposition

It was not the Commission’s intention to require savings calculations by direct use of TMY3 data (source 5). The Commission has provided pre-calculated values for typical dehumidifier capacities. The Commission has added clarifying text to the TRM that explains that savings values for unlisted capacities can be calculated by linear interpolation between adjacent provided values.

### Section 2.4.12 – ENERGY STAR Air Purifiers

#### Comments

PECO recommends revising the text regarding proof of eligibility to clarify that an ENERGY STAR label is sufficient and providing UL Safety Listing information is not required. In addition, PECO comments that the “CADR” variable should specify the appropriate units (e.g., cubic feet per minute). PECO Comments at 9.

#### Disposition

The Commission agrees with PECO’s recommendation and added a footnote clarifying that ENERGY STAR certification is sufficient and UL safety listing certification is not required. Furthermore, in response to PECO’s comment, the Commission also added the CADR units.

### Section 2.6.2 – Weather-Stripping, Caulking, and Outlet Gaskets

#### Comments

Franklin Energy suggests adding additional savings achieved through reduced fan run time for systems with a gas furnace. Franklin Energy also suggest the addition of fuel-based energy savings for gas systems. Franklin Energy Comments at 160. Franklin Energy notes that, in the Illinois TRM, an alternate method is used to determine the reduction in air leakage at 50 pascals (Δ*CFM50*) for gaskets, caulking, and weather‑stripping, based on a 2010 Evaluation report.[[9]](#footnote-10) Franklin Energy Comments at 161. Franklin Energy notes that default heat pump savings, Heating Seasonal Performance Factor (HSPF), is adjusted in the Illinois TRM with an 85% distribution factor to account for duct losses in ducted ASHP and GSHPs. Franklin Energy Comments at 161. Franklin Energy notes that the Illinois TRM has separate N correlation factors (to account for climate, building height, wind shielding, and building leakiness) for heating and cooling seasons, while the proposed manual has one value for all seasons. Franklin Energy Comments at 162.

#### Disposition

The Commission rejects Franklin Energy’s suggestion to add fan savings to this measure. This measure is limited to a maximum 400 kWh in claimed annual savings. Savings from reduced furnace fan run time would be a small fraction of the total, within the margin of error for the assumed default values already included in this measure. The Commission also declines to add natural gas savings to this measure. The Act 129 2021 TRM is a guide for quantifying electricity savings. The Commission does not see a compelling reason to adopt the methodology of the Illinois TRM. The source cited by Franklin Energy included pre- and post-weather‑stripping blower door tests for a sample of only three homes.

The Commission rejects Franklin Energy’s suggestion to include a distribution factor for duct losses, as we believe that a single value for this factor, in the absence of data on duct location, duct sealing or insulation, and diagnostic testing of ducts, will not increase the accuracy of the savings estimate. Producing an accurate estimate of distribution losses would unnecessarily increase the data collection and evaluation burdens for this savings-limited measure. We also reject Franklin Energy’s suggestion to complicate the assumed value for the correlation factor (N). As written, the measure already includes a table of twelve possible N values for different shielding situations and building heights for a term that is a simplification of the interaction of complicated environmental characteristics. Furthermore, in the interest of simplifying the TRM and to minimize the introduction of inconsistent values in the future, the Commission has replaced the table of default heating and cooling system efficiency values for this measure with a reference to Table 2-8: Default Baseline Equipment Efficiency for High Efficiency Equipment in Section 2.2.1 - High Efficiency Equipment: ASHP, CAC, GSHP, PTAC, PTHP.

### Section 2.6.6 – Residential Window Repair

#### Comments

FirstEnergy requests clarification on the definition of weather-stripping and if the term “hung” window refers to double- or single-hung windows and states that the algorithm is missing a term for window area and a correction for the units given for the CFM term. FirstEnergy Comments at 7. Franklin Energy points out that there is a discrepancy in the sources listed for the measure and identifies an error in the units for C, the flow coefficient. Franklin Energy Comments at 182.

#### Disposition

The Commission finds that the definition of weather-stripping is covered sufficiently in the introduction to the measure but has added text to the proposed manual specifying that “hung” windows refers to both single- and double-hung windows. Regarding FirstEnergy’s comment about missing elements of the algorithm, we have added an algorithm to calculate the CFM value using window area and CFM/ft2. In response to Franklin Energy’s request, the Commission has fixed the discrepancy in the listed sources and an error in the units for the flow coefficient. We also added a specific reference to the existing infiltration assumptions used in the measure for clarification. Previously, the text referred to the values being in a table “above” the text, but they were actually located in a table that followed. No comments were received on this aspect of the measure, but in the interest of simplifying the TRM and reducing the opportunity for introducing inconsistent values in the future, the Commission has replaced the table of default heating system efficiency values in this measure with a reference to Table 2-8: Default Baseline Equipment Efficiency for High Efficiency Equipment in Section 2.2.1 - High Efficiency Equipment: ASHP, CAC, GSHP, PTAC, PTHP.

### Section 2.7.3 – Home Energy Reports

#### Comments

Both PPL and Franklin Energy request clarification on how lifetime savings are calculated using the formulas referenced. PPL Comments at 3 and Franklin Energy Comments at 200. FirstEnergy requests clarification on which month the decay rate starts and suggests using a monthly decay rate and monthly kWh savings instead of an annual value. FirstEnergy Comments at 8. PPL suggests EDCs have the flexibility to use an EDC-specific decay rate calculated from its own evaluation research. PPL would like the Commission to confirm that the treatment effect estimates in the algorithm and examples are adjusted for joint savings (uplift). PPL Comments at 4.

Oracle notes that they believe addition of the (x – 0.5) term in the lifetime savings calculation pushes savings into the year following savings. Oracle Comments at 3. PPL and PECO provide several comments on text display, as well as explanations that do not substantively alter the content. PPL comments at 3-4; PECO comments at 29-33. Oracle suggests using a one-year measure life, as recommended in several other states, with another potential option to have each year’s savings spread out equally across the program years (so that program savings of 150kWh in Year 1 of a three-year program are credited with 50kW per year). They also critique the assumed linearity and constancy of the savings decay rate as something not historically observed. Furthermore, Oracle notes that for residential HER programs, businesses are not included in the comparison group and that the TRM contains program design and implementation guidance, they consider to be inappropriate for a TRM. Oracle Comments at 4. PECO suggests simplifying the decay rate to assume a 33.3% decay per year beginning after two years of consecutive treatment, rather than the 31.3% value the Commission proposed. PECO’s preferred method for lifetime savings includes a 1.92 factor that incorporates both the 33.3% decay rate and a 6% churn rate over three years. PECO Comments at 9 and 29-33.

#### Disposition

The formulae of the lifetime savings calculations have been updated to minimize confusion. We find that PPL’s suggestion that EDCs have the flexibility to provide their own decay rate calculated from their own evaluation is reasonable. As a result, we have updated the “decay” term in Table 2-135 to allow “EDC Data Gathering” while preserving the 31.3% annual decay rate as a default value. The Commission appreciates PPL’s comment regarding dual participation in other EE programs. The Final 2021 TRM clarifies that all treatment effect estimates in the algorithms should be adjusted for joint savings. In regard to FirstEnergy’s comment, the decay rate is applied annually. Monthly readings can be calculated in a similar fashion. The Commission, however, finds that an annual savings calculation is more intuitive and simpler to apply to HER cost-benefit calculations as Act 129 goals and reporting are on an annual basis. Responding to Oracle’s request to include the (x- 0.5) term in the lifetime savings equation, the Commission notes that the decay factor of 31.3% is the decay by the end of the year, not the average observed across the whole year. Including this adjustment captures the midpoint of the savings in each year, better reflecting the amount of decay throughout the program year.

Oracle makes several suggestions about how to adjust the savings calculations. On the critiques of the linearity and constancy of the persistence rate, the Commission notes Oracle’s concern, but maintains that a simple, linear model provides the best tradeoff between accuracy and ease of comprehension and use. The suggestion to use a one-year measure life for the HER program cannot be supported with the results of persistence studies across the United States, but particularly in Pennsylvania. Oracle also suggests using an average savings model if the program does run across multiple years. The Commission reviewed the referenced report from Illume Advising in Minnesota[[10]](#footnote-11) and found that, rather than supporting the average savings method, the Minnesota Department of Commerce Division of Energy Resources recommended that Minnesota switch to the avoided decay method that is functionally equivalent to our proposal in the Tentative 2021 TRM.

Finally, Oracle notes that due to the complex nature of the savings accounting, the program has the potential for “increased risk in forecasting and program delivery, an inconsistent and negative customer experience, and challenges achieving equitable scale.” The Commission does not share Oracle’s concerns in these areas. Instead, we expect that a transparent and accurate accounting method will allow EDCs and CSPs to focus on optimizing program delivery in a way that delivers defensible and cost-effective energy savings to the Commonwealth and its ratepayers. The purpose of the TRM is to document the calculation methods for savings. We find that program design and customer experience considerations are outside of the scope of the TRM and best handled through EDC EE&C plans.

The Commission finds that PECO’s suggestion to adjust the decay rate to 33.3% is arbitrary, as the decay rate was found empirically from data from six Pennsylvania EDCs with natural persistence experiments in their HER programs. The Commission, however, agrees with PPL that the EDCs should be able to use their own decay rate found from empirical research. The Commission appreciates PECO’s method summarizing the lifetime savings calculation as a scalar factor of customer churn, decay rate, and incremental savings for that delivery year. That method and its explanation have been added to the discussion of lifetime savings in the Manual, although the SWE-calculated scalar value is slightly higher with lifetime savings equal to 2.44 times the incremental annual savings. Finally, the Commission concurs with two of Oracle’s comments. Residential HER programs do not include commercial customers in their comparison groups, and program design and implementation guidance are not appropriate for inclusion in a technical discussion of how to calculate program savings. The relevant segments of Section 2.7.5 have been adjusted to reflect this feedback.

### Properly Sized Cooling[[11]](#footnote-12)

#### Comments

PECO recommends incorporating this as a factor into the High Efficiency Equipment measures (Sections 2.2.1 and 2.2.2 in the proposed 2021 TRM) and excluding properly sized baseline units from eligibility. PECO Comments at 7, 22, 23, 28. FirstEnergy comments that a page reference in the cited source document from Northeast Energy Efficiency Partnerships is incorrect. FirstEnergy Comments at 1.

#### Disposition

The Commission agrees with PECO’s recommendation and has removed the separate measure for Properly Sized Cooling. This measure is now an additional term in the savings algorithm for the High Efficiency Equipment: ASHP, CAC, GSHP, PTAC, PTHP measure and the High Efficiency Equipment: Ductless Heat Pumps with Midstream Delivery Option (Sections 2.2.1 and 2.2.2 in the 2021 TRM). In response to FirstEnergy’s comment, the Commission has corrected the page reference error.

### Basement Wall Insulation[[12]](#footnote-13)

#### Comments

FirstEnergy requests additional values to be added to Table 2-122, Below-Grade R-values, to include below-grade R-values at depths greater than eight feet. FirstEnergy Comments at 7. FirstEnergy and Franklin Energy point out an error in the savings algorithm in which the additional R-value is subtracted from the existing R-value when it should be added. FirstEnergy Comments at 7, Franklin Energy Comments at 171. Franklin Energy requests clarification on whether the existing R-value variable is needed since the R-value of added insulation already includes R1 for the existing concrete wall. They cite the Illinois TRM as not including an existing R-value for this measure. Franklin Energy requests an additional factor to be added to both the heating and cooling savings algorithms, an adjustment factor that accounts for prescriptive engineering algorithms overclaiming savings. They cite the Illinois TRM as including this factor. Franklin Energy requests an additional distribution efficiency factor to be added to the savings algorithm to account for duct losses for air source heat pumps. They cite the Illinois TRM as having this factor. Franklin Energy Comments at 171, 173.

#### Disposition

After reviewing FirstEnergy’s and Franklin Energy’s comments for this measure and the comments received regarding Crawl Space Wall Insulation (Section 2.6.7 in the 2016 TRM), the Commission has, in the interest of consistency, combined these two similar measures. Also, in the interest of simplifying the TRM and reducing the opportunity for introducing inconsistent values in the future, the Commission has replaced the table of default heating and cooling system efficiency values in this measure with a reference to Table 2-8: Default Baseline Equipment Efficiency for High Efficiency Equipment in Section 2.2.1 - High Efficiency Equipment: ASHP, CAC, GSHP, PTAC, PTHP. The Commission has also added clarifying text to the Below Grade Thermal Resistance Values table. The Commission has been unable to find an authoritative source for thermal resistance values at depths greater than eight feet and therefore, rejects FirstEnergy’s request to include additional values in this table. We also find that foundation walls greater than eight feet below grade are rare enough that the provided values will cover the great majority of projects under this measure.

The Commission agrees with FirstEnergy and Franklin Energy regarding the error in the savings algorithm and has corrected this for the combined measure. In response to Franklin Energy’s request, the Commission clarifies that the existing R-value variable is included to account for situations in which additional insulation is added to a stud wall with existing insulation. Furthermore, the Crawl Space Wall Insulation measure included an adjustment factor for prescriptive engineering algorithms overclaiming savings. This factor is maintained in the combined measure. The Commission rejects Franklin Energy’s suggestion to add a distribution efficiency adjustment factor to this measure, and notes that the Illinois TRM does not cite any source for the distribution efficiency factor used in their measure.

### Low-Rise Multifamily New Construction[[13]](#footnote-14)

#### Combining with Residential New Construction, Expanding Eligibility

##### Comments

PECO and Performance Systems Development recommend combining this measure with the Residential New Construction measure to increase flexibility. PECO Comments at 9. ­Performance Systems Development recommends eliminating the height limit of three stories for this measure as many buildings greater than three stories use individual residential electricity meters and should be serviced by residential EE&C programs. They note that the ENERGY STAR homes program does not limit participating buildings to three stories and express concern that a three-story limit will limit participation of affordable housing developers. They note that allowing buildings of greater than three stories will require a set of separate baseline values as these buildings are covered by the commercial building code, which has different requirements than the residential building code. Performance Systems Development Comments at 4.

##### Disposition

The Commission agrees with PECO’s and Performance Systems Development’s recommendation that a single Residential New Construction measure that covers single and multifamily buildings is preferable to separate measures. The Commission has removed the Low-Rise Multifamily New Construction measure and expanded the eligibility under Residential New Construction to include multifamily residential buildings that meet the following requirements, adapted from ENERGY STAR guidelines[[14]](#footnote-15):

* All units must be individually metered.
* Each unit must have its own residential-grade heating, cooling, and water heating equipment.
* The building must be under six stories.
* Dwelling units must comprise at least 80% of the occupiable[[15]](#footnote-16) space of the building.[[16]](#footnote-17)

Furthermore, we added separate baseline building specifications for buildings of four stories or more that are subject to the commercial building code.

#### Energy Modeling

##### Comments

Performance Systems Development recommends offering per-unit and whole-building modeling paths for calculating savings, stating that this will be best aligned with industry practice and ENERGY STAR guidelines for single and multifamily new construction. They recommend allowing additional modeling software options for whole-building modeling of multifamily structures, including approaches used in the IECC Total Building Performance Pathway and ASHRAE 90.1, Appendix G. They also support allowing all savings to be calculated using energy modeling, rather than only the savings due to weather-dependent elements, such as insulation and infiltration. Performance Systems Development Comments at 3, 4, 8, 9. PECO recommends allowing use of additional modeling platforms, such as BEOpt, that would allow EDCs to use calibrated models based on actual consumption or billing data. PECO Comments at 9. FirstEnergy recommends allowing sampling in multifamily buildings and simulation in software like EnergyPlus to reduce implementation costs due to energy modeling of several identical unit designs. FirstEnergy Comments 7.

##### Disposition

The Commission agrees with Performance Systems Development’s recommendation that a measure based solely on modeled savings with no requirement to calculate savings for non-weather sensitive measures using separate sections of the TRM would simplify program participation, savings calculations, and evaluation. The Commission has modified the measure so that all energy savings are calculated using energy models. The Commission declines to adopt PECO’s recommendation to specify additional approved energy modeling software. Expanding the list of approved software will require additional research into current and planned EDC program design, industry trends around energy modeling and tools, and implications of additional models on program evaluation. In response to FirstEnergy’s recommendation, the Commission has added language defining three methods to calculate savings for multifamily building savings: 1) by modeling all of the building’s individual units using any approved software, 2) by modeling the entire building using Passive House accreditation software, or 3) by using RESNET multifamily sampling protocols and modeling a representative sample of units in a building.[[17]](#footnote-18)

#### Other Comments

##### Comments

PPL asks for clarification about assumptions for lighting and appliance standards to be used in the baseline reference model. PPL comments that the values for frame wall U-factor for IECC climate zone 6A should be 0.045 instead of 0.060, and that the infiltration requirement should be 5.0 ACH50 instead of 3.0 ACH 50, to reflect Pennsylvania-specific amendments to the 2015 IECC code. PPL Comments at 4.

##### Disposition

Regarding PPL’s comment on lighting and appliance standards, the Commission has updated the language in the TRM to clarify the appropriate values. The Commission has proposed an annual review process that will allow updates to the TRM to include updates to state and federal standards (see B.2 Process for Code Change Updates). The Commission agrees with PPL’s comments and has corrected the values for frame wall U‑factor and maximum air infiltration to reflect Pennsylvania amendments to the 2015 IECC.

## Additional C&I EE-&C Measure Protocols

As with residential measures, expansion of the C&I section of the TRM is also essential for the accurate and timely M&V of these EE&C programs. Based on collaborative discussions between the SWE and the EDCs, as well as a review of the available research, we proposed the inclusion of 25 new C&I EE&C measures and associated protocols. As these measures are new, the section numbers in the list below reference the 2021 TRM, not the 2016 TRM. The measures are as follows:

* Section 3.1.7 – Lighting Improvements for Midstream Delivery Programs;
* Section 3.2.10 – Computer Room Air Conditioner;
* Section 3.2.11 – Computer Room Air Conditioner / Handler Electronically Commutated Plug Fans;
* Section 3.2.12 – Computer Room Air Conditioner / Handler VSD on AC Fan Motors;
* Section 3.2.13 – Circulation Fan: High-volume Low-speed;
* Section 3.3.5 – ECM Circulator Pump;
* Section 3.3.6 – High-efficiency Pumps;
* Section 3.5.16 – Air-cooled Refrigeration Condenser;
* Section 3.5.17 – Refrigerated Case Light Occupancy Sensors;
* Section 3.5.18 – Refrigeration Economizers;
* Section 3.6.2 – ENERGY STAR Bathroom Ventilation Fan in Commercial Applications;
* Section 3.7.5 – ENERGY STAR Combination Oven;
* Section 3.7.6 – ENERGY STAR Commercial Convection Oven;
* Section 3.7.7 – ENERGY STAR Commercial Fryer;
* Section 3.7.8 – ENERGY STAR Commercial Hot Food Holding Cabinet;
* Section 3.7.9 – ENERGY STAR Commercial Dishwasher;
* Section 3.7.10 – ENERGY STAR Commercial Griddle;
* Section 3.9.5 – Server Virtualization;
* Section 3.10.5 – Variable-speed Drive Air Compressor;
* Section 3.10.6 – Compressed Air Controller;
* Section 3.10.7 – Compressed Air Low-pressure Drop Filters;
* Section 3.10.8 – Compressed Air Mist Eliminators;
* Section 3.11.1 – High-efficiency Transformer;
* Section 3.11.2 – Engine Block Heat Timer; and
* Section 3.11.3 – High-frequency Battery Chargers.

The following sections describe clarifications and modifications to the new C&I EE&C measure protocols. Some of the proposed changes received no stakeholder comments. Those proposed changes, which are not reproduced in the sections to follow, are hereby adopted by the Commission for use in Phase IV. Affected measures include:

* Section 3.2.10 – Computer Room Air Conditioner:
* Section 3.7.5 – ENERGY STAR Combination Oven;
* Section 3.7.6 – ENERGY STAR Commercial Convection Oven;
* Section 3.9.5 – Server Virtualization

Comments received on the remaining new C&I EE&C measure protocols are addressed below.

### Section 3.1.7 – Lighting Improvements for Midstream Delivery Programs

#### Comments

FirstEnergy comments that in Table 3-21, for omnidirectional lamps, the first bin should be the same as the second bin. The first bin shows a WATTSbase of 25 (same as incandescent equivalent) while the second bin has a WATTSbase of 8 with the same incandescent equivalent of 25. FirstEnergy Comments at 8. PECO recommends including LED exit signs as eligible for midstream implementation, consistent with a currently approved IMP. PECO Comments at 10. EAP comments propose the inclusion of “composite” inputs to savings algorithm. EAP Comments at 5-37.

PPL comments that Tables 3-21, 3-22, and 3-23 assume the 45 lumen per watt standard will apply to all bulbs sold starting in 2020 (except for lumen ranges above 3,301) and notes that this standard will not apply to reflector lamps, previously-exempt specialty bulbs, and lamps over 2,600 lumens if the DOE’s proposed withdrawal of its revised definition of a General Service Lamps is finalized. PPL recommends that the TRM be updated to allow for the application of either market or pre-EISA standard baselines to non-General Service Lamp bulbs if this proposed rulemaking becomes final. PPL comments further that, should DOE’s proposed withdrawal of its revised definition of a GSL *not* be implemented, meaning the 45 lumen per watt standard applies to high-lumen lamps, then WATTSbase for minimum lumen bin of 3,301 should be 81 (instead of 200 showing in Table 3-21), and WATTSbase for minimum lumen bin of 4,000 should be 111 (instead of 300 showing in Table 3-21). PPL Comments at 7. PPL comments that in Table 3-22 the last minimum lumen value should read 1050 and not 1049. In addition, PPL comments that in Table 3-23 the WATTSbase for the lumen bin 3,301 for Reflector Lamp >2.25" and reflector lamp PAR MR MRX should be 87 not 200, unless exempt. PPL requests that if they are exempt, this fact should be stated in the tables. PPL Comments at 8.

#### Disposition

The Commission rejects FirstEnergy’s comment regarding the appropriate WATTSbase for the 250-309 lumen bin in Table 3-21. Per the January 2017 Final Rule (Energy Conservation Program: Energy Conservation Standards for General Service Lamps; Final Rule. Federal Register / Vol. 82, No. 12. January 19, 2017), a general service lamp “has an initial lumen output of greater than or equal to 310 lumens (or 232 lumens for modified spectrum general service incandescent lamps) and less than or equal to 3,300 lumens.” Therefore, the 2020 efficacy backstop provision implemented in EISA 2007 does not apply to lamps with lumen output of less than 310 lumens. We also reject PECO’s recommendation regarding the eligibility of LED exit signs for midstream implementation. Federal standards require that all illuminated exit signs manufactured on or after January 1, 2006, have an input power of 5 Watts or less per face, essentially requiring LED exit signs. In other words, those purchasing a new exit sign in 2021 or beyond have no choice but to choose an efficient option, making a midstream approach inappropriate.

In response to PPL’s comments on the U.S. DOE’s potential withdrawal of the revised GSL definition and the associated recommendation to include baseline wattages that address both the new and old GSL definitions to cover both potential outcomes, we note that the TRM historically includes only those standards (and associated product definitions) that have been established in a Final Rule. The U.S. DOE’s proposal to withdraw the GSL definition change is currently in the Notice of Proposed Rulemaking Status (NOPR). As recent public comments to the NOPR have shown, the proposal to withdraw the GSL definition change is heavily contested by all but the product manufacturers and their trade organizations.[[18]](#footnote-19) Furthermore, if the U.S. DOE should follow through with the proposed withdrawal, it is likely that litigation will continue for months, if not years. Therefore, the Commission rejects PPL’s recommendation to update the TRM to allow for the application of either market or pre-EISA standard baselines to non-General Service Lamp bulbs. The Commission accepts PPL’s recommendation to correct Table 3-22. The last minimum lumen value should read 1050 and not 1049; we have made this correction.

In response to PPL’s comment, that in Table 3-23 the WATTSbase for the lumen bin 3,301 for Reflector Lamp >2.25" and reflector lamp PAR MR MRX should be 87 not 200, unless exempt. We note that, per the January 2017 Final Rule, lamps with lumen output greater than 3,300 lumens do not fall under the GSL definition and are therefore exempt from standards; however, a footnote will be added to the TRM to clarify this exemption.

The Commission accepts EAP’s suggestion to include “composite” inputs for the street lighting form factor and has made the appropriate change. No comments were received on this aspect of the measure, but the Commission notes that a new IMP for PY11 for Lighting Improvements for Midstream Delivery Programs updating SVG assumptions and addressing fixtures with integrated controls has been completed. The TRM now incorporates these revisions to the measure protocol.

### Section 3.2.11 – Computer Room Air Conditioner / Handler Electronically Commutated Plug Fans Programs

#### Comments

FirstEnergy comments that in Table 3-58, the documented Source 5 for UDSF results in an additional 12.7%, not 13.3%, savings from installing the fans underfloor as opposed to installing them in the unit. FirstEnergy Comments at 9. Franklin Energy comments note that installing any mechanism that could potentially modify the airflow of the supply fan on a DX system (CRAC units) has potential to freeze the coil. Franklin Energy recommends that any installation of an ECM on a CRAC unit should be verified with the manufacturer. Franklin Energy Comments at 319.

#### Disposition

The Commission accepts FirstEnergy’s and Franklin Energy’s recommendations and has updated the measure protocol accordingly.

### Section 3.2.12 – Computer Room Air Conditioner / Handler VSD on AC Fan Motors

#### Comments

Franklin Energy comments that installing any mechanism that could potentially modify the airflow of the supply fan on a DX system (CRAC units) has potential to freeze the coil. Franklin Energy recommends that any installation of a VFD on a CRAC unit should be verified with the manufacturer. Franklin Energy Comments at 322.

#### Disposition

The Commission accepts Franklin Energy’s recommendation and has updated the measure protocol accordingly.

### Section 3.2.13 – Circulation Fan: High-volume Low-speed

#### Comments

FirstEnergy comments that the measure description should be revised to change the reference from “IMP” to “measure.” FirstEnergy Comments at 9. PECO comments that “Efficient wattage source,” “baseline definition,” and “baseline source” are not defined terms and recommends defining these terms by wattage required to move an equivalent amount of air, volume, or size. PECO Comments at 10.

#### Disposition

The Commission accepts FirstEnergy’s suggestion to change the reference from “IMP” to measure and has updated the measure protocol accordingly. The Commission, however, rejects PECO’s suggestion to define terms by wattage required to move an equivalent amount of air, volume or size. The measure already presents baseline (Wconventional) and efficient (WHVLS) wattages based on the efficient fan diameter assuming equivalent air movement.

### Section 3.3.5 – ECM Circulator Pumps

#### Comments

Franklin Energy suggests adding a load factor to maintain consistency with other pumping measures. Franklin Energy Comments at 350. Franklin Energy also comments that another application of this measure is freeze protection for hot water coils. Franklin Energy Comments at 349. FirstEnergy suggests reframing the savings factor because of a perceived format inconsistency. FirstEnergy also comments that the measure description was lacking mention of baseline and efficient case controls. FirstEnergy Comments at 9 and 10.

#### Disposition

The Commission accepts Franklin Energy’s suggestion regarding load factor and has added the load factor with a default value of 0.9 defined to the energy and demand savings algorithms for this measure. We, however, decline to make additional adjustments regarding freeze protection for hot water coils because of the limited applicability of that application. The Commission rejects FirstEnergy’s suggestion to reframe the savings factor formatting. After further review, we found the current version of the algorithm and savings factor to be correct. The Commission however accepts FirstEnergy’s recommendation regarding the baseline definition in the measure description and we have added text to the measure description to more clearly define the appropriate baseline condition.

### Section 3.3.6 – High Efficiency Pumps

#### Comments

FirstEnergy suggests removing motor load factor and efficiency from the algorithms for this measure. Their reason is that PEI (Pump Energy Index) values already incorporate those values. FirstEnergy Comments at 10. Franklin Energy comments, more specifically, that motor efficiency is unnecessary for pump packages. Franklin Energy Comments at 354.

#### Disposition

The Commission agrees with Franklin Energy’s comment that motor efficiency is included in the PEI value for pump packages wherever a pump is being sold as a packaged unit with the motor included. In these cases, motor efficiency does not need to be included in the algorithm. Based on that, we have clarified the algorithm definition for pump packages by stipulating a motor efficiency of 1.0 for that type of equipment. Bare pump PEI values do not include motor efficiency. Additionally, no PEI values include load factor for any equipment configuration, for that reason the Commission did not adjust that part of the algorithm.

### Section 3.5.16 – Air-cooled Refrigeration Condenser

#### Comments

FirstEnergy recommends changing the kW/ton value in the peak demand savings algorithm to “kWh/ton/8760” to be consistent with the methodology of previous sections. FirstEnergy Comments at 11.

#### Disposition

The Commission agrees with the spirit of this comment. Consistency across sections is generally good; however, in this case, the protocol uses a methodology consistent with the source documents, therefore FirstEnergy’s request to change the kW/ton value in the peak demand savings algorithm is rejected.

### Section 3.5.18 – Refrigeration Economizers

#### Comments

Franklin Energy suggests that using “runs 24 hours” as an eligibility requirement is unrealistic, as the fans will not run during active defrost. Franklin Energy Comments at 411. Franklin Energy also notes that the default COP value seems high based on values that were used in other measures. Franklin Energy Comments at 414. PECO suggests utilizing the “Discus” type as an option for one of the algorithm inputs when the type of compressor is unknown. PECO Comments at 11.

#### Disposition

The Commission agrees with Franklin Energy’s suggestion regarding the eligibility requirement and has added a note to the TRM about defrost cycles. Regarding the other comment made by Franklin Energy about the COP value, the Commission agreed and changed the source for this value to the same source that is used in the 2021 TRM section 3.5.7 (previously section 3.5.8 of the 2016 TRM). This COP value is specific to walk-ins, not reach-ins, which explains why it seems high. We also agree with PECO’s suggestion that of the three compressor types the “Discus” type provides the least savings and have made the appropriate changes.

### Section 3.6.2 – ENERGY STAR Bathroom Ventilation Fan in Commercial Applications

#### Comments

FirstEnergy notes that in Table 3-132, the table and corresponding source refer to residential fans, but this is a commercial protocol. They also request default efficiencies for each of the CFM ranges. FirstEnergy Comments at 12.

#### Disposition

FirstEnergy was correct in identifying that the source material applies to residential fans. However, the products covered by the ENERGY STAR standards for ventilation are also approved for commercial applications, as noted in the ENERGY STAR product criteria scoping section. The Commission has removed the word residential from the table title to avoid confusion but notes that the information therein is correct. In response to FirstEnergy requesting default efficiencies, the Commission agreed and has included the default efficiency values as a matter of convenience. The difference between the energy efficient and baseline values is consistent across CFM ranges and the default savings are provided by binned CFM ranges.

### Section 3.7.7 – ENERGY STAR Commercial Fryer

#### Comments

FirstEnergy comments that the baseline IDLE energy rate for standard fryers be revised to 1,050 watts per the ENERGY STAR calculator. FirstEnergy Comments at 13.

#### Disposition

The Commission accepts FirstEnergy’s proposed revision to the baseline IDLE energy rate for standard fryers and has made the appropriate changes. This revision to the baseline IDLE energy rate resulted in a change to the default energy and demand savings for standard fryers.

### Section 3.7.8 – ENERGY STAR Commercial Hot Food Holding

#### Comments

PECO recommends that the TRM provide a default value for the volume of the Hot Food Holding Cabinet. PECO Comments at 12.

#### Disposition

The Commission accepts PECO’s recommendation and has added a default value of 15 cubic feet for the Hot Food Holding Cabinet volume, based on ENERGY STAR. Adding the default volume value resulted in a change to the default energy and demand savings for this measure.

### Section 3.7.9 – ENERGY STAR Commercial Dishwasher

#### Comments

FirstEnergy notes that a correction needs to be made to the units for a conversion factor and asks whether a rounded value was used for the conversion factor as their calculations did not match those in the proposed TRM. In addition, FirstEnergy recommends adding default kW savings to the TRM. FirstEnergy Comments at 13. PECO suggests defining “low temperature” and “high temperature” to help facilitate implementation. Furthermore, PECO recommends a default savings value based on the lowest energy savings values provided in the TRM or based on a typical/average installation type. PECO Comments at 12.

#### Disposition

The Commission accepts FirstEnergy’s recommendation to correct the units for a conversion factor and to add default kWpeak savings. Accordingly, we have made the appropriate changes. The Commission notes that the values in the default annual energy savings match the values shown in the ENERGY STAR calculator. The discrepancy between the default savings values shown in the TRM and the values calculated by FirstEnergy could be explained by decimal precision. For this reason, we have adjusted the default value for the “density of water” input to contain three significant digits rather than one. The Commission also accepts PECO’s suggestion and has added a definition for “low temperature” and “high temperature” machines. However, we reject PECO’s suggestion to add one default value for this measure. Default energy and demand values are already provided in the TRM at a level of detail that can be gathered by the CSP/contractor.

### Section 3.7.10 – ENERGY STAR Commercial Griddle

#### Comments

FirstEnergy recommends inserting a vinculum symbol in the default values for production capacity and notes an error in the units for default energy savings. FirstEnergy Comments at 13.

* + 1. **Disposition**

The Commission rejects FirstEnergy’s recommendation to insert a vinculum symbol in the default values for production capacity. However, we agree with FirstEnergy and corrected the error in the units for the default energy savings.

### Section 3.10.5 – Variable Speed Drive Air Compressor

#### Comments

FirstEnergy suggests that the useful measure life should be 13 years based on the source cited for the measure life (Illinois TRM v7.0). FirstEnergy Comments at 14. Franklin Energy comments that the default baseline compressor factor characterization may not be representative and may be too aggressive. Franklin Energy Comments at 497.

#### Disposition

The Commission agrees with the FirstEnergy suggestion that the measure life of the variable speed drive air compressor should be 13 years based on the Illinois TRM and has made the appropriate changes. However, we disagree with Franklin Energy’s opinion that a change to the default value of the baseline compressor factor is necessary. While the comment has merit, there is not sufficient data to support an alternate point estimate condition. The measure eligibility is established at a low horsepower threshold, where compressor controls are less prevalent. The primary source of the baseline compressor factor should be site-specific conditions, as available, and the default value should represent the unknown baseline conditions only.

### Section 3.10.6 – Compressed Air Controller

#### Comments

FirstEnergy and Franklin Energy suggest clarification that VFDs are not included with this measure. Franklin Energy comments that the measure eligibility should require a minimum storage capacity and that the default compressor load factor should match factors in other compressor air measures. Furthermore, Franklin Energy opines that the default motor efficiency may be overstated for some conditions. FirstEnergy Comments at 14, Franklin Energy Comments at 499, 500.

#### Disposition

The Commission agrees with suggestions from FirstEnergy and Franklin Energy and has added clarification to eliminate the reference to VFDs for this measure. We also agree with Franklin Energy’s suggestion to add a minimum storage requirement and have incorporated a minimum value of three gallons per CFM based on engineering judgement and industry experience. However, we disagree with Franklin Energy’s recommendation that changes to the default compressor load factor and the value of the baseline compressor motor efficiency are necessary for this measure. This measure utilizes the same default compressor load factor of 0.92 for other compressed air measures and is to be applied to existing motors and an efficiency below current manufacturing standards may be possible. The primary source of the baseline compressor factor should be site-specific conditions, as available, and the default value should only represent the unknown baseline conditions.

### Section 3.10.7 – Compressed Air Low Pressure Drop Filters

#### Comments

Franklin Energy comments that the measure algorithm should include a load factor in the algorithm. Franklin Energy Comments at 502.

#### Disposition

The Commission agrees with Franklin Energy’s suggestion to add a system load factor for consistency with other compressed air measures. A load factor of 0.92 has been added to the algorithm. This load factor is based on a load factor study on motors, including compressed air applications, completed by Cascade Energy for the Regional Technical Forum (RTF).[[19]](#footnote-20)

### Section 3.10.8 – Compressed Air Mist Eliminators

#### Comments

PECO comments that the measure eligibility should be limited to 40 HP for consistency with other compressed air measure eligibility thresholds. PECO Comments at 14. Franklin Energy comments that the default compressor load factor is too low. Franklin Energy Comments at 506.

#### Disposition

The Commission agrees with PECO’s suggestion to align the system threshold horsepower with other compressed air measures and has made changes accordingly. The Commission disagrees with Franklin Energy’s opinion that a change to the default compressor load factor is necessary for this measure. This measure utilizes the same default compressor load factor of 0.92 for other compressed air measures.

### Section 3.11.1 – High Efficiency Transformers

#### Comments

FirstEnergy comments on several typographical issues in the measure description and source numbering. Franklin Energy suggests that several eligibility requirements should be updated to align with the Illinois Technical Reference Manual. FirstEnergy Comments at 14, Franklin Energy Comments at 508.

#### Disposition

The Commission agrees with First Energy’s recommendation that typographical issues should be corrected and has made appropriate corrections. However, we disagree with Franklin Energy’s recommendation that the scope of the Pennsylvania TRM should be expanded to include non-dry type transformers solely to align with the Illinois TRM. The suggested expansion has limited application.

### Section 3.11.3 – High Frequency Battery Chargers

#### Comments

Franklin Energy provides several comments on this measure. The first comment deals with duplicate sentences in the eligibility section of the measure. Franklin Energy also notes that the interactive effects multipliers used in this measure are based on reduced waste heat from LED bulbs, and suggests that LED bulb waste heat may not be representative of battery charger waste heat. In addition, Franklin Energy recommends using different default coincidence factor values based on the number of charges completed per day (rather than one default value). The Illinois TRM uses multiple defaults, and this measure is based on a measure on the Illinois TRM.[[20]](#footnote-21) Franklin Energy Comments at 514, 515. PECO suggests that the TRM include conservative default savings for unknown options to allow for midstream or instant discounts. PECO Comments at 13.

#### Disposition

The algorithms for this measure are drawn from an identical measure in the Illinois TRM.[[21]](#footnote-22) The algorithms in the Illinois TRM do not account for waste heat. Therefore, we concur with Franklin Energy’s opinion that waste heat produced by an inefficient bulb may not be a good proxy for the waste heat produced by the baseline battery charger. Further research did not reveal a better value to use in place of the lighting waste heat factors. Additionally, it is likely that these chargers are commonly used in unconditioned spaces. For these reasons, the Commission has removed interactive effect multipliers from the annual energy and peak demand savings algorithms for this measure.

Regarding coincidence factors, the Commission agrees with Franklin Energy’s suggestion that using one default value may be overly simplistic. One of the papers, on which this algorithm is based, suggests that charging typically begins at 5:00 pm for single and two-shift schedules.[[22]](#footnote-23) As a result, a coincidence factor of 0.25 (5:00 pm – 6:00 pm represents 25% of the peak load period) is now the default coincidence factor in the TRM for single and two-shift schedules. For three-shift and four-shift schedules, charging occurs 24 hours per day. Therefore, a coincidence factor of 1 is now the default coincidence factor in the TRM for these schedules. In response to PECO’s comment regarding including conservative defaults, the Commission agrees with PECO’s recommendation and has adjusted the default savings table so that the “one-Shift Schedule,” which produces less savings than the other schedules, and is set as the “Default” schedule type if the actual schedule is unknown.

### Additional C&I EE&C Measures Protocols Recommended by Commenters

#### Comments

Brian McGowan recommends that drain water heat recovery measure protocols should be added for several C&I applications. Brian McGowan Comments at 2-3.

#### Disposition

The Commission acknowledges the energy savings potential of drain water heat recovery systems but believes the energy savings of such systems are better assessed with custom, site-specific protocols. The appropriate analysis of these systems depends on piping configurations, water usage patterns, and other factors.

## Existing Residential EE&C Measure Protocols and Processes

The following sections describe clarifications and modifications to the residential measure protocols. Some of the proposed changes received no stakeholder comments. Those proposed changes, which are not reproduced in the sections to follow, are hereby adopted by the Commission for use in Phase IV. Affected measures include:

Section 2.1.1 – ENERGY STAR Lighting (Default Values for Non-residential End-uses (Cross-sector Sales))

Section 2.1.2 – Residential Occupancy Sensors

Section 2.1.3 – Electroluminescent Nightlight

Section 2.1.4 – LED Nightlight

Section 2.2.2 – Fuel Switching: Electric Heat to Gas / Propane / Oil Heat

Section 2.2.3 – Ductless Mini-split Heat Pumps (Add Midstream Delivery Option; Rename)

Section 2.2.5 – Room AC (RAC) Retirement

Section 2.2.6 – Duct Sealing (Measure Verification Methods)

Section 2.2.7 – Furnace Whistle

Section 2.2.10 – Packaged Terminal Systems

Section 2.3.5 – Water Heater Tank Wrap

Section 2.4.3 – Refrigerator / Freezer Recycling with and without Replacement (Part Use Factor Default Values; Measure Life)

Section 2.4.4 – ENERGY STAR Clothes Washers

Section 2.4.6 – Fuel Switching: Electric Clothes Dryer to Gas Clothes Dryer

Section 2.4.7 – ENERGY STAR Dishwashers

Section 2.4.8 – ENERGY STAR Dehumidifiers

Section 2.5.2 – ENERGY STAR Office Equipment

Section 2.6.8 – Rim Joist Insulation

Section 2.7.2 – Variable Speed Pool Pumps (with Load Shifting Option)

The following sections describe clarifications and modifications to the residential measure protocols. The changes proposed by the Commission in our Tentative Order that received stakeholder comments are addressed below.

### Section 2.1.1 – ENERGY STAR Lighting[[23]](#footnote-24)

#### Baseline Wattage

The Commission proposed replacing the table of tiered baseline wattages based on lumen ranges with a simple calculation based on the Energy Independence and Security Act of 2017 (EISA) standard of 45 lumens per watt.

##### Comments

Duquesne comments that it is premature to shift to a 45 lm/W baseline, given the U.S. DOE’s Notice of Proposed Rulemaking (NOPR) from February 11, 2019[[24]](#footnote-25) states that the U.S. DOE had not yet made a determination on whether to amend standards for general service lamps (GSLs) and thus, had not determined whether the 45 lm/W standard established in EISA would be imposed. Duquesne Comments at 5-6. FirstEnergy comments that our proposed 2021 TRM does not contain the lumen bins and baseline wattages table mentioned in the text. FirstEnergy Comments at 2.

##### Disposition

In the absence of a final ruling from the U.S. DOE, rescinding the 45 lm/W baseline, the Commission disagrees with Duquesne’s comment. As recent public comments on the NOPR have shown, this proposal is heavily contested by all, except the product manufacturers and their trade organizations.[[25]](#footnote-26) Furthermore, should the U.S. DOE follow through with the proposed withdrawal, it is likely that litigation will continue for months, if not years. In response to FirstEnergy’s comment, the Commission agrees and has removed the erroneous language.

#### Specialty Lamp Baselines Removed

The Commission proposed eliminating the separate baseline wattages for specialty lamps table to reflect the broadened definition of general service lamps under the provisions of EISA. This recommendation was based on a U.S. DOE ruling in 2017 that would eliminate exemptions from the 45 lm/Watt standard for specialty lamp types including reflectors and 3-way lamps, to take effect January 2020.[[26]](#footnote-27) The status of this ruling is currently in question as the U.S. DOE has proposed to take back the 2017 ruling and maintain the exemptions for reflectors and other specialty lamp types. The U.S. DOE held a public meeting on February 27, 2019 regarding this proposed rulemaking with public comments due by May 3, 2019.[[27]](#footnote-28) At this time, a final decision has not been made.

##### Comments

Duquesne suggests that the U.S. DOE NOPR retracts the broadened definition of general service lamps, for this reason it is premature to impose the 45 lm/W baseline to standard and specialty lamp types in the 2021 TRM. Duquesne Comments at 5-6. PPL also notes that the U.S. DOE NOPR would retain exemptions from the 45 lm/W standard for certain lamp types and suggests an approach in the 2021 TRM that would allow for application of the market or pre-EISA standard baselines to the exempted lamp types if the proposed rulemaking becomes final. PPL Comments at 3.

##### Disposition

As previously stated in the Commission’s disposition in section E.1.a.ii regarding the 45 lm/W baseline, we disagree with Duquesne’s and PPL’s recommendations in the absence of a final ruling from the U.S. DOE on this topic, and the probability that lengthy litigation will leave this issue unresolved through 2021.

### Section 2.1.5 – Holiday Lights[[28]](#footnote-29)

The Commission did not propose any changes to Section 2.1.5 – Holiday Lights. However, comments were received and are addressed below.

#### Comments

FirstEnergy comments that the measure unit in the introductory table indicates a 25-bulb strand, while the default value for the algorithm is a 50-bulb strand.

#### Disposition

The Commission agrees with FirstEnergy’s recommendation and has corrected the introductory table to define the measure unit as a 50-bulb strand.

### Section 2.2.1 – Electric HVAC[[29]](#footnote-30)

#### Changes to Name and Section Structure

This measure in the 2016 TRM includes a variety of HVAC-related but dissimilar measures. The Commission proposed to limit this measure to new electric HVAC equipment, with the other measures separated into their own sections of the TRM, and to rename this measure High-efficiency Equipment: ASHP, CAC, GSHP, PTAC, PTHP to clearly define the equipment covered. PTAC and PTHP systems had previously been included in Section 2.2.10 – Packaged Terminal Systems,[[30]](#footnote-31) though the savings algorithms are similar to other electric HVAC equipment. We proposed to remove the measures related to Properly Sized Cooling, ECM Circulation Fans, GSHP Desuperheaters, and Air Conditioner & Heat Pump Maintenance from the section.

##### Comments

PECO recommends incorporating Properly Sized Cooling as a factor into the High Efficiency Equipment measures (see Sections 2.2.1 and 2.2.2 in the proposed TRM) but to exclude properly sized baseline units from eligibility. PECO Comments at 7, 22, 23, 28.

##### Disposition

The Commission agrees with PECO’s recommendation and has removed the separate measure for Properly Sized Cooling. This measure is now an additional term in the savings algorithm for the High Efficiency Equipment: ASHP, CAC, GSHP, PTAC, PTHP measure and the High Efficiency Equipment: Ductless Heat Pumps with Midstream Delivery Option (see Sections 2.2.1 and 2.2.2).

#### Updates to Default Values

The Commission proposed to update the default efficiencies for early replacement equipment using data from the 2018 Pennsylvania Residential Baseline Study and the default efficiencies for replace on burnout or new construction installations based on applicable updates to federal standards. This measure is also affected by updates to climate-dependent values, described in Section B.5.

##### Comments

FirstEnergy comments that the value definition for the algorithm term EFLHheat refers to “Secondary HP” in Vol. 1, App. A (Table 1-8) and that Secondary HP is not clearly defined there. Furthermore, FirstEnergy comments that default values are not provided for PTHPs and PTACs and that it is unclear if PTACs and PTHPs should be used for CAC and HP rows in the table of default oversize factor values as they are not “central. ” FirstEnergy Comments at 1.

##### Disposition

The Commission agrees with FirstEnergy’s suggestion and has clarified the definition of Secondary HP in Volume 1, Appendix A and also added a table of primary and secondary locations to the Appendix A spreadsheet tool. The Commission notes that default efficiency values for PTHPs and PTACs are capacity-dependent and must be calculated using the provided formulas. We agree with FirstEnergy’s opinion that oversize factors do not depend on installation of a central system and therefore has added PTAC to the table of default oversize factors for clarity.

### Section 2.2.3 – Ductless Mini-split Heat Pumps[[31]](#footnote-32)

#### Eligibility and Default Values

The Commission proposed that eligibility for efficient ductless heat pumps be limited to ENERGY STAR-qualified models. We also proposed to update the default efficiencies for early replacement equipment, using data from the 2018 Pennsylvania Residential Baseline Study, and for replace on burnout or new construction installations based on applicable updates to Federal standards. This measure is also affected by updates to climate-dependent values, described in Section B.

##### Comments

FirstEnergy comments that the table numbering is incorrect for Table 2-13: Oversize and Duct Leakage factors for High Efficiency Equipment (Table in the TRM) and that the page referenced in the cited source document from Northeast Energy Efficiency Partnerships is incorrect. Furthermore, FirstEnergy requests that the Commission consider adding a statewide weighted average EFLH in the absence of zip code data for purchased products as the installation zip code may not always be available. FirstEnergy Comments at 1. Franklin Energy comments that the baseline could also be no air conditioning for installation cases other than New Construction. Franklin Energy Comments at 28. PECO comments that certain composite EFLH values are not consistent with the values in approved IMPs and recommends that the TRM be updated to be consistent with the approved IMP. PECO Comments at 7.

##### Disposition

The Commission agrees with FirstEnergy’s recommendation and has corrected the table numbering for Oversize and Duct Leakage factors for High Efficiency Equipment and the page reference for the Northeast Energy Efficiency Partnerships source document. We also agree with FirstEnergy’s suggestion to add detail to assist with the calculation of blended EFLH values for use in midstream program delivery where the service address of the participant is unknown and have made the appropriate corrections. We do not provide all EDC specific EFLH values, but these can be calculated using a simple weighted average of the EDC Climate Region Weights (Table 1-6) and the EFLH cooling and heating values provided in the Residential HVAC Equivalent Full Load Hour and Coincidence Factor Assumptions table (Table 1-8). See Section 5 of this order for further discussion and a calculation example.

The Commission rejects Franklin Energy’s recommendation regarding baseline conditions. In cases of homes with no air conditioning, the baseline assumption, as defined in the measure, is a standard-efficiency ductless unit. We also reject PECO’s suggestion regarding consistency of the composite EFLH values with the IMP. As described in section B.4 – Updated Climate Assumptions of this order, the Commission has developed an updated set of EFLH values to be used for all applicable TRM measures. See also general comments on the issue of consistency with values in Phase III IMPs in section C.1 of this order.

#### Evaluation Protocols

##### Comments

PECO comments that in our proposed TRM the Commission added additional evaluation protocols, such as verification of installation and pre/post metering or billing analysis, which were not part of the relevant IMP. PECO recommends that the evaluation protocols be consistent with the IMP. PECO Comments at 7.

##### Disposition

The Commission agrees with PECO’s recommendation regarding additional evaluation protocols and has changed the evaluation protocols.

### Section 2.2.4 – ENERGY STAR Room Air Conditioners[[32]](#footnote-33)

The Commission proposed using the Combined Energy Efficiency Ratio (CEER), the current Federal standard metric for room air conditioner efficiency, in the savings algorithms. We also proposed to update the default for average RAC capacity, based on data from the 2018 Pennsylvania Residential Baseline Study. This measure was also affected by updates to climate-dependent values, described in Section B.

#### Comments

FirstEnergy points out errors in units for a value in Table 2-23 and a federal standard efficiency value in Table 2-24. FirstEnergy Comments at 1.

#### Disposition

The Commission agrees with FirstEnergy’s suggestion and has corrected the applicable default values.

### Section 2.2.6 – Duct Sealing[[33]](#footnote-34)

The Commission proposed renaming this measure to Duct Sealing and Insulation to reflect the added option of duct insulation. We also proposed to include the installation of duct insulation in unconditioned or semi-conditioned spaces in addition to duct sealing with mastic or metal tape in this measure. Duct insulation provides sealing qualities that can be assessed using the Evaluation of Distribution Efficiency method already in use in the 2016 TRM. In cases where duct insulation is involved with the improvement, we proposed that the TRM require the use of the Evaluation of Distribution Efficiency method for assessing the work as opposed to RESNET Test 380 4.4.2.

#### Comments

FirstEnergy comments that the algorithm includes a term for the COP of heating equipment but provides default values only for HSPF. They request clarification on default assumptions for “Leaky,” “Average,” and “Tight” ducts in Table 2-31. FirstEnergy also requests clarification on a reference to ductless mini-splits in this section. FirstEnergy Comments at 1.

#### Disposition

The Commission agrees with FirstEnergy’s request and has modified the algorithm to use HSPF instead of COP, along with a note to refer to GSHP derating for converting COP values to HSPF. In addition, we added more language for guidance on distribution efficiency assessment from the Building Performance Institute (BPI). In the interest of simplifying the TRM and reducing the opportunity for introducing inconsistent values in the future, the Commission has replaced the table of default heating and cooling system efficiency values in this measure with a reference to Table 2-8: Default Baseline Equipment Efficiency for High Efficiency Equipment in Section 2.2.1 - High Efficiency Equipment: ASHP, CAC, GSHP, PTAC, PTHP.

### Section 2.3 – Domestic Hot Water

The current U.S. DOE metric for efficiency of water heaters is the Uniform Energy Factor (UEF), which has superseded the prior metric, Energy Factor (EF). The Commission proposed to update residential measures for domestic hot water to specify baseline and efficient equipment by UEF and also the table of minimum baseline UEF values to comply with current Federal standards for water heaters.

#### Comments

Bradford White points out some inconsistency in the use of Energy Factor or EF instead of Uniform Energy Factor or UEF in the Domestic Hot Water section. Bradford White Comments at 3.

#### Disposition

The Commission agrees with Bradford White’s recommendation and has updated instances where “Energy Factor” was used to read “Uniform Energy Factor,” where not already updated.

### Section 2.3.1 – Heat Pump Water Heaters,[[34]](#footnote-35) Section 2.3.2 – Solar Water Heaters,[[35]](#footnote-36) and Section 2.3.3 – Fuel Switching: Electric Resistance to Fossil Fuel Water Heater[[36]](#footnote-37)

The Commission proposed to revise the assumed cold-water inlet temperature to 52F, and the assumed value for hot water used per day to 45.5 gallons, with these values to be applied across all measures that incorporate these factors. Section 2.3.1 – Heat Pump Water Heaters was also affected by updates to climate‑dependent values, described in Section B (in relation to interactive heating / cooling effects).

#### Comments

FirstEnergy requests clarification or correction for several values in the heat pump water heater measure; including correcting the units for default UEFee, correcting the HPWH default savings value, and clarifying the definition of the Vr variable in the UEFbase table. FirstEnergy Comments at 2. PECO requests that UEF values be rounded to two digits to align with federal standards, as well as clarification on sources for listed default efficiencies and for defining the draw pattern used to determine efficiency values (this applies to Sections 2.3.2 and 2.3.3 as well). PECO Comments at 8.

#### Disposition

The Commission agrees with FirstEnergy’s and PECO’s recommendations and has corrected the specified values and provided clarification where requested. This includes adding a table defining draw pattern for water heaters. Although no stakeholders commented on the error, we noticed during the review of our proposed manual that Section 2.3.3 – Fuel Switching still referenced oil-fired water heaters, which the Commission has removed.

### Section 2.3.6 –Water Heater Temperature Setback[[37]](#footnote-38)

The Commission proposed adding a term for the assumed number of clothes washer cycles per year, which is not included in the 2016 TRM, though the algorithm includes a term for the volume of hot water used in each clothes washer cycle. In addition, the current U.S. DOE metric for efficiency of water heaters is the Uniform Energy Factor (UEF), which has superseded the prior metric, Energy Factor (EF). The Commission proposed updating this measure to specify baseline and efficient equipment by UEF.

#### Comments

FirstEnergy comments that incorrect units are used for the VHW variable, and that the incorrect source table was given for the Atank variable. FirstEnergy Comments at 2. PECO comments that cycleswash values were not aligned between tables within the measure and requests clarification on the presence of a washer in default savings scenarios utilizing the cycleswash variable. PECO Comments at 8.

#### Disposition

The Commission accepts all suggestions from FirstEnergy and PECO and has made the necessary corrections and updates. Although no stakeholders commented on the error, we noticed during the review of our proposed manual that the UEF values were not consistently rounded to the second digit. The Commission has updated these UEF values.

### Section 2.3.7 – Water Heater Pipe Insulation[[38]](#footnote-39)

The Commission proposed updating the assumed energy use of an electric water heater to correspond with updated baseline values in Section 2.3.1 – Heat Pump Water Heaters. This results in a deemed savings of 8.82 kWh per year per foot of pipe insulation, versus the former value of 9.43 kWh per year per foot.

#### Comments

FirstEnergy comments that the eligibility description of the measure uses an insulation thickness of ¾," while other thicknesses (½" to 1") would be acceptable. FirstEnergy Comments at 2. Franklin Energy suggests including a more detailed definition of unconditioned space. Franklin Energy Comments at 87.

#### Disposition

The Commission agrees with FirstEnergy’s opinion, acknowledging that multiple insulation and pipe configurations can meet the insulation levels necessary to claim savings. We have changed the eligibility definition of the measure to be the 2015 IECC code minimum of R-3 or above, rather than specifying insulation thickness.[[39]](#footnote-40) However, the Commission disagrees with the suggestion made by Franklin Energy to include a more detailed definition of unconditioned space.

### Section 2.3.8 – Low-flow Faucet Aerators[[40]](#footnote-41) and Section 2.3.9 – Low-flow Showerheads[[41]](#footnote-42)

The Commission proposed to revise the assumed cold-water inlet temperature to 52F, as used in other updated domestic hot water measures and to update values for persons per household, faucets per home, and share of homes with electric water heaters using results from the 2018 Pennsylvania Residential Baseline Study. We also proposed to include a default in-service rate of 28% for aerators and 35% for showerheads delivered in kits, based on evaluations of PY9 from FirstEnergy EDCs.

#### Comments

FirstEnergy requests clarification that both aerators and low-flow shower heads can be installed in new construction. FirstEnergy Comments at 2. Franklin Energy requests that clarification be provided in the introduction to both the aerator and shower head measures about what type of equipment is eligible (HPWH, standard resistive, or instantaneous electric water heaters) and what types are not (non-electric water heaters). Franklin Energy comments under faucet aerators that laminar flow restrictors should also be eligible under this measure. Franklin Energy Comments at 89 and 94. FirstEnergy requests the addition of a default value for GPMlow of 1.5 GPM for low-flow showerheads. FirstEnergy comments at 6.

Franklin Energy comments that legend text for load shape graphs is unclear in figures included for faucet aerators and shower heads. In addition, Franklin Energy asks if a default GPM is necessary for a new unit where a proposed GPM might be unknown for faucet aerators and requests the addition of “EDC Data Gathering” as an option for GPMbase for the shower head measure. Furthermore, Franklin Energy recommends noting that 0.98 is a default for electric resistance water heaters where default values are listed for both faucet aerators and low-flow shower heads. Franklin Energy Comments at 90 and 95. PECO points out that ISRs for both faucet aerators and shower heads in the proposed manual are based on PY9 data from FirstEnergy EDCs and recommends including data from additional EDCs over the course of multiple years. PECO Comments at 8.

#### Disposition

The Commission agrees with requests for clarification from FirstEnergy and Franklin Energy regarding the eligibility of new construction for each measure, equipment type eligibility, load shape types in graph legends, and specifying 0.98 as a default for electric resistive water heaters. We have made the corresponding edits. The Commission rejects FirstEnergy’s request for a default GPMlow value of 1.5 for low-flow showerheads. Low-flow showerheads are commonly available in a wider range of flow values than faucet aerators (where a default GPMlow of 1.5 is provided). We find that it is not an undue burden to require EDCs to submit data on the specific flow rates of showerheads provided through their programs. A review of prior years’ project files identified just one specification sheet for low-flow showerheads provided by FirstEnergy, which listed a flow rate of 1.6 GPM.

The Commission agrees with Franklin Energy’s suggestion that this measure is applicable to laminar flow restrictors and we have therefore expanded the eligibility to include them. A default value of 1.5 GPMlow is provided for use in faucet aerator savings calculations where EDC gathered data is not available, the Commission believes this satisfies Franklin Energy’s question regarding a value for GPMlow where the proposed GPM of a replacement aerator is unknown. The Commission agrees with Franklin Energy’s opinion that “EDC Data Gathering” should be an option for the GPMbase variable in the showerhead measure and as a result has added “EDC Data Gathering” as an alternative. The Commission appreciates PECO’s recommendation to include additional data from other EDCs and other program years to be used for faucet aerator and shower head ISRs. However, we decline PECO’s request to include data from other EDCs as we have not seen specific research that provides additional kit versus direct-install data for each measure.

### Section 2.3.10 – Thermostatic Shower Restriction Valve[[42]](#footnote-43)

The Commission proposed updating default values to reflect findings from the 2018 Pennsylvania Residential Baseline Study. Updated data available from the study includes persons per household, showerheads per home, and the default percent of homes with electric heat. We also proposed revising the assumed cold-water inlet temperature to 52F, as used in other updated domestic hot water measures. Default savings will change with adjustments to these inputs. In addition, the Commission proposed that the measure life for thermostatic shower restriction valves be increased from ten to the maximum of 15 years. This is based on the International Association of Plumbing and Mechanical Officials’ Uniform Plumbing Code (UPC) standards that require a device last 10,000 cycles without failure.[[43]](#footnote-44)

#### Comments

FirstEnergy requests clarification that this measure can be installed in new construction and points out a typographical error in the source used to determine the coincidence factor (CF) that informs the calculation of the energy to demand actor (ETDF). FirstEnergy Comments at 2. Franklin Energy asks for clarification on equipment type eligibility, the load shape types included in the legend of the load shapes plot, and that the default 0.98 recovery efficiency is specific to electric resistance water heaters. Franklin Energy Comments at 99 and 100.

#### Disposition

The Commission accepts the recommendations from FirstEnergy and Franklin Energy and has consequently made all suggested additions and clarifications to Section 2.3.10 – Thermostatic Shower Restriction Valve. We have also added a footnote to the load shapes plot and included new construction to the eligibility. Furthermore, we have corrected the erroneous CF value and added language to specify the default savings assume an electric resistance water heater with a recovery efficiency of 0.98.

### Section 2.4.1 – ENERGY STAR Refrigerators[[44]](#footnote-45) and Section 2.4.2 – ENERGY STAR Freezers[[45]](#footnote-46)

The Commission proposed updating the equations for Adjusted Volume to correspond to the Federal definition of this term. In addition, for Section 2.4.1 only, the Commission proposed updating the criteria for determining the maximum energy use of refrigerators with top-mounted freezers to correspond to the ENERGY STAR Most Efficient specifications. Furthermore, the Commission proposed using an updated value for the Energy to Demand Factor (ETDF) term that matches the value found in the Mid-Atlantic, Illinois, and Wisconsin TRMs.

#### Comments

FirstEnergy comments that total volume rather than adjusted volume is used in the default savings calculations for the refrigerator and freezer measures. FirstEnergy also comments that, in the table of maximum energy consumption formulas for refrigerators, refrigerator category 956 is unclear and categories 3, 3-BI, 3-I do not include the Eann term. FirstEnergy Comments at 6.

#### Disposition

The Commission agrees with FirstEnergy’s suggestions and has updated the assumed adjusted volume values used in the default savings calculations and the default savings values. Furthermore, we have corrected the typographical error for freezer category 6 and clarified the Eann formulas.

### Section 2.4.3 – Refrigerator / Freezer Recycling with and without Replacement[[46]](#footnote-47)

The 2016 TRM provides a set of EDC-specific default coefficients for calculating the Unit Energy Consumption (UEC) of existing refrigerators. The Commission proposed removing these values and requiring the use of program data to calculate UEC values. A recycling program, by its nature, provides EDCs the opportunity to collect the required information to calculate the actual UEC rather than using defaults.

#### Comments

Duquesne requests that default values be retained and updated based on EM&V sampling for appliance recycling. Duquesne Comments at 2. FirstEnergy comments that the equation for the UEC of refrigerators is missing the variable for the fraction of refrigerators manufactured before 1990 and that the value for ETDF in Table 2-75 is not consistent with the ETDF for the same measures in previous sections. FirstEnergy Comments at 6.

#### Disposition

The Commission rejects Duquesne’s recommendation that default values be retained and updated based on EM&V sampling for appliance recycling. CSPs have provided data for every recycled unit in Phases I to III. The Commission however agrees with FirstEnergy’s statement that the equation for the UEC of refrigerators is missing the variable for the fraction of refrigerators manufactured before 1990, and therefore have made the appropriate corrections to Section 2.4.3 – Refrigerator / Freezer Recycling with and without Replacement.

### Section 2.4.5 – ENERGY STAR Dryers[[47]](#footnote-48)

The Commission proposed changing the name of this section to ENERGY STAR Clothes Dryers to add specificity. In addition, we proposed to introduce terms for baseline and efficient dryer cycle times in lieu of the single cycle time term in the current algorithm. Furthermore, the Commission proposed updating default values in this measure to reflect data on frequency of clothes dryer use from the U.S. DOE 2015 Residential Energy Consumption Survey. The Commission proposed to use the same CF value as used for ENERGY STAR Clothes Washers.

#### Comments

PECO comments that this measure should include ventless ENERGY STAR clothes dryers. PECO Comments at 8.

#### Disposition

The Commission agrees with PECO’s suggestion and has modified this measure to include ventless ENERGY STAR clothes dryers.

### Section 2.4.10 – ENERGY STAR Ceiling Fans[[48]](#footnote-49)

The Commission proposed a simplified algorithm with a default assumed wattage reduction table that depends on fan type and diameter. The default wattage reductions are based on currently available ENERGY STAR-qualified models and a weighted average fan airflow.

#### Comments

PECO recommends adding 25 kWh/year and 0.002 kW as default values for units with diameters greater than 36 inches. PECO Comments at 8.

#### Disposition

The Commission disagrees with PECO’s recommendation to add 25 kWh/year and 0.002 kW as default values for units with diameters greater than 36 inches. These default values are already listed in the default savings table.

### Section 2.5.3 – Smart Strip Plug Outlets[[49]](#footnote-50)

The Commission proposed renaming this measure to Advanced Power Strips (APS) to better reflect market terminology. We also proposed to replace the existing algorithms with similar but simplified versions that use assumed values for particular end uses of advanced power strips (home office, entertainment center, unspecified), an Energy Reduction Percentage value that depends on end use and strip type (Tier 1 or Tier 2), an in-service rate, and a realization rate. The new algorithms and default values are based on recent research in Massachusetts by NMR Group, Inc. The default energy and demand savings increase for Tier 1 advanced power strips and decrease for Tier 2 strips compared to the 2016 TRM.

#### Comments

FirstEnergy comments that the shares of Tier 1 APSs used in home and office settings, as noted in the footnote for Annual\_Usageunspecified, do not match the values in the source document. FirstEnergy Comments at 6. Franklin Energy comments that the measure life is seven years for C&I advanced power strips but only five years for residential advanced power strips. Franklin Energy Comments at 152. Tricklestar, Inc. comments that the terminology used for this measure is inconsistent in the text and that all references should be changed to “Advanced Power Strips.” Tricklestar, Inc. Comments at 1, 2.

#### Disposition

The Commission agrees with FirstEnergy’s recommendation and has corrected the values in the footnote for Annual\_Usageunspecified. We also agree with Franklin Energy’s suggestion and have updated the measure life value for the C&I advanced power strips measure to match the value of five years for residential advanced power strips. See Section F.37 of this order. In addition, in agreement with Tricklestar, Inc.’s suggestion, we have updated the measure to refer only to “Advanced Power Strips.”

### Section 2.6.1 – Ceiling / Attic and Wall Insulation[[50]](#footnote-51)

The Commission proposed consolidating above-grade insulation measures in this section, to include the existing Ceiling / Attic and Wall insulation measures, as well as Rim Joist insulation (Section 2.6.8 of the 2016 TRM) and Floor Insulation (from a Phase III IMP).[[51]](#footnote-52) To reflect these changes, we proposed renaming the section to Ceiling / Attic, Wall, Floor, and Rim Joist Insulation. In addition, the Commission proposed a similar but simplified and reduced set of algorithms for calculating savings using the same set of terms and to update default baseline HVAC system efficiency values with data from the 2018 Pennsylvania Residential Baseline Study. This section is also affected by updates to climate-dependent values, described in Section B.

#### Comments

FirstEnergy requests the addition of a default COPg value for ground source heat pumps. FirstEnergy Comments at 7.

#### Disposition

The Commission rejects FirstEnergy’s request to add a default COPg value for ground source heat pumps. A COPg value is required only to calculate the value of HSPF for the savings algorithm when not using default efficiency values. A default HSPF value is provided for ground source heat pumps in Section 2.2.1 High Efficiency Equipment, referred to in this measure.

### Section 2.6.2 – ENERGY STAR Windows[[52]](#footnote-53)

Savings estimates under this section depend on an energy model of a representative prototype home. The Commission proposed replacing the current model with a new energy model created in BEopt v.2.8.0, a modeling tool developed by NREL.[[53]](#footnote-54) The characteristics of the prototype model are based on data from the 2018 Pennsylvania Residential Baseline Study. Results from running the model under varying climate reference locations and HVAC configurations are used to generate a table of Unit Energy Savings (UES) factors identifying the kWh savings per square foot of replaced window. These factors are used in a new algorithm, along with window area and the ratio of heating or cooling system efficiency in the actual baseline home to the assumed system efficiency in the prototype model.

#### Comments

FirstEnergy requests clarification on what values to use for the , the equipment efficiency of the prototype home. FirstEnergy Comments at 7.

#### Disposition

The Commission agrees with FirstEnergy’s request that including a clarification in this measure would be helpful and has therefore added general guidance on calculating values, as well as clarification on the nature of the and . In the interest of simplifying the TRM and reducing the opportunity for introducing inconsistent values in the future, the Commission has replaced the table of default heating and cooling system efficiency values in this measure with a reference to Table 2-8: Default Baseline Equipment Efficiency for High Efficiency Equipment in Section 2.2.1 - High Efficiency Equipment: ASHP, CAC, GSHP, PTAC, PTHP.

### Section 2.6.3 – Residential New Construction[[54]](#footnote-55)

The 2016 TRM requires two methods to estimate savings under this measure. Climate-dependent savings, such as from insulation or HVAC systems, are estimated using the results of energy modeling comparing the as-designed home to a minimally code-compliant baseline building. Non-climate-dependent savings from measures such as lighting and appliances must be calculated using the specific measure algorithm from the appropriate section elsewhere in the TRM. The Commission proposed allowing the option of estimating all savings using energy modeling. We also proposed expanding the range of energy modeling software approved for estimating savings under this measure to include any RESNET-accredited software, as well as Passive House accreditation packages Passive House Planning Package and WUFI Passive. Furthermore, the Commission proposed updating the parameters of the baseline code-compliant home according to the requirements of the 2015 IECC and updated Federal standards.

#### Combining with Low-Rise Multifamily Measure

##### Comments

PECO and Performance Systems Development recommend combining this measure with the Residential New Construction measure to increase flexibility. PECO Comments at 9 and Performance Systems Development Comments at 4.

##### Disposition

The Commission agrees with the suggestions of PECO and Performance Systems Development suggestion that a single Residential New Construction measure covering both single and multifamily buildings is preferable to separate measures and has therefore removed the Low-Rise Multifamily New Construction measure and expanded the eligibility under Residential New Construction to include multifamily residential buildings. See C.15 – Low Rise Multifamily New Construction for a more detailed description of proposed changes regarding multifamily buildings under this measure.

#### Energy Modeling

##### Comments

FirstEnergy requests that the savings calculation methods that use TRM algorithms be expanded to allow reasonable and appropriate approximation methods to estimate and simulate savings rather than force an inventory in each home. FirstEnergy Comments at 7. Performance Systems Development supports the use of models for all savings calculations, removing the distinction between weather-sensitive and non-weather-sensitive measures. They also recommend calculating demand savings for all measures, not just weather-sensitive measures. Performance Systems Development Comments at 3, 13.

##### Disposition

The Commission agrees with the suggestions of FirstEnergy and Performance Systems Development that a measure based solely on modeled savings with no requirement to calculate savings for non-weather sensitive measures using separate sections of the TRM would simplify program participation, savings calculations, and evaluation. The Commission has therefore modified the measure so that all energy savings are calculated using energy models. The approved energy models for this measure cannot calculate demand savings for measures other than cooling, so the Commission rejects Performance Systems Developments’ request to calculate demand savings for all measures. The Commission has included the option of calculating and claiming additional demand savings from other measures by using the corresponding demand savings algorithms in the specific TRM measures for which demand savings will be claimed.

#### Other Comments

##### Comments

PPL requests clarification that the Commission’s intent is for software and the baseline reference design home to include up-to-date assumptions reflecting current state and federal lighting and appliance standards. PPL Comments at 3. FirstEnergy, Performance Systems Development, and PPL comment that the values for frame wall U-factor for IECC climate zone 6A should be 0.045 instead of 0.060, and that the infiltration requirement should be 5.0 ACH50 instead of 3.0 ACH 50, to reflect Pennsylvania-specific amendments to the 2015 IECC code. FirstEnergy Comments at 7, Performance Systems Development Comments at 3, and PPL Comments at 4. Franklin Energy suggests language changes to clarify the meaning of the “baseline” home and suggests using “building modeling” instead of “software output.” Franklin Energy Comments at 185, 186. PECO suggests a correction to the description in the Algorithms section to remove a reference to “multifamily.” PECO also identifies an erroneous use of “EF” instead of “UEF” for water heater efficiency units. PECO Comments at 9.

##### Disposition

The Commission agrees with PPL’s comment regarding lighting and appliances in the tables of baseline values to use in the reference building and has added clarifying language. The Commission notes that EDCs should use the values as included in the current version of the TRM. The Commission has proposed an annual review process that will allow updates to the TRM to include updates to state and federal standards that occur during Phase IV (see B.2 Process for Code Change Updates). The Commission agrees with the comments of FirstEnergy, Performance Systems Development, and PPL and has corrected the values for frame wall U-factor and maximum air infiltration to reflect Pennsylvania amendments to the 2015 IECC. The Commission agrees with Franklin Energy’s and PECO’s comment and has revised the language in the measure to address the textual changes. Also, in the interest of simplifying the TRM and reducing the opportunity for introducing inconsistent values in the future, the Commission has replaced the default heating and cooling system efficiency values in this measure with a reference to Table 2-8: Default Baseline Equipment Efficiency for High Efficiency Equipment in Section 2.2.1 - High Efficiency Equipment: ASHP, CAC, GSHP, PTAC, PTHP.

### Section 2.6.5 – ENERGY STAR Manufactured Homes[[55]](#footnote-56)

#### Comments

FirstEnergy requests adding “or by other models approved by the SWE” to Algorithms section defining approved energy modeling software. FirstEnergy Comments at 8. PPL asks the Commission to confirm the approved software for energy modeling. PPL Comments at 4. PECO notes that the minimum water heater efficiency unit should be UEF and not EF. PECO Comments at 9. Performance Systems Development supports the use of models for all savings calculations, removing the distinction between weather-sensitive and non-weather-sensitive measures. They also recommend calculating demand savings for all measures, not just weather-sensitive measures. Performance Systems Development Comments at 3, 13.

#### Disposition

The Commission rejects FirstEnergy’s suggestion and confirms, responding to PPL, that the only currently approved software models are those on the RESNET list of accredited software rating programs, as cited in the measure. The Commission agrees with PECO’s suggestion and has corrected the efficiency units for water heaters. We also agree with Performance Systems Development suggestion that a measure based only on modeled savings would be preferable to simplify program participation, savings calculations, and evaluation. The Commission has modified the measure so that all energy savings are calculated using energy models. The approved energy models for this measure cannot calculate demand savings for measures other than cooling, so the Commission rejects Performance Systems Development’s request to calculate demand savings for all measures. The Commission has included the option of calculating and claiming additional demand savings from other measure by using the corresponding demand savings algorithms in the specific TRM measures for which demand savings will be claimed.

Also, in the interest of simplifying the TRM and reducing the opportunity for introducing inconsistent values in the future, the Commission has replaced the default heating and cooling system efficiency values in this measure with a reference to Table 2-8: Default Baseline Equipment Efficiency for High Efficiency Equipment in Section 2.2.1 - High Efficiency Equipment: ASHP, CAC, GSHP, PTAC, PTHP.

### Section 2.6.6 – Residential Air Sealing[[56]](#footnote-57)

Savings estimates under this section depend on an energy model of a representative prototype home. The Commission proposed replacing the current model with a new energy model created in BEopt v.2.8.0, a modeling tool developed by NREL.[[57]](#footnote-58) The characteristics of the prototype model are based on data from the 2018 Pennsylvania Residential Baseline Study. Results from running the model under varying climate reference locations and HVAC configurations were used to generate a quadratic regression model and a table of regression coefficients. Savings are calculated by selecting the appropriate coefficients for the location and HVAC configuration and applying them in the algorithm along with factors defining the ratio of duct efficiency and HVAC equipment efficiency in the air-sealed home versus the prototype model and the pre- and post-air sealing air infiltration measurements in the home.

#### Comments

FirstEnergy asks if the measure is also applicable to buildings with 2-4 dwelling units or manufactured/mobile homes. FirstEnergy points out that the value for *Ductbase* is currently limited to measurement via EDC data gathering and asks if there is a default value. FirstEnergy Comments at 6, 7.

#### Disposition

The Commission notes that savings calculations for this measure depend on coefficient values generated from prototype models based on data from detached single‑family homes from the 2018 Pennsylvania Residential Baseline Study. This dataset includes manufactured and mobile homes and the Commission has updated the proposed manual to clarify eligibility. Therefore, the Commission rejects FirstEnergy’s suggestion that the measure eligibility be expanded to two-four dwelling unit structures. The Commission has added clarifying text to the 2021 TRM regarding *Ductbase*, values which may come from measurement or by selecting an appropriate value from the Distribution Efficiency table provided in the Duct Sealing & Insulation measure. There will not be a default value provided for *Ductbase*.

### Section 2.6.7 – Crawl Space Wall Insulation[[58]](#footnote-59)

The Commission proposed updating default baseline HVAC system efficiency values with data from the 2018 Pennsylvania Residential Baseline Study. This section is also affected by updates to climate-dependent values, described in Section B.

#### Comments

FirstEnergy asks if a crawl space is required to contain ductwork to be eligible for this measure and requests a default *COPGSHP* be provided. FirstEnergy Comments at 7.

#### Disposition

The Commission has revised the eligibility to remove reference to ductwork. The Commission disagrees with FirstEnergy’s suggestion and rejects the request to add a default *COPGSHP*because a default HSPF is already provided. No comments were received on this aspect of the measure, but upon review of the comments for this measure and those for Basement Wall Insulation (See A.14), the Commission has elected to combine these two similar measures in the interest of consistency. The proposed manual includes a single measure entitled Basement and Crawl Space Wall Insulation. The Commission has made these changes in combining the measures:

* Expanded eligibility to include basements as well as crawl spaces;
* Added an adjustment factor to related insulated area to area served by room air conditioners, FRAC, which was included in the Basement Wall Insulation measure.
* Updated the default R-value and source to a value of R-1.
* Updated the source for the framing factor values.

Furthermore, in the interest of simplifying the TRM and to minimize the introduction of inconsistent values in the future, the Commission has replaced the table of default heating and cooling system efficiency values for this measure with a reference to Table 2-8: Default Baseline Equipment Efficiency for High Efficiency Equipment in Section 2.2.1 - High Efficiency Equipment: ASHP, CAC, GSHP, PTAC, PTHP. The Commission has also added clarifying text to the Below Grade Thermal Resistance Values table.

### Section 2.9.1 – Direct Load Control and Behavior-Based Demand Response Programs

The Commission did not propose changes to Section 2.9.1 – Direct Load Control and Behavior-Based Demand Response Programs. However, comments were received and are addressed below.

#### Comments

PPL Electric requests that the Commission clarify: (1) the basis for this assumption; and (2) whether the 10-year measure life applies to behavioral DR programs, or whether the measure life for behavioral DR programs should be a one-year measure life. PPL Comments at 5.

#### Disposition

The Commission agrees with PPL that behavior-based DR programs should have a different measure life from direct load equipment. Regarding the measure life of direct load control equipment, we have updated the proposed measure life of ten years to 11 years to align with the assumed measure life of ENERGY STAR Connected Thermostats in Section 2.2.12 as we believe connected thermostats will be the most common form of residential direct load control in any future residential DR programs.

### Measure Number Changes

The changes proposed herein will result in new measure numbers for several residential measures. The table below shows the current measure name and number and the new measure name and number for all affected measures. The table also shows measures that the Commission proposed removing—these measures are discussed in more detail later.

| **Current Measure Number** | **Current Measure Name** | **New Measure Number** | **New Measure Name** |
| --- | --- | --- | --- |
| 2.1.3 | Electroluminescent Nightlight | 2.1.3 | LED and Electroluminescent Nightlights |
| 2.1.4 | LED Nightlight | 2.1.3 | LED and Electroluminescent Nightlights |
| 2.1.5 | Holiday Lights | 2.1.4 | Holiday Lights |
| 2.2.1 | Electric HVAC | 2.2.1 | High-efficiency Equipment: ASHP, CAC, GSHP, PTAC, PTHP |
| 2.2.2 | Fuel Switching: Electric Heat to Gas / Propane / Oil Heat | 2.2.6 | Fuel Switching: Electric Heat to Gas / Propane / Oil Heat |
| 2.2.3 | Ductless Mini-split Heat Pumps | 2.2.2 | High-efficiency Equipment: Ductless Heat Pumps with Midstream Delivery Option |
| 2.2.4 | ENERGY STAR Room Air Conditioners | 2.2.7 | ENERGY STAR Room Air Conditioners |
| 2.2.5 | Room AC (RAC) Retirement | 2.2.8 | Room AC (RAC) Retirement |
| 2.2.6 | Duct Sealing | 2.2.9 | Duct Sealing and Insulation |
| 2.2.7 | Furnace Whistle | 2.2.10 | Air Handler Filter Whistle |
| 2.2.8 | Programmable Thermostat | - | Deleted |
| 2.2.9 | Residential Whole House Fans | - | Deleted |
| 2.2.10 | Packaged Terminal Systems | 2.2.1 | High-efficiency Equipment: ASHP, CAC, GSHP, PTAC, PTHP |
| 2.3.4 | Fuel Switching: Heat Pump Water Heater to Fossil Fuel Water Heater | - | Deleted |
| 2.3.5 | Water Heater Tank Wrap | 2.3.4 | Water Heater Tank Wrap |
| 2.3.6 | Water Heater Temperature Setback | 2.3.5 | Water Heater Temperature Setback |
| 2.3.7 | Water Heater Pipe Insulation | 2.3.6 | Water Heater Pipe Insulation |
| 2.3.8 | Low-flow Faucet Aerators | 2.3.7 | Low-flow Faucet Aerators |
| 2.3.9 | Low-flow Showerheads | 2.3.8 | Low-flow Showerheads |
| 2.3.10 | Thermostatic Shower Restriction Valve | 2.3.9 | Thermostatic Shower Restriction Valve |
| 2.4.5 | ENERGY STAR Dryers | 2.4.5 | ENERGY STAR Clothes Dryers |
| 2.4.6 | Fuel Switching: Electric Clothes Dryer to Gas Clothes Dryer | 2.4.7 | Fuel Switching: Electric Clothes Dryer to Gas Clothes Dryer |
| 2.4.7 | ENERGY STAR Dishwashers | 2.4.8 | ENERGY STAR Dishwashers |
| 2.4.8 | ENERGY STAR Dehumidifiers | 2.4.9 | ENERGY STAR Dehumidifiers |
| 2.4.9 | ENERGY STAR Water Coolers | 2.4.10 | ENERGY STAR Water Coolers |
| 2.4.10 | ENERGY STAR Ceiling Fans | 2.4.11 | ENERGY STAR Ceiling Fans |
| 2.5.1 | ENERGY STAR Televisions | - | Deleted |
| 2.5.2 | ENERGY STAR Office Equipment | 2.5.1 | ENERGY STAR Office Equipment |
| 2.5.3 | Smart Strip Plug Outlets | 2.5.2 | Advanced Power Strips |
| 2.6.1 | Ceiling / Attic and Wall Insulation | 2.6.3 | Ceiling / Attic, Wall, Floor, and Rim Joist Insulation |
| 2.6.2 | ENERGY STAR Windows | 2.6.6 | ENERGY STAR Windows |
| 2.6.3 | Residential New Construction | 2.7.1 | Residential New Construction |
| 2.6.4 | Home Performance with ENERGY STAR | 2.7.2 | Home Performance with ENERGY STAR |
| 2.6.5 | ENERGY STAR Manufactured Homes | 2.7.4 | ENERGY STAR Manufactured Homes |
| 2.6.6 | Residential Air Sealing | 2.6.1 | Residential Air Sealing |
| 2.6.7 | Crawl Space Wall Insulation | 2.6.5 | Crawl Space Wall Insulation |
| 2.6.8 | Rim Joist Insulation | 2.6.3 | Ceiling / Attic, Wall, Floor and Rim Joist Insulation |
| 2.7.1 | Pool Pump Load Shifting | - | Deleted |
| 2.7.2 | Variable Speed Pool Pumps (with Load Shifting Option) | 2.8.1 | Variable Speed Pool Pumps |
| 5.2 | Direct Load Control and Behavior-based Demand Response Programs | 2.9.1 | Direct Load Control and Behavior-based Demand Response Programs |

## Existing C&I EE&C Measure Protocols

The following sections describe clarifications and modifications to the C&I measure protocols. Some of the proposed changes in our Tentative Order received no stakeholder comments. Those proposed changes, which are not reproduced in the sections to follow, are hereby adopted by the Commission for use in Phase IV. Affected measures include:

* Section 3.1.1 – Lighting Improvements (Measure Consolidation; T12 Linear Fluorescent Baseline Adjustment)
* Section 3.1.3 – Lighting Controls
* Section 3.1.7 – LED Refrigeration Display Case Lighting
* Section 3.2.3 – Water Source and Geothermal Heat Pumps
* Section 3.3.2 – Variable Frequency Drive Improvements (Algorithm Revision; Evaluation Protocols)
* Section 3.3.3 – ECM Circulation Fans (Algorithm Revision – Interactive Factor; Algorithm Revision – Default Motor Watts)
* Section 3.4.1 – Heat Pump Water Heaters (Coefficient of Performance Adjustment Factors; Algorithm Changes)
* Section 3.4.2 – Low-flow Pre-rinse Sprayers for Retrofit Programs (Load Shapes; Flow Rate and Usage Duration)
* Section 3.4.4 – Fuel Switching: Electric Resistance Water Heaters to Gas/Oil/Propane
* Section 3.5.2 – High-efficiency Evaporator Fan Motors for Reach-in Refrigerated Cases (Merge with High-efficiency Evaporator Fan Motors for Walk-In Refrigerated Cases Measures)
* Section 3.5.3 – High-efficiency Evaporator Fan Motors for Walk-in Refrigerated Cases
* Section 3.5.8 – Variable Speed Refrigeration Compressor (Algorithm Revision)
* Section 3.5.9 – Strip Curtains for Walk-in Freezers and Coolers
* Section 3.5.12 – Door Gaskets for Walk-in and Reach-in Coolers and Freezers
* Section 3.5.13 – Special Doors with Low or No Anti-Sweat Heat for Low Temp Cases
* Section 3.5.15 – Refrigerated Display Cases with Doors Replacing Open Cases (Default Values; Algorithm Revision)
* Section 3.7.1 – High-efficiency Ice Machines (Minimum Efficiency Requirements; Duty Cycle; Coincidence Factor)
* Section 3.7.2 – Controls: Beverage Machine Controls (Eligibility)
* Section 3.7.3 – Controls: Snack Machine Controls
* Section 3.7.4 – ENERGY STAR Electric Steam Cooker (Coincidence Factor; Default Demand Savings; Default Energy Savings)
* Section 3.9.1 – ENERGY STAR Office Equipment (Computer Measures Update; Fax Machine Deemed Savings Value and Measure Life; Monitor Deemed Savings and Measure Life)
* Section 3.10.1 – Cycling Refrigerated Thermal Mass Dryer (Coincidence Factor; Default Savings)
* Section 3.10.2 – Air-Entraining Air Nozzle (Hours of Operation; Coincidence Factor)
* Section 3.10.3 – No-loss Condensate Drains (Coincidence Factor)
* Section 3.10.4 – Air Tanks for Loads / No Load Compressors (Hours of Operation; Coincidence Factors)
* Section 4.1.1 – Automatic Milker Takeoffs
* Section 4.1.2 – Dairy Scroll Compressors
* Section 4.1.4 – Heat Reclaimers

The following sections describe clarifications and modifications to the C&I measure protocols. Stakeholder comments regarding the Commissions proposed changes are addressed below. C&I measures in the 2016 TRM that are not discussed in our Final Order or in our Tentative Order have been included in the 2021 TRM without any changes.

### Section 3.1.1 – Lighting Improvements[[59]](#footnote-60)

#### Measure Life

The Commission proposed assuming different measure lives for Type A, Type B, and Type C linear LEDs. Type A linear LEDs use integrated drivers and are designed to work with a linear fluorescent lamp ballast. Type B linear LEDs also use integrated drivers but are designed to work directly on mains voltage. Type C linear LEDs operate off remote LED drivers, but the low-voltage outputs of the drivers are connected to sockets as opposed to the mains voltage, as is the case for Type B equipment. Because of these differences, Type A equipment is assumed to have diminished longevity due to the reliance on an existing (or new) linear fluorescent lamp ballast. Therefore, a measure life of five years is proposed for Type A equipment and a measure life of 15 years is proposed for Type B and Type C equipment.

##### Comments

Duquesne comments that the proposed differentiation of four-foot tube types for discrete assignment of EUL, specifically addressing “Type A” LED linear fluorescent replacements, is based on flawed assumptions, would require changes to the tracking system, and should not be accepted. Duquesne Comments at 4.

##### Disposition

The Commission disagrees with Duquesne’s opinion that the proposed differentiation of four-foot tube types for discrete assignment of EUL, specifically addressing “Type A” LED linear fluorescent replacements, is based on flawed assumptions. We, however, have made the following revision to this measure. “Type A” LED linear fluorescent replacements are dependent on an existing, compatible fluorescent lamp ballast to function. While it may be true that many or even most participants would replace their ballasts upon failure, failure of existing equipment upon which a measure relies to yield savings effectively ends the measure life. Nevertheless, we acknowledge that the proposed five-year EUL is somewhat arbitrary and have therefore increased the EUL for “Type A” equipment to seven years consistent with the estimated remaining useful life of existing electronic ballasts based on field data cited by Southern California Edison.

#### General Service Lamp Baseline Adjustment

The Energy Independence and Security Act of 2007 (EISA) “backstop” provision introduced new efficacy standards for general service lamps (effective January 1, 2020) effectively requiring a minimum efficacy of 45 lm/W for most general service lamps. This will induce a shift in what a participant would have purchased in the absence of the program because standard and halogen incandescent lamps will no longer be viable options. Because of this, the Commission proposed the use of a generic general service lamp with an efficacy of 45 lm/W as the assumed baseline for screw-based lighting retrofit beginning in PY13. The comparable baseline for any removed incandescent lamps will be a generic general service lamp with similar lumen output. The assumed generic general service lamp baseline lamps / fixtures and wattages associated with the most common incandescent lamp / fixture configurations are presented in the new table titled Assumed Generic GSL Baseline Lamps / Fixtures for Removed Incandescent Lamps / Fixtures.

##### Comments

Duquesne comments that it is premature to shift to a 45 lm/W baseline in the 2021 TRM as the EISA 2007 backstop was never “triggered” and that the U.S. DOE did not have the legal authority to amend the definitions of General Service Lamps and General Service Incandescent Lamps. Duquesne Comments at 5-6.

##### Disposition

In the absence of a final ruling from the U.S. DOE, rescinding the 45 lm/W baseline, the Commission disagrees with Duquesne’s comment. As recent public comments on the NOPR have shown, this proposal is heavily contested by all, except the product manufacturers and their trade organizations.[[60]](#footnote-61) Furthermore, should the U.S. DOE follow through with the proposed withdrawal, it is likely that litigation will continue for months, if not years.

#### Hours of Use

The Commission proposed updating the hours of use (HOU) for Exterior (All Building Types) from 3,833 to 3,604 hours and Parking Garages from 6,552 to 8,678 hours in both the Lighting HOU and CF by Building Type for Screw-Based Bulbs and Lighting HOU and CF by Building Type for Other General Service Lighting tables based on more recent sources or newer versions of the current data sources.

##### Comments

Duquesne comments that the proposed adjustment to exterior lighting hours of operation is too low and recommends a value of 4,305 darkness hours based on the 2019 U.S. Naval Observatory. Duquesne Comments at 4-5. PPL recommends adding to Tables 3-5 and 3-6 a “24/7 convenience/retail store” building type with 8,760 hours of use. PPL Comments at 6.

##### Disposition

The Commission acknowledges Duquesne’s comment but notes that a value of 4,305 would only be appropriate if the exterior lighting in question is photocell controlled and operates from dusk-to-dawn. As a result, we have updated the measure protocol to assume 4,305 hours of use where photocell control is present and 3,604 hours in other cases. The Commission disagrees with PPL’s recommendation. The measure protocol already includes a mechanism for using custom hours of use in certain cases. As described in our tentative order, “If the project cannot be described by the building type categories listed in Table 3-5 and Table 3-6, or if the facility’s actual lighting hours deviate by more than 10% from the tables, or if the project retrofitted only a portion of a facility’s lighting system for which whole building hours of use would not be appropriate, the deemed HOU and CF assumptions can be overridden by inputting custom operating schedules into the Lighting Operation Schedule portion of the “General Information” tab of Appendix C. The custom schedule inputs must be corroborated by an acceptable source such as posted hours, customer interviews, building monitoring system (BMS), or metered data.” The custom treatment of this scenario, and the associated documentation requirements, are intended to reduce potential misuse of an hours of use value approaching 8,760.

#### Coincidence Factor

The Commission proposed updating the coincidence factors (CF) for Exterior (All Building Types) from 0.00 to 0.11; Industrial Manufacturing – 1 Shift, Industrial Manufacturing – 2 Shift, and Industrial Manufacturing – 3 Shift from 0.57 to 0.96; Multifamily Common Areas from 0.62 to 0.73; and Parking Garages from 0.62 to 0.98 in both the Lighting HOU and CF by Building Type for Screw-Based Bulbs and Lighting HOU and CF by Building Type for Other General Service Lighting tables based on more recent sources or newer versions of the current data sources.

##### Comments

PPL recommends adding a “24/7 convenience/retail store” building type with 1.0 coincidence factor to Tables 3-5 and 3-6. PPL Comments at 6.

##### Disposition

The Commission disagrees and rejects PPL’s recommendation. See the related discussion on “Hours of Use” within this measure subsection for more details. Upon further review of this measure in relation to the comment above, Commission has corrected the coincidence factor for the Industrial Manufacturing – 1 Shift building type to 0.50. This reflects the fact that single-shift facilities typically operate from 8:00 am to 4:00 pm or 7:00 am to 3:00 pm.

#### General

Additional comments were received unrelated to the changes proposed by the Commission. These comments are discussed below.

##### Comments

PPL requests clarification of the basis for disconnected lighting wattage in Table 3-10 and requests the addition a footnote to this table providing this clarification. PPL Comments at 6. FirstEnergy comments that the factors in Table 3-4 for daylighting controls (interior daylight dimmers) should be scalable to the operating hours of the facility explaining that the longer the facility runs (especially outside of daylight hours) the lower this savings factor will be. FirstEnergy Comments at 8. EAP comments propose to combine 3.1.1 and 3.1.7 so that TRM measure selection and TRM savings estimation is independent of implementation method and to include “composite” inputs to savings algorithm. EAP Comments at 5-37.

##### Disposition

Regarding PPL’s request for clarification on Table 3-10, the disconnected lighting wattage was adopted from the Missouri Technical Reference Manual.[[61]](#footnote-62) According to that document, the default wattage reductions are based on averaging the savings from moving from a 2 to 1, 3 to 2, and 4 to 3 lamp fixtures, as provided in the Southern California Edison Standard Performance Contract Procedures Manual: Appendix B: Table of Standard Fixture Wattages. Further, the source notes that an adjustment was made to the T8 delamped fixture to account for the significant increase in ballast factor. Based on that, the Commission has updated the manual to reflect this source. Regarding FirstEnergy’s comment on daylighting controls savings factors, the Commission acknowledges that the actual savings from daylighting controls will vary from site-to-site depending on a variety of factors including, but not limited to, the site-specific lighting schedules. However, the factor in the 2021 TRM represents a trade-off between usability and accuracy. Furthermore, the Appendix C Lighting Audit and Design Tool already allows for the use of custom lighting control savings factors, where appropriate documentation exists.

The Commission disagrees and rejects EAP’s suggestion to combine measure protocols for 3.1.1 and 3.1.7. There are practical differences between applying downstream and midstream measure protocols. For example, the midstream approach employs a lamps-lumen equivalence methodology that would be inappropriate in many cases for downstream measures. Where possible and appropriate, the two measure protocols already use consistent assumptions. Regarding EAP’s proposal to include “composite” inputs to the savings algorithm, the Commission acknowledges the intended, stated goals of increased program delivery options and streamlined program processes. However, the composite inputs would greatly reduce savings accuracy on a project-level basis and increase the risk of potential misuse. In particular, even within the “form factor” categories presented in EAP’s comments, there is significant variation in delta watts depending on the specific baseline and efficient fixture types and technologies. Under EAP’s proposed approach, the same “delta watts” could conceivably be applied to LEDs replacing high output HID fixtures and LEDs replacing relatively low-wattage track lighting as both would be considered “Other General Service.”

More specifically, the proposed inputs for screw-in lamps are based on historical evaluation-verified data and have not been adjusted for potential impacts of the EISA 2007 “backstop” requiring a minimum efficacy of 45 lumens per watt for General Service Lamps sold as of January 1, 2020. For example, the baseline wattage for “Screw-Based” lamps as presented in the EAP comments is 55 watts. As of January 1, 2020, a 75-watt incandescent-equivalent federal standards-compliant lamp, one of the most common lamps, will only consume a maximum of 28 watts. Clearly, basing the baseline wattage on historical data that does not consider the impending standards change will greatly exaggerate savings.

In addition, the use of a single hours of use value for each lighting “form factor” as opposed to building type would greatly reduce savings accuracy on a project‑specific basis; clearly, there are significant differences, for example, between a public service facility with 1,419 hours of use and 3-shift manufacturing facility with 6,631 hours of use, but these could both use 5,341 hours under EAP’s proposed approach. EAP’s proposed value of 5,000 hours of use when building type and equipment type are unknown is particularly concerning as there is a very low barrier to collecting such basic project information. Finally, the proposed approach has the potential to greatly reduce the collection of lighting project data—data of significant value to program planning activities. The Commission is concerned that establishing such a generous default value would significantly discourage CSPs from collecting data as the data collection would typically lower project savings. However, as these issues are of less concern for street lighting, the Commission agrees and has included the composite inputs proposal for this form factor but rejects the methodology for screw-based and other general service form factors. We have updated the manual to reflect the default “DeltakW” for street lighting measures. See related discussion in Section 1 of this Order.

### Section 3.1.2 – New Construction Lighting[[62]](#footnote-63)

The Commission proposed updating the maximum lighting power densities and common space types presented in the Lighting Power Densities from ASHRAE 90.1-2007 Building Area Method, Lighting Power Densities from ASHRAE 90.1-2007 Space-by-Space Method and Baseline Exterior Lighting Power Densities tables to reflect the requirements in the 2015 International Energy Conservation Code (IECC), the current statewide Pennsylvania energy code. We also proposed to update the values in the Default Baseline Savings Control Factors Assumptions for New Construction Only table to reflect the fact that 2015 IECC requires lighting controls in additional space types relative to the previous code, 2009 IECC.

#### Comments

FirstEnergy comments that emergency fixtures and exit signs should be included in the list of lighting that does not need to be included in a detailed inventory list for new construction projects. FirstEnergy Comments at 8.

#### Disposition

The Commission agrees with FirstEnergy’s recommendation. Emergency lighting and exit signs do not need to be included in the detailed lighting inventory for the purposes of determining lighting power density. We have made this change in the manual.

### Section 3.1.5 – LED Exit Signs[[63]](#footnote-64)

See discussion in Section F.2. regarding baseline savings control factors.

#### Comments

EAP comments propose the inclusion of “composite” inputs to savings algorithm. EAP Comments at 5-37.

#### Disposition

The Commission agrees with EAP comments and has incorporated the composite inputs proposal for the exit sign form factor. See related discussion in Section F.1.G of this Order.

### Section 3.1.6 – LED Channel Signage[[64]](#footnote-65)

The Commission proposed limiting the application of this measure to red LED systems. The referenced research suggests that savings are minimal for other LED lighting colors. We also proposed changing the savings algorithm for this measure protocol to include sign length. As a result, the inputs for the kW of baseline (pre‑retrofit) lighting (kWbase) and kW of post-retrofit or energy-efficient lighting system (kWee) are expressed on a per linear foot of signage basis. This update is the result of using updated sources for the baseline and efficient case power consumption. Previously, the baseline and efficient lighting power consumption were expressed on a per letter basis and differentiated by two sign height categories.

#### Comments

PECO comments that measure eligibility should not be limited to red-colored signs and that the statement in the TRM that other colors do not save energy is not adequately supported. PECO recommends that color-agnostic criteria be used instead. PECO Comments at 10.

#### **Disposition**

The Commission agrees with PECO’s recommendation. The statement that only LED retrofits for red-colored signs achieve energy savings was based on a California study from 2008. LED technology has advanced considerably since then, and it is likely that LED products now exist that compete with other sign colors. The TRM has been updated to remove the eligibility limitation to red LED systems and now allows custom kWbase and kWee values consistent with EDC data gathering. We have made the appropriate changes and the default kWbase and kWee values are now limited to red LED systems consistent with the underlying source.

### Section 3.2.1 – HVAC Systems[[65]](#footnote-66)

The Commission proposed updating the baseline equipment efficiencies (IEERbase, EERbase, SEERbase, COPbase, HSPFbase) to be consistent with current federal standards requirements or the 2015 IECC, whichever is more stringent. Federal standards and the 2015 IECC do not establish post‑January 2, 2023, minimum EER requirements for air‑source air conditioners and heat pumps. We also proposed establishing minimum EER requirements using the average EER of units meeting minimum IEER requirements, by type and size category, from the Air-Conditioning, Heating, and Refrigeration Institute Directory of Certified Product Performance.

#### Comments

FirstEnergy comments that in Table 3-21, the existing heating equation for new construction PTHP is presented as “3.7 - (0.052 x Cap / 1,000) COP” but the equation in IECC 2015 is “3.2 - (0.026 x Cap / 1,000) COP.” FirstEnergy Comments at 8.

#### Disposition

The Commission agrees with FirstEnergy’s comment and provides the two following clarifications. Regarding the equation for the heating baseline for the new construction PTHP, in this case, the federal standards exceed and therefore supersede the 2015 IECC requirements for the baseline equipment. Also, we have updated the source for the baseline heating requirement to reference the federal standards. In addition, the Commission notes that the Tentative 2021 TRM did not define the term “Cap” used on the calculation. Therefore, we have updated Table 3-27 to add the following table note, “Cap represents the rated cooling capacity of the product in Btu/h. If the unit’s capacity is less than 7,000 Btu/h, 7,000 Btu/h is used in the calculation. If the unit’s capacity is greater than 15,000 Btu/h, 15,000 Btu/h is used in the Calculation.”

### Section 3.2.2 – Electric Chillers[[66]](#footnote-67)

The Commission proposed updating the baseline equipment efficiencies (kW/tonbase, EERbase, IPLVbase) to be consistent with the 2015 IECC requirements.

#### Comments

Franklin Energy comments that heat recovery chillers would also qualify as non‑standard applications for the purposes of measure eligibility and that chillers using glycol will need to use adjustment factors in the savings calculations. Furthermore, Franklin Energy recommends that the savings algorithms be multiplied by the following, “× GCC × GPC,” where GCC is the Gylcol Capacity Correction and GPC is the Gylcol Power Correction Factor. Franklin Energy Comments at 276.

#### Disposition

The Commission agrees with Franklin Energy’s first comment that states heat recovery chillers are non-standard applications. However, we disagree with Franklin Energy’s recommendation to revise the savings algorithms but have modified the measure protocol to indicate that chiller applications using glycol must follow a site‑specific protocol.

### Section 3.2.4 – Ductless Mini-split Heat Pumps – Commercial < 5.4 Tons[[67]](#footnote-68)

The Commission proposed updating the baseline efficiencies (HSPFb, SEERb) for ductless mini-split heat pumps (DHP) for consistency with the available ductless mini-split heat pumps with the lowest efficiency listed in the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Directory of Certified Product Performance. We also proposed updating the baseline efficiencies for air-source heat pumps (ASHP), packaged terminal heat pumps (PTHP), packaged terminal air conditioners (PTAC), and central air conditioners for consistency with 2015 IECC or federal standards, whichever is more stringent.

#### Comments

FirstEnergy comments that in Table 3-40, the HSPFb equation for new construction PTHP is presented as “3.7 - (0.052 x Cap / 1,000) COP,” but the equation in IECC 2015 is “3.2 - (0.026 x Cap / 1,000) COP.” Furthermore, FirstEnergy comments that in Table 3-40, the units of HSPF are the same as EER; however, the PTHP replacement and new construction baseline units are in units of COP. FirstEnergy recommends that the PTHP equations should be multiplied by 3.412 to convert them to the same units of EER and have consistent units with the savings equations. The new equations would be as follows: PTHP (Replacements): (2.9 - (0.026 x Cap / 1,000)) x 3.412 HSPF and PTHP (New Construction): (3.7 - (0.052 x Cap / 1,000)) x 3.412 HSPF. In addition, FirstEnergy comments that in Table 3-40, HSPFb for Standard ductless mini-split heat pumps minimum efficiencies for split systems is described by ENERGY STAR in Source 2 as 8.5, but Table 3-40 has a value of 8.2. FirstEnergy Comments at 9.

#### Disposition

The Commission disagrees with all recommendations made by FirstEnergy on this measure protocol. Regarding the equation for HSPFb for “PTHP (New Construction),” in this case, the federal standards exceed and therefore supersede the 2015 IECC requirements for the baseline equipment. Regarding the heating efficiency metric inconsistency, the measure protocol already includes the recommended revision as part of Footnote 31. Finally, regarding the apparent disparity between the baseline heating efficiency requirements for Standard ductless mini-split heat pumps, the ENERGY STAR value of 8.5 noted in FirstEnergy’s comment is the minimum ENERGY STAR requirement, not the baseline requirement. The baseline efficiency is established assuming the lowest efficiency currently available in the Air-Conditioning, Heating, and Refrigeration Institute directory of available ductless mini-split heat pumps and corresponding efficiencies as described in Source 5 of the measure protocol.

### Section 3.2.5 – Fuel Switching: Small Commercial Electric Heat to Natural Gas / Propane / Oil Heat[[68]](#footnote-69)

See discussion in Section F.5 regarding baseline efficiency changes.

#### Comments

PECO comments that billing analysis is an appropriate option for determining measure savings but should not be mandatory. PECO Comments at 10.

#### Disposition

The Commission disagrees with PECO’s comment that billing analysis is an appropriate option for determining measure savings but should not be mandatory. As stated in the 2021 TRM at 83, “EDCs *may* [emphasis added] use billing analysis using program participant data to claim measure savings, in lieu of using the defaults provided in this measure protocol.” Billing analysis is only intended to be an option. Billing analysis is not mandatory.

### Section 3.2.6 – Small C&I HVAC Refrigerant Charge Correction[[69]](#footnote-70)

In the prior TRM, the algorithm for peak kW reduction (ΔkWpeak) for heat pumps omitted the RCF factor from the equation. The Commission proposed correcting the algorithm to include this factor. The Commission also proposed to change the baseline efficiency, as discussed in Section F.6., above.

#### Comments

PECO requests that Table 3-44 be clarified, as follows: (1) indicate that “orifice” means a “non-TXV” unit and (2) that the three columns of “% of nameplate charge added (removed)” are the independent variables. PECO Comments at 10.

#### Disposition

The Commission agrees with PECO’s recommendation and has made appropriate revisions to Table 3-44.

### Section 3.2.7 – ENERGY STAR Room Air Conditioner[[70]](#footnote-71)

The Commission proposed reducing the measure life from 12 years to nine years based on the most current EUL in the California DEER. We also proposed using CEER as the exclusive efficiency metric in both energy and peak demand savings algorithms. Previously, EER could be used if CEER was not available. In addition, the Commission proposed introducing the EFLHRAC-CAC factor in the energy savings algorithm to account for the fact that room air conditioners are used far less frequently than the central systems the cooling equivalent full load hours were developed to represent. Furthermore, the federal standard CEER for units with louvered sides and a capacity from 25,000 to 27,999 Btu/h was incorrectly transcribed in the 2016 TRM as 9.0. The Commission proposed correcting this to the actual value from the federal standard, 9.4.

#### Comments

FirstEnergy requests clarification of the description of CEERbase in Table 3-45 to read as follows, “New Construction or Replace on Burnout: Default Federal Standard values from Table 3-46 to Table 3-48.” FirstEnergy Comments at 9. PECO notes that they were unable to find justification for the proposed addition of a 31% EFLHRAC-CAC multiplier in the referenced source, and requests additional support for this factor. PECO Comments at 10.

#### Disposition

In response to FirstEnergy’s request to clarify the description of CEERbase in Table 3-45, the Commission has updated the description of CEERbase to read “New Construction or Replace on Burnout: Default Federal Standard values from Table 3-46 to Table 3-48.” The Commission also agrees with PECO’s statement that they were unable to find justification for the proposed addition of a 31% EFLHRAC-CAC multiplier in the referenced source and has provided additional documentation for this factor in the measure protocol. The factor was adopted from the 2019 version of the Illinois Statewide Technical Reference Manual v7.0 for the “ENERGY STAR and CEE Super-Efficient Room Air Conditioner” measure. In that document, the justification for the factor is described as follows, “Full load hours for room AC is significantly lower than for central AC. The average ratio of FLH for Room AC (provided in RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008)) to FLH for Central Cooling for the same location (detailed in the ENERGY STAR Room Air Conditioner Savings Calculator) is 31%. The Commission has applied this ratio to the FLH from the unitary and split system air conditioning measure.”

### Section 3.2.9 – Controls: Economizer[[71]](#footnote-72)

See discussion in Section F.5 regarding baseline efficiency changes. The Commission proposed adding a second set of algorithms specifically for the retrofit measure vintage. The algorithm will remain unchanged for the replace-on-burnout and new construction measures. One of the inputs to the proposed algorithm for retrofit measures was drawn from the 2018 Pennsylvania Non-Residential Baseline Study.

#### Comments

FirstEnergy recommends the retrofit kWh algorithm have the option to use EER, SEER, or IEER as the efficiency metric and not just be limited to using kW/ton. FirstEnergy Comments at 9.

#### Disposition

The Commission agrees with FirstEnergy’s recommendation and has updated the measure protocol to allow the use of EER, SEER, or IEER as the efficiency metric.

### Section 3.3.1 – Premium Efficiency Motors[[72]](#footnote-73)

The Commission proposed to update the default load factor value of 0.75 for all HVAC motors to 0.76 for motors driving HVAC fans and 0.79 for motors driving HVAC pumps. These values were derived through a metering study that incorporated an array of different in-service HVAC motors. Increasing the load factor default values will increase the level of savings associated with these measures by the ratio of the proposed load factors to the original default load factor of 0.75.

#### Comments

FirstEnergy comments that the default load factor for pumps in the Appendix D calculator (0.78) was not aligned with the default load factor for pumps in the TRM Section 3.3.1 (0.79). FirstEnergy Comments at 5.

#### Disposition

In response to FirstEnergy’s comment, the Commission reviewed the references for this measure and determined that 0.79 is the correct value and has updated the Appendix D calculator accordingly.

### Section 3.3.2 – Variable Frequency Drive (VFD) Improvements[[73]](#footnote-74)

Energy codes increasingly require VFD control for HVAC fans and pumps. The 2015 IECC, effective in Pennsylvania for work construction permits issued on October 1, 2018, or later, specifies motor control requirements that can only be satisfied by VFDs for several equipment types, including fans serving multiple zones and hydronic system pumps with a combined motor capacity of 10hp or larger. The Commission proposed updating the eligibility criteria for this measure to specifically state that VFD equipment installed according to code requirement is not eligible for incentives.

#### Comments

PECO suggests adding additional clarification on the metering requirements for projects with savings expected to exceed 250,000 kWh. PECO also suggests adding additional emphasis to the metering requirements in the measure description. PECO Comments at 10.

#### Disposition

The Commission agrees with PECO’s first suggestion and has added additional clarifying text and a reference to Section 1.3.3 End-use Categories & Thresholds for Using Default Values. However, we do not agree with PECO’s suggestion to add additional emphasis in the measure description, as this part of the measure protocol is unchanged from prior versions of the TRM and the current format aligns with other measures where thresholds apply.

### Section 3.3.3 – ECM Circulating Fan[[74]](#footnote-75)

The Commission did not propose changes to this protocol regarding eligibility or the expansion of the savings algorithms. However, comments were received and are addressed below.

#### Comments

Franklin Energy asks whether this measure applies to exhaust fans. Franklin Energy also comments that some air handling units provide ventilation air outside of space conditioning requirements, such as in the case of hospital fan coil units that may introduce fresh air as required by building codes. Franklin Energy Comments at 344 and 345.

#### Disposition

In response to Franklin Energy’s inquiry, the Commission notes that the measure does not apply to exhaust fans. The Commission agrees with Franklin Energy that circulating fans providing ventilation air should be included in this measure. Therefore, the Commission has added additional algorithms for fans providing ventilation but did not define default hours of operation for ventilation. EDCs claiming savings for a fan in ventilation-only mode must determine the appropriate hours of operation for that mode.

### Section 3.3.4 – VSD on Kitchen Exhaust Fan[[75]](#footnote-76)

The Commission proposed revising the energy savings and peak demand savings per total exhaust fan horsepower for this measure. The 2016 TRM incorporates values taken directly from a Pacific Gas & Electric (PG&E) work paper, which has since been updated and now incorporates reduced per unit savings values. The Commission proposed updating the TRM, reducing energy savings to 4,423 kWh per exhaust fan horsepower, a 1% reduction. The Commission also proposed reducing the coincident peak demand savings to 0.55 kW per exhaust fan horsepower, a 27% reduction.

#### Comments

FirstEnergy comments that the New Construction Measure Vintage was missing. FirstEnergy Comments at 9.

#### Disposition

The Commission agrees with FirstEnergy’s suggestion and has added New Construction to the list of eligible Measure Vintages.

### Section 3.4.1 – Heat Pump Water Heaters[[76]](#footnote-77)

#### Load Shapes

The Commission proposed to update the load shapes for the entire Water Heating section. Proposed load shapes are created from building-type specific daily load schedules provided by the U.S. DOE’s *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Water Heating Equipment*.[[77]](#footnote-78) From these load shapes, new Energy to Demand Factors are created based on the Act 129 peak demand definition.

##### Comments

FirstEnergy requests the inclusion of units for the ETDF values in Table 3-83. FirstEnergy Comments at 6.

##### Disposition

In response to FirstEnergy’s comment, the Commission notes that ETDF values are described in Table 3-85 as unitless. This assumption is carried throughout the manual and can explain the absence of units in Table 3-83.

#### Unknown Installation Location

The Commission proposed to provide an option for savings calculations when water heater installation location is unknown. The Commission provided default savings values for the unknown installation and allowed the EDCs to calculate the building-type and install-location specific values when relevant.

##### Comments

PECO requests clarity in the derivation of the default energy savings. There is a drastic distinction between large and small default savings, and the company wants further explanation. PECO Comments at 5.

##### Disposition

In response to PECO’s request, the Commission notes that the default energy savings are calculated by plugging default values into the savings algorithms. Default values for each component of the algorithms are provided in the case that details are unknown. These input values are provided in Tables 3-83, 3-84, 3-85, and the text above Table 3-87. Entering default values into the first equation will provide the values denoted in Table 3-87. Since the default information is available to the user for calculations, we do not include this in the text. However, in order to provide clarity, we have provided the calculations below for large and small default units.

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The distinctions between small and large default values arise only from the differences between the proposed and baseline UEF values. The Commission recommends adjusting these inputs for any known values rather than using defaults.

#### Uniform Efficiency Factors

The Commission proposed updating the UEF to meet current U.S. Federal Standards for Residential Water Heaters. New formulas are provided by tank size for both baseline and proposed units.

##### Comments

PECO and FirstEnergy note that the variable Vr in Table 3-86 is not defined. PECO Comments at 5 and FirstEnergy Comments at 6.

##### Disposition

The Commission agrees with PECO’s and FirstEnergy’s recommendation and has adjusted the table, as well as the neighboring text, to clarify that Vr indicates Rated Storage Volume. These adjustments clarify that the volume of the water heater should be plugged into the appropriate equation to calculate the Uniform Energy Factor.

### Section 3.4.2 – Low-flow Pre-rinse Sprayers for Retrofit Programs[[78]](#footnote-79)

#### Merge of Low-flow Pre-rinse Sprayer Measures

The Commission proposed to combine Sections 3.4.2 and 3.4.3. These measures relate to the same product improvement but have minor differences relating to product application. To account for this merger, the proposed algorithms are simplified and generalized to allow for application specific inputs. We also proposed to provide an option for savings calculations when installation location is unknown.

##### Comments

FirstEnergy recommends that the eligibility requirements be adjusted to match the source and remove the cleanability performance component. FirstEnergy Comments at 6.

##### Disposition

The Commission agrees with FirstEnergy’s recommendation and has removed the plate cleaning performance requirement. The eligibility is now aligned with the Energy Policy Act source and requires only that the replacement sprayers use less than 1.6 gallons per minute.

#### Measure Life

The Commission proposed updating the Pre-rinse Sprayer measure life to reflect a more recent estimate as reported in DNV-GL’s *Impact Evaluation of Massachusetts Prescriptive Gas Pre-rinse Spray Valve Measure* from 2014.[[79]](#footnote-80) This impact study guides our recommendation of an eight-year measure life.

##### Comments

FirstEnergy notes that the measure life for Pre-rinse Spray Valves is five years in the source provided. FirstEnergy Comments at 6.

##### Disposition

The Commission disagrees with FirstEnergy’s comment regarding measure life. While the Massachusetts TRM does technically use five years for the measure life of the Pre-rinse Spray Valves, the report includes a recommendation to adjust this measure life. The source includes three reasons for a proposed adjustment to eight years: a survey, forensic inspection of old units, and specific technological improvements of new units that support longer lifetimes than the existing units.

#### Uniform Energy Factor

The Commission proposed a standard UEF for existing water heaters based on results from the Act 129 2018 Pennsylvania Non-Residential Baseline Study. The study suggests a UEF of 0.90 for existing C&I Water Heating units.

##### Comments

Franklin Energy comments that the (UEF) for electric water heaters seems low. They provided the Illinois TRM source, which uses 97% to support this proposed change. Franklin Energy Comments at 364.

##### Disposition

The Commission disagrees with Franklin Energy and declines to change the UEF for electric water heaters on the basis that replacement of Pre-rinse Spray Valves does not necessarily occur at the same time as replacement of water heaters. The suggested 97% value originates from a code minimum, but spray valves can be replaced with existing water heaters, which tend to have lower levels of efficiency than new regulation minimums. The 90% UEF value was calculated from the baseline study of Pennsylvania C&I sites and represents 2018 average efficiency values in the region. Therefore, the Commission chooses to maintain the 90% UEF value.

#### Additional Comments

In addition to the comments described in this protocol, other comments were received that do not relate to a specific proposed change. These comments are addressed below.

##### Comments

FirstEnergy notices some unclear practices in the handling of ETDF values and references. Specifically, there is an issue in Table 3-89 where default ETDF values are shown to be in Table 3-83 rather than Table 3-88. Additionally, the ETDF value used for the calculation of Retrofit: Food Service appears to come from an ETDF table in a previous section. FirstEnergy Comments at 6. Franklin Energy proposes a modification of days per year from 365 to 312 to match the six days per week from the Illinois TRM and also notes the idea that efficient Pre-rinse Spray Valves should reduce the amount of water used yet maintain the time of use. With specific references to the Illinois TRM and Ohio TRM, Franklin supports using a constant time of use for baseline and efficient spray valves based on type of business. Franklin Energy Comments at 364, 365. PECO requests an adjustment to the text that clarifies which defaults should be used in the case of unknown installation location. PECO Comments at 5.

##### Disposition

The Commission agrees with FirstEnergy’s recommendation and has updated the ETDF value reference to direct users to the correct ETDF table, Table 3-88, which provides a higher level of granularity in ETDF values than can be found in Table 3-83. We also agree with FirstEnergy’s suggestion to clarify the text describing Table 3-91 and have added detail to explain that all ETDF values originate from Table 3-88, but the ETDF used for Retrofit: Food Service as an average of the provided Full and Quick service ETDF values. The Commission appreciates Franklin Energy’s comment that most businesses are not open every day of the year, but we find that the actual days of operation is closer to the full year than the 312 days recommended. Therefore, we have not modified the assumption of 365 operating days per year. In response to Franklin Energy’s request to use a constant time of use for baseline and efficient spray valves based on type of business, the Commission notes that using Pre-rinse Spray Valves with lower pressure will require an increase in the time used to pre-rinse dishes. The primary source provided by Franklin Energy indicates the number of hours of use by business type for this device. The proposed source was published in 2007 and the study was performed the same year as the provided primary source, 2005. We do not view the evidence for adjustment as sufficient and therefore have not changed the shared time of use values for baseline and efficient spray valves.

The Commission agrees with PECO’s recommendation to clarify the appropriate use case for unknown installation location and has made the appropriate changes. We have updated Table 3-90 and 3-91 to clarify which component should be used in the Unknown case for the Retrofit and Time of Sale programs, and we also modified the text describing Table 3-91 to explain which default should be used in the case of unknown installation setting.

### Section 3.5.1 – High-efficiency Refrigeration / Freezer Cases[[80]](#footnote-81)

The Commission proposed updating the ENERGY STAR Requirements and default efficient kWh values based on the ENERGY STAR Product Criteria for Commercial Refrigerators and Freezers version 4.0. We also proposed to update the default baseline kWh values based on the U.S. DOE’s publishing of a final rule on March 28, 2014, adopting more stringent energy conservation standards for commercial refrigerator and freezers.

#### Comments

FirstEnergy and Franklin Energy both note that the equations for solid door freezers do not match the ENERGY STAR specifications. FirstEnergy Comments at 10 and Franklin Energy Comments at 372.

#### Disposition

The Commission agrees with the comments provided by FirstEnergy and Franklin Energy and has changed the relevant algorithm to match the ENERGY STAR specification.

### Section 3.5.2 – High-efficiency Evaporator Fan Motors for Reach-in Refrigerated Cases[[81]](#footnote-82)

#### Algorithm Revision

The Commission proposed revising the annual energy savings and peak demand savings algorithms for this measure based on the Commercial Refrigeration Loadshape Project, a 2014 research effort from Northeast Energy Efficiency Partnership, Cadmus, and the Demand Management Institute.[[82]](#footnote-83) This research effort examined the annual energy and peak demand savings associated with the installation of evaporator fan motors for reach-in and walk-in refrigerated cases. The updated algorithms will allow for either electronically commutated motors or permanent magnet synchronous motors in the efficient case (rather than just electronically commutated motors). By virtue of revising the savings algorithms, the Commission proposed removing the default savings tables, as some values in the algorithms must be collected by EDCs.

##### Comments

FirstEnergy notes that the algorithms assume a 100% load factor. They recommend adding a load factor, so the calculated motor power matches the measured motor power. FirstEnergy Comments at 10.

##### Disposition

The Commission agrees with FirstEnergy’s recommendation and has added a load factor of 0.90 to the algorithms.

#### Default Values

In updating the sources upon which this measure is based, several default values were either introduced or changed.

##### Comments

FirstEnergy states that the default value for baseline motor efficiency for PSC motors does not match the value given in the source. Additionally, FirstEnergy notes that the waste heat factor should not depend on the baseline existing fan motor. They recommend waste heat factor should depend on the refrigeration temperature and is independent of the equipment installed or removed. FirstEnergy Comments at 10. Franklin Energy suggests that the source information seems high for the “%On\_Uncontrolled” variable. They state evaporator fans will not run when the evaporator is in defrost mode, otherwise it would be increasing the temperature of the space. Franklin Energy Comments at 374.

##### Disposition

In response to FirstEnergy’s comment that the default value for baseline motor efficiency for PSC motors does not match the value given in the source, the Commission disagrees. We note that the baseline motor efficiency for PSC motors and the default value match the source. The relevant table in the source shows an efficiency range of 50‑70% for PSC motors.[[83]](#footnote-84) A midpoint of 60% is used in the TRM. Regarding FirstEnergy’s comment concerning the default values for the waste heat factor and Franklin Energy’s comment concerning the default value for the “%On\_Uncontrolled” variable, the Commission notes that the default values for these inputs are taken directly from the source upon which this protocol is developed. The Commission finds the defaults to be reasonable. No changes were made in response to either comment.

### Section 3.5.4 – Controls: Evaporator Fan Controllers[[84]](#footnote-85)

The Commission proposed updating the measure life of refrigeration evaporator fan controllers with the most current DEER EUL value of 15 years. We also proposed revising the annual energy savings and peak demand savings algorithms for this measure based on the Commercial Refrigeration Loadshape Project, a 2014 research effort from NEEP, Cadmus, and the Demand Management Institute.[[85]](#footnote-86) This research effort examined the annual energy and peak demand savings associated with the installation of evaporator fan controllers for reach-in and walk-in refrigerated cases. The algorithms in the 2016 TRM cite the 2012 Massachusetts TRM, and the sources for many of the default values could not be found upon review in 2018. The default values in the proposed revision draw primarily from the NEEP research effort mentioned herein.

#### Comments

FirstEnergy notes that the algorithms assume a 100% load factor. They recommend adding a load factor so the calculated motor power matches the measured motor power. FirstEnergy Comments at 10. Franklin Energy suggests that the source information seems high for the “%On\_Uncontrolled” variable. They state evaporator fans will not run when the evaporator is in defrost mode, otherwise it would be increasing the temperature of the space. Franklin Energy Comments at 377.

#### Disposition

The Commission agrees with FirstEnergy’s recommendation and has added a load factor into the algorithms (with a default value of 0.90) for this measure. Regarding FirstEnergy’s comment concerning the default values for the waste heat factor and Franklin Energy’s comment concerning the default value for the “%On\_Uncontrolled” variable, the Commission notes that the default values for these inputs are taken directly from the source upon which this protocol is developed. The Commission finds that the defaults are reasonable. No changes were made in response to either comment.

### Section 3.5.5 – Controls: Floating Head Pressure Controls[[86]](#footnote-87)

The Commission proposed updating the default values for the COP for refrigerator / freezer condensing units and remote condensers based on an updated version of the RTF measure upon which these defaults are currently sourced (Grocery Floating Head Pressure Controls for Single Compressor Systems).[[87]](#footnote-88) The most recent version of the RTF measure was updated in 2016; the 2016 TRM draws from a 2010 version of the RTF measure. For condensing units, the proposed COP values are slightly higher. For remote condensers, the proposed COP values are slightly lower. These proposed updates will flow through to the default savings tables included in this protocol.

#### Comments

FirstEnergy states that Source 2 for this protocol in the manual notes that deemed savings estimates for the Pennsylvania weather cities are extrapolated based on deemed savings value for eight cities in the Northwest (using cooling degree days, CDD), and suggests that the use of regression here is improper, as they were unable to find a linear relationship between the deemed savings estimate and the CDD for each city. FirstEnergy Comments at 11.

#### Disposition

The Commission largely rejects FirstEnergy’s comment. There are four sets of savings values to consider in this measure: condensing units in refrigerators, condensing units in freezers, remote condensers in refrigerators, and remote condensers in freezers. For the three sets other than remote condensers in refrigerators, the deemed savings estimates are highly correlated with annual CDD (based on typical meteorological year weather) for the eight cities in the RTF study. For condensing units in refrigerators, the correlation between deemed savings estimate and CDD is -0.94. For condensing units in freezers, the correlation between deemed savings estimate and CDD is also -0.94. For remote condensers in freezers, the correlation between deemed savings estimate and CDD is -0.97. For remote condensers in refrigerators, deemed savings are correlated with annual CDD if two outliers are removed. Since the deemed savings values are strongly correlated with CDD for the other three technologies, we find that it is permissible to ignore the outliers for the fourth technology (remote condensers in refrigerators). The Commission has updated the default savings values for this technology were updated in the TRM based on a new regression model.

### Section 3.5.6 – Controls: Anti-sweat Heater Controls[[88]](#footnote-89)

The Commission proposed revising the annual energy savings and peak demand savings algorithms for this measure based on the Commercial Refrigeration Loadshape Project, a 2014 research effort from NEEP, Cadmus, and the Demand Management Institute.[[89]](#footnote-90) This research effort examined the annual energy and peak demand savings associated with the installation of anti-sweat heater controls. We also proposed making this change for two reasons: (1) The NEEP study is more recent than the sources used in the 2016 TRM and (2) several of the default values in the 2016 TRM could not be verified in 2018. The default values in the proposed revision draw solely from the NEEP research effort mentioned herein.

#### Comments

FirstEnergy notes a typo in the eligibility section. Additionally, FirstEnergy states that the default values for the waste heat factors are off by one decimal. FirstEnergy Comments at 11.

#### Disposition

The Commission agrees with both of FirstEnergy’s recommendations and has updated the typo in the eligibility section and the default waste heat factors.

### Section 3.5.7 – Controls: Evaporator Coil Defrost Control[[90]](#footnote-91)

The Commission did not propose changes to Section 3.5.7 – Controls: Evaporator Coil Defrost Control. However, comments were received and are addressed below.

#### Comments

FirstEnergy notes that the measure uses an EUL of 10 but Source 1 states the only moving part is a relay with an EUL over 15 years. Additionally, FirstEnergy recommends aligning the waste heat factor used in this measure with waste heat factors used elsewhere in the TRM (namely, sections 3.5.2 and 3.5.3). FirstEnergy Comments at 11.

#### Disposition

Responding to FirstEnergy’s statement regarding the ten-year EUL, the Commission finds that this is a conservative estimate based on the expected lifecycles of the components. Regarding FirstEnergy’s comment about waste heat factors, the Commission notes that the waste heat factor values used in this measure are very similar to the values used earlier in Section 3.5 (Commercial Refrigeration). This measure involves a slightly different technology compared to the measures referenced by FirstEnergy; therefore, this comment is rejected.

### Section 3.5.8 – Variable Speed Refrigeration Compressor[[91]](#footnote-92)

The Commission proposed changing the default COP value based on 2009 commercial refrigeration research by the U.S. DOE[[92]](#footnote-93) and based on the Act 129 2018 Pennsylvania Non-residential Baseline Study. The COP value used in the 2016 TRM is based on a 1996 U.S. DOE publication. Additionally, we proposed providing EDCs with a “Data Gathering” option for COP since the default is a blend of reach-in coolers and reach-in freezers.

#### Comments

FirstEnergy recommends providing default COP values for different temperature ranges rather than a single default COP value. FirstEnergy Comments at 11. Franklin Energy recommends using a single source for all COP values in the Refrigeration section of the TRM. Franklin Energy Comments at 389.

#### Disposition

The Commission agrees with FirstEnergy’s suggestion, and has included different default COP values for different temperatures (freezers and refrigerators). The Commission appreciates Franklin Energy’s recommendation to use a single source for all COP values. However, the source used for COP in this section is identical to the source used in Section 3.5.18 of the Pennsylvania TRM. A different source is used for COP in section 3.5.4 (previously 3.5.5). The source used for COP in 3.5.4 is identical to the source used for other inputs in that section (namely, EUL and default savings values per HP).

### Section 3.5.10 – Night Covers for Display Cases[[93]](#footnote-94)

The Commission did not propose changes to Section 3.5.10 – Night Covers for Display Cases. However, comments were received and are addressed below.

#### Comments

FirstEnergy recommends moving the measure description out of the eligibility section. FirstEnergy Comments at 11. Franklin Energy notes that one of the sources is rather old but is consistent with other programs. Franklin Energy Comments at 394. PECO recommends that the TRM include 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. PECO 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. PECO Comments at 11.

#### Disposition

The Commission agrees with FirstEnergy’s suggestion to move the measure description out of the eligibility section and has made changes accordingly. We also agree with PECO’s recommendation to include a default value for annual HOU and have made appropriate changes. In addition, an “unknown” cooler case temperature was added to the default energy savings factor table. However, we do not agree with PECO’s recommendation to change the metric “width of opening” to “quantity of night covers”, as “width of opening” seems better suited here. For example, suppose a 4-foot and an 8-foot cover are installed. Here, the quantity is two and the width is 12. However, if two 8-foot covers are installed, the overall width changes without changing the quantity. Thus, using “quantity of covers” will not always accurately capture the width of the opening.

### Section 3.5.11 – Auto Closers[[94]](#footnote-95)

The Commission proposed updating the default savings values associated with the measure. The default savings values in the 2016 TRM are drawn from auto closer research done in California. The California research provides annual energy savings estimates for each of California’s 16 climate zones. The default savings values in the 2016 TRM are based on savings estimates for California’s climate zone four, which differs substantially from the Pennsylvania climate. (The reference city for climate zone four is San Jose.) Rather than use California climate zone four as a proxy for Pennsylvania’s climate, the Commission proposed using the savings estimates for each climate zone, along with average annual CDD and HDD for each climate zone, to develop a regression model. This model, which predicts energy savings based on annual CDD and HDD, can be used to estimate annual energy savings specific to Pennsylvania’s climate.

#### Comments

Franklin Energy suggests that the discussion on how regression is used to estimate default savings should be moved from the Sources section to the Algorithms section (to be consistent with how this is approached elsewhere). Franklin Energy Comments at 396. PECO recommends using the default savings for coolers as the default savings when it is not known if the auto closers are installed in a cooler or a freezer (e.g., installed in an “unknown” location). PECO Comments at 11.

#### Disposition

The Commission agrees with and therefore has adopted Franklin Energy’s suggestion, to be consistent with how this is approached elsewhere. Although we deem that it is not burdensome to collect information regarding where the auto closers were installed, we have adopted PECO’s recommendation. If the installation location is unknown, EDCs may use the default savings values for coolers that are more conservative than the default savings values for freezers.

### Section 3.5.14 – Suction Pipe Insulation for Walk-in Coolers and Freezers[[95]](#footnote-96)

The default savings values in the 2016 TRM are drawn from suction pipe insulation research done in California. These values were based on savings observed in California climate zone four (San Jose area), which shows little resemblance with Pennsylvania in terms of climate. Rather than use California climate zone four as a proxy for Pennsylvania’s climate, the Commission proposed using the savings estimates for each California climate zone, along with average annual CDD and HDD for each California climate zone, to develop a regression model. This model, which predicts energy savings based on annual CDD and HDD, can be used to estimate annual energy savings specific to Pennsylvania’s climate. This results in an increase in annual energy and peak demand savings.

#### Comments

FirstEnergy suggests that the EUL for this measure is 6.7 years rather than 11 years. FirstEnergy Comments at 11. 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. PECO Comments at 11.

#### Disposition

The Commission disagrees with FirstEnergy’s suggestion that the EUL for this measure is 6.7 years rather than 11 years, as the source noted in the manual indicates an EUL of 11 years. We also find that collecting information regarding the length of the insulation should be part of the requirements to receive program support, therefore have not added a default value for length of insulation.

### Section 3.5.15 – Refrigerated Display Cases with Doors Replacing Open Cases[[96]](#footnote-97)

The Commission did not propose changes to the eligibility component of this protocol. However, comments were received and are addressed below.

#### Comments

FirstEnergy suggests that lighting retrofits should be removed from eligibility, as the description states that lighting should be considered as separate projects. FirstEnergy Comments at 11.

#### Disposition

The Commission finds that the current text in the manual addresses FirstEnergy’s concerns adequately. The eligibility section notes, “If a lighting retrofit is included with the new case, it must consume the same amount of energy or less than the old lighting. Upgrades to lighting or other system components should be processed separately.” Additionally, the measure description notes, “Lighting or other upgrades should be considered as separate projects.”

### Section 3.5.16 – Adding Doors to Existing Refrigerated Display Cases[[97]](#footnote-98)

#### Default Values

The Commission proposed updating the default values associated with this measure. The 2016 TRM references a CLEAResult work paper that is not publicly available. As such, the default values drawn from this source cannot be checked for accuracy. The Commission proposed aligning this measure with a 2010 paper submitted to the International Refrigeration and Air Conditioning Conference, which compares the energy use of doored and open refrigeration display cases.[[98]](#footnote-99) This proposition would result in slightly higher annual energy and peak demand savings.

##### Comments

PECO recommends that the manual include conservative default savings to reduce data requirements. PECO Comments at 11.

##### Disposition

The Commission disagrees with PECO’s recommendation to include conservative default savings to reduce data requirements. The Commission deems that it is not burdensome to collect information regarding the width of the case opening. Default values are provided for all other variables.

#### Algorithm Revision

As noted in Section F.29.a, the Commission proposed aligning this protocol with a research effort that compared energy use in doored display cases and open display cases. This research effort only looked into energy consumption, not peak demand savings. In aligning this protocol with the referenced study, the Commission proposed adjusting the peak demand savings algorithm. The proposed algorithm assumes flat energy savings throughout the 8,760 hours of the year.

##### Comments

Franklin Energy notes that the methodology used herein is based on a comparison of doored display cases and open display cases. However, this measure entails adding doors to refrigerated cases. In addition, Franklin Energy proposes an alternative approach, which is supported by the paper upon which the initial methodology was based on. Franklin Energy Comments at 406.

##### Disposition

The Commission agrees with Franklin Energy’s suggestion and has updated the annual energy savings algorithms with an alternative approach, that is supported by the paper upon which the initial methodology was based on.

### Section 3.6.1 – ENERGY STAR Clothes Washer[[99]](#footnote-100)

#### Testing Procedure

The U.S. DOE test procedures for clothes washers are codified at title 10 of the Code of Federal Regulations part 430, subpart B. The modified energy factor (MEF) for the previous standard was calculated using appendix J1; whereas, the new federal standards use MEFJ2. This new standard is calculated according to the test procedures of Appendix J2. Since the current federal standard, ENERGY STAR standard, and many of the default values now refer to the J2 testing procedure, the Commission proposed updating the algorithms in the TRM to use Appendix J2 MEFs. Adopting the new test procedure changes the federal efficiency standard for both top and front-loading washers. In conjunction with adopting the new testing procedures as described above, the Commission proposed updating the ENERGY STAR Requirements and integrated MEFJ2 values with the ENERGY STAR Product Criteria for Commercial Clothes Washers Version 8 for both top-loading and front-loading washers.

##### Comments

FirstEnergy notes that top-loading machines are included in the descriptions and calculations, but top-loading units do not qualify for ENERGY STAR and therefore do not need to be included in related tables. FirstEnergy Comments at 11.

##### Disposition

We agree with FirstEnergy’s statement that no top-loading commercial washing machines qualify for the ENERGY STAR designation. Given that the measure vintage is replace on burnout, a front-loading washer is the only available ENERGY STAR choice and a code minimum front-loading washer should be used as baseline comparison. The Commission has removed tables that provide default values for replacing a top loading commercial washing machine with an ENERGY STAR appliance.

#### Default Values

The Commission proposed updating the default values for number of loads, maximum load weight, capacity, and dryer usage factor to reflect the new testing procedures. We also proposed to change the measure life to reflect the values in the current federal standard and also to update default values for water heater fuel shares to reflect Pennsylvania-specific findings from the Act 129 2018 Pennsylvania Non-Residential Baseline Study.

##### Comments

FirstEnergy states that in Table 3-126, the MEt and LAF values were not provided in Source 1, and suggests that in Table 3-129 and 3-131, the savings values for “electric hot water heater, gas dryer” and “gas hot water heater, electric dryer” are swapped. Finally, they request verification on the default values of appliances in a laundromat. FirstEnergy Comments at 12.

##### Disposition

The Commission agrees with FirstEnergy’s comment about the source for the MEt and LAF values. These values were mistakenly attributed to Source 1, the federal standard itself, when they should have been attributed to Source 3, the test procedure. Regarding FirstEnergy’s second comment, the Commission verified that the current values for the savings associated with “electric hot water heater, gas dryer” and “gas hot water heater, electric dryer” are correct. The savings associated with using less hot water initially exceed the savings associated with a lower remaining moisture content and thus, less drying energy needed. As such, the savings from an ENERGY STAR commercial washer are greater when the hot water heater is electric than when the dryer is electric. In response to FirstEnergy’s final comment, the Commission has confirmed that the default value of savings for laundromats are correct. In order to qualify for savings, the laundromat must verify that there is an electric fuel component.

### Section 3.7.1 – High-efficiency Ice Machines[[100]](#footnote-101)

#### Measure Life

The Commission proposed a change in the measure life for Ice Machines. The change in measure life from ten years to eight years was proposed to reflect the current measure life utilized by ENERGY STAR.

##### Comments

FirstEnergy proposes the California Public Utilities Commission DEER be used as an alternate source for the measure life. FirstEnergy Comments at 12.

##### Disposition

The Commission disagrees with FirstEnergy’s proposal to consider an alternate source for the measure life. In our tentative order we proposed a change in measure life from ten years to eight years to reflect the current measure life utilized by ENERGY STAR.

#### Baseline Efficiencies

The Commission proposed changes to the baseline efficiencies for the batch-type and continuous-type ice machines. The changes reflect the most recent updates to baseline efficiencies made as part of the Federal Register Final Rule (Energy Conservation Program: Energy Conservation Standards for Automatic Commercial Ice Makers; Final Rule. Federal Register / Vol. 80, No. 18. January 28, 2015). The changes include the revision and addition of categories for the ice harvest rates for both batch-type and continuous-type ice machines, as well as the associated revisions and additions to the algorithms and values for the baseline energy use for these categories.

##### Comments

Franklin Energy suggests including a source link for the Federal Register Final Rule (Energy Conservation Program: Energy Conservation Standards for Automatic Commercial Ice Makers; Final Rule. Federal Register / Vol. 80, No. 18. January 28, 2015). Franklin Energy Comments at 428.

##### Disposition

The link provided by Franklin Energy did not link to the correct document. However, the Commission accepts Franklin Energy’s suggestion to include a source link for the Federal Register Final Rule and has added the correct link to the 2021 TRM list of sources.

### Section 3.7.2 – Controls: Beverage Machine Controls [[101]](#footnote-102)

The Commission proposed a revision to the algorithm used to calculate energy savings for the Beverage Machine Controls measure to account for more specific characteristics of the machine. The change incorporates the use of the wattage of the beverage machine, the annual hours of operation of the machine, and the energy savings factor of the machine. Based on this change in the algorithm, the Commission proposed that the EDC gathers data for the components of the savings algorithm or uses default values provided. We provided default values for two types of machines: refrigerated beverage vending machine and glass front refrigerated cooler. We also proposed default values for wattage and energy savings factors, based on the Illinois Statewide Technical Reference Manual v7.0.

#### Comments

FirstEnergy comments that the savings algorithm assumes the machine is operating at full capacity and that this is not being taken into consideration in the savings algorithm. FirstEnergy also suggests using values from an NREL study that accounts for separate load management and lighting control. FirstEnergy Comments at 12. PECO recommends that when equipment type is unknown, “Refrigerated Beverage Vending Machine” should be used as the default value. PECO Comments at 12.

#### Disposition

The Commission rejects both suggestions from FirstEnergy. The default Watts of the refrigerated machine already assume the cycling of the compressor/refrigeration equipment for a standard machine. The default energy savings factors are used in several other recent TRMs and are based on specific Product Sheets. We also reject PECO’s recommendation to define the equipment type when unknown. The Commission is concerned by the theme in PECO’s comments suggesting basic equipment characteristics not be collected prior to providing program support with ratepayer money.

### Section 3.7.4 – ENERGY STAR Electric Steam Cooker [[102]](#footnote-103)

In response to the FirstEnergy comments of the 2016 TRM Tentative Order,[[103]](#footnote-104) the Commission proposed a change to three default parameters for the electric steam cooker measure. The proposed changes are for the following default parameters: Power Idle (kW), Capacity (lb/hr), and Cooking Energy Efficiency (%). The proposed changes align with the current version of ENERGY STAR’s Commercial Kitchen Equipment Calculator.

##### Comments

FirstEnergy notes that the terms *lbsFood* and *HOURSop* will not have nameplate values as noted in Table 3-143. FirstEnergy also suggests a revision to the location of the parenthesis in the algorithm for *Daily kWhee*. FirstEnergy Comments at 12. Franklin Energy suggests adding the direct link to the ENERGY STAR commercial kitchen equipment calculator to Source 1. Franklin Energy Comments at 436.

##### Disposition

The Commission accepts FirstEnergy’s suggestion regarding the terms *lbsFood* and *HOURSop* and have changed “nameplate” to “EDC Data Gathering” for these values in Table 3-143. The Commission also accepts FirstEnergy’s correction of the location of the parenthesis in the algorithm for *Daily kWhee*, and has made the change. We also accept Franklin Energy’s suggestion to add the direct link to the ENERGY STAR commercial kitchen equipment calculator for Source 1.

### Section 3.8.1 – Wall and Ceiling Insulation[[104]](#footnote-105)

The Commission proposed updating the default initial R values for ceilings and walls in new construction settings from IECC 2009 to IECC 2015. The Commission also proposed removing default initial R values for existing premises since these parameters are collected by the EDCs. Using actual R values rather than default R values will result in more accurate savings calculations.

#### Comments

Duquesne recommends retaining the default values and updating them based on EM&V sampling. Duquesne Comments at 5. FirstEnergy suggests adding a minimum “R\_base” value for existing scenarios (e.g., not new construction), similar to the Residential section. FirstEnergy Comments at 13. PPL recommends updating the table that houses default “R\_initial” values with table C403.1.3 from IECC 2015. PPL Comments at 8.

#### Disposition

The Commission rejects Duquesne’s suggestion. We find that the default values in question do not need to be retained, nor does a minimum need to be added. If the final R value must be measured, then the initial R value will be known. We reject, for the same reason, FirstEnergy’s recommendation to add a minimum “R\_base” value for existing scenarios (e.g., not new construction), similar to the Residential section. However, we accept PPL’s recommendation regarding the table that houses default “R\_initial” values. Table C403.1.3 from IECC 2015 replaced the relevant TRM table in question.

### Section 3.9.1 – ENERGY STAR Office Equipment[[105]](#footnote-106)

The Commission received comments unrelated to the proposed changes discussed in the Tentative Order. These comments are addressed below.

#### Comments

FirstEnergy states that default values listed in Table 3-168 need to be updated to reflect the most recent ENERGY STAR calculator. FirstEnergy Comments at 13.

#### Disposition

The Commission rejects the recommendation from FirstEnergy. The default savings in Table 3-168 reflect the most recent iteration of the ENERGY STAR Qualified Office Equipment savings calculator, as is noted in Source 2 of Section 3.9.1 of the TRM.

### Section 3.9.2 – Office Equipment – Network Power Management[[106]](#footnote-107)

The Commission proposed to update the deemed energy and demand savings and the EUL source for Network Power Management. The previous deemed savings were sourced from an RTF workbook, which has since been retired by the RTF. The updated deemed savings are sourced from the ENERGY STAR Computer Power Management Savings Calculator.

#### Comments

FirstEnergy notes a different default savings value for the measure permutation of “Workstation – Laptop Computer with Monitor” based on the cited ENERGY STAR calculator. FirstEnergy Comments at 13. PECO requests a baseline definition be provided that indicates a baseline condition of networks without management software. PECO Comments at 12.

#### Disposition

The Commission understands the discrepancy noted in FirstEnergy’s comment. This discrepancy is due to a misinterpretation of the measure unit; therefore, we have added a footnote to Table 3-170 to clarify the assumptions of the default savings value. The Commission accepts the baseline definition proposed by PECO, as it is consistent with the default savings assumption, and has added the baseline definition to the Default Savings section of 3.9.2 in the TRM.

### Section 3.9.3 – Advanced Power Strips[[107]](#footnote-108)

#### Measure Name Change and Algorithm Update

The Commission proposed updating the measure name to better reflect current market products. The Commission also proposed updating the algorithm for Advanced Power Strips to provide a simpler calculation approach that requires fewer parameter inputs relative to the prior algorithm. The new algorithm was based on recent research from Massachusetts[[108]](#footnote-109) and relied on total energy consumption and an energy reduction percentage factor to estimate energy savings.

##### Comments

TrickleStar, Inc. suggests revisions to the measure description to clarify the terms used to describe the technology name and its functionality. TrickleStar, Inc. Comments at 2 and 3. Franklin Energy seeks clarification on why the EUL value assumptions differ between the residential and C&I versions of the advanced power strip (APS) measure. Additionally, Franklin Energy suggests adding an in-service rate parameter to the measure algorithms to improve the accuracy of the savings estimate. Franklin Energy Comments at 470.

##### Disposition

The Commission agrees with the suggested revisions in measure description proposed by TrickleStar, Inc. and has amended the text in section 3.9.3, as well as Tables 3-172 and 3-173 in the TRM. Regarding Franklin Energy’s comment concerning EUL assumptions, the Commission acknowledges the differing EUL assumptions and has revised the C&I APS EUL to reflect the same value and source used in for the residential APS EUL based on the source documents. However, we disagree and reject Franklin Energy’s suggestion to add an ISR parameter to the C&I APS algorithm as no data or research was found to be available to support an ISR for APS within the C&I sector at the time of drafting the 2021 TRM.

#### Measure Permutation

The Commission proposed to add two measure permutations to the Advanced Power Strips measure – Tier 1 and Tier 2 strips. Savings for each permutation vary based on their respective energy reduction percentage factor. The update provided greater measure resolution that allows the user to apply technology-specific deemed savings.

##### Comments

Franklin Energy challenges the annual use value cited in Table 3-171, as it assumes 8,760 annual hours of operation and relies on a source that mentions outdated technologies in its analysis. Franklin Energy also recommends the energy reduction percent (ERP) listed in Table 3-172 for the “unknown” power management scenario be “weighted heavily” toward the ERP scenario in which a workstation power management system is present as opposed to an equal weighting of the ERP between workstations with and without a power management system. Franklin Energy Comments at 471.

##### Disposition

The Commission rejects Franklin Energy’s challenge to the annual use value cited in Table 3-171. This value reflects the full assumed load of a workstation and is based on an assumed workstation containing the presence of a laptop computer, docking station, two LED backlit LED monitors, and a LED task light. The Commission does not consider these technologies as obsolete. Furthermore, we reject Franklin Energy’s recommendation to weight the “unknown” ERP towards the workstation with a power management system, as there was not sufficient data to support an alternate point estimate condition for how workstation power management systems are operated in working environments at the time of drafting the 2021 TRM.

### Section 3.10.1 – Compressed Air Cycling Refrigerated Thermal Mass Dryer[[109]](#footnote-110)

The Commission proposed updating the measure life of compressed air cycling refrigerated thermal mass dryers to 15 years based on a measure life study for Wisconsin Focus on Energy, 2009. We also proposed to revise the hours of compressor operation of compressed air cycling refrigerated thermal mass dryers for multiple shift conditions at the facility. The Commission proposed making this change to account for holidays and scheduled downtime as supported by more recent sources, including the Efficiency Vermont Technical Reference User Manual.

#### Comments

FirstEnergy states that the useful measure life should be ten years based on the cited source.[[110]](#footnote-111) Additionally, FirstEnergy suggests that additional descriptions of the baseline and efficient technologies be added for clarity. FirstEnergy Comments at 13.

#### Disposition

The Commission agrees with both FirstEnergy suggestions, and therefore have updated the applicable measure life and have updated the descriptions of the baseline and efficient technologies for clarity.

### Section 3.10.2 – Compressed Air-entraining Air Nozzle[[111]](#footnote-112)

The Commission did not propose changes to the savings algorithms for this measure. However, comments were received and are addressed below.

#### Comments

FirstEnergy suggests that the measurement units should be clarified to be volumetric. FirstEnergy also suggests that the useful measure life should be ten years based on cited source.[[112]](#footnote-113) FirstEnergy Comments at 14. PECO recommends that conservative default values be provided for all algorithm parameters to allow for easier implementation. PECO Comments at 12.

#### Disposition

The Commission supports FirstEnergy’s suggestion to clarify the parameter units and has provided the clarifying language. The Commission, however, rejects FirstEnergy’s suggestion to reduce the measure life to ten years. The source in question shows a measure life of 15 years, which is the value used in the TRM. The Commission partially accepts PECO’s suggestion regarding default values. We agree that it would be useful to provide a conservative Unknown default value for the compressor per KW value as this is less likely to be known by the program participant and has added the value to Table 3-186. However, the Commission finds that it is reasonable to require basic information on the technology size and basic usage pattern, accordingly, no additional unknown defaults have been provided.

### Section 3.10.3 – Compressed Air-no-loss Condensate Drains[[113]](#footnote-114)

The Commission proposed to revise the hours of compressor operation of compressed air no loss condensate drains for multiple shift conditions at the facility. The Commission proposed making this change to account for holidays and scheduled downtime as supported by more recent sources, including the Efficiency Vermont Technical Reference User Manual.

##### Comments

PECO notes that there are typos in table 3-191 shift descriptions. PECO recommends that conservative default values be provided for all algorithm parameters to allow for easier implementation. PECO Comments at 13. FirstEnergy suggests that the measure life should utilize the same source as other compressed air measures. FirstEnergy Comments at 14.

##### Disposition

The Commission partially accepts PECO’s recommendations. We have corrected the errors in table 3-191. We also agree that it would be useful to provide a conservative Unknown default value for the compressor per KW value as this is less likely to be known by the program participant; such a value has been added to Table 3-190. However, the Commission finds that it is reasonable to require basic information on the technology size and basic usage pattern; therefore, no additional unknown defaults have been provided. The Commission rejects FirstEnergy’s suggestion because the reference source for most compressed air measures does not have measure life information for compressed air drains. The cited Vermont Technical Reference Manual utilizes a preferred value.

### Section 3.10.4 – Compressed Air-tanks for Loads / No Load Compressors[[114]](#footnote-115)

The Commission did not propose changes to the eligibility requirements for this protocol. However, comments were received and are addressed below.

#### Comments

FirstEnergy suggests that the eligibility should be clarified and make clear that equipment should be new equipment. FirstEnergy Comments at 14.

#### Disposition

The Commission agrees with FirstEnergy’s suggestion and has added clarification to the measure eligibility section of the protocol.

### Section 3.11.1 – ENERGY STAR Servers[[115]](#footnote-116)

The Commission proposed to update the ENERGY STAR Servers measure with additional background content to provide further understanding and explanation for how the measure performs and how savings may be achieved. The Commission also proposed relocating the measure from the Miscellaneous C&I section (3.11.1) to the Consumer Electronics C&I section of the TRM (3.9.4) due to its relationship with ENERGY STAR computer-based measures in the Consumer Electronics section.

#### Comments

FirstEnergy notes that the measure description is inaccurate due to a statement that indicates a savings factor of 1.9 based on a 30% efficiency gain. FirstEnergy believes an efficiency gain of 65% is required to achieve a savings factor of 1.9. FirstEnergy Comments at 13.

#### Disposition

The Commission disagrees with the observation made by FirstEnergy. The measure description indicates that for every 1 watt saved at the server there will be approximately 1.9 watts saved across the facility due to additional efficiencies gained in systems that indirectly benefit from the efficiency gain achieved at the server.

### Section 4.1.3 – High-efficiency Ventilation Fans with and without Thermostats[[116]](#footnote-117)

The Commission proposed condensing the three formulas that feed into annual energy savings into one formula. The 2016 TRM provided separate algorithms based on whether thermostats are installed with the ventilation fans. However, the presence of thermostats can be handled by adjusting one of the inputs in a single, combined algorithm. The Commission also proposed adding two cities to the tables containing default annual operating run hours. Additionally, the Commission proposed removing any ambiguity around Table 4-6. The 2016 TRM was unclear as to whether this table contained default annual operating run hours for facilities that installed thermostats along with the ventilation fan or if this table contained the reduction in operating hours due to the installation of a thermostat along with the ventilation fan. The Commission proposed updating the table such that it represented the former default hours when a thermostat is present.

#### Comments

FirstEnergy recommends updating the EUL to 15 years based on the DEER EUL for HVAC fan motors. FirstEnergy Comments at 14. PECO recommends using the most conservative value(s) in the default savings table as the default for an “unknown” facility type. PECO Comments at 13.

#### Disposition

The Commission agrees with the recommendations made by FirstEnergy and PECO and has adopted them in the 2021 TRM.

### Section 4.1.5 – High Volume Low Speed Fans[[117]](#footnote-118)

The Commission did not propose changes to Section 4.1.5 – High Volume Low Speed Fans. However, comments were received and are addressed below.

#### Comments

Franklin Energy comments that some TRMs use different temperatures for different animal types (e.g., 70 for Dairy and 60 for hog based). They suggest using an average of 65 degrees. Franklin Energy Comments at 535.

#### Disposition

Franklin Energy described this comment simply as an observation. The Commission directs the SWE to investigate the possibility of animal-specific temperatures in subsequent TRM updates, but no changes were made to the measure in the 2021 TRM.

### Section 5.1 – Load Curtailment for Commercial and Industrial Programs[[118]](#footnote-119)

The Commission did not propose changes to Section 5.1 – Load Curtailment for Commercial and Industrial Programs. However, comments were received and are addressed below.

#### Comments

PECO recommends adjusting the text of load methodology – customer baselines (CBL) so that it is clear that weather adjustments are not necessary. PECO Comments at 36. FirstEnergy requests clarification regarding which days are not eligible to be used in the calculation of the reference load. The TRM currently states that Act 129 event days and PJM event days are ineligible. FirstEnergy requests clarification for weekends, holidays, and shutdown days. FirstEnergy Comments at 14.

#### Disposition

The Commission agrees that clarification regarding the points made by PECO and FirstEnergy would be useful. In response to PECO’s recommendation the text regarding the CBL reference load methodology was updated to indicate weather adjustments are not necessary. Responding to FirstEnergy’s recommendation, text was added to designate weekends, holidays, and planned shutdown days as days that may be ignored in the calculation of the reference load.

### Measure Number Changes

The changes proposed herein will result in new measure numbers for several C&I measures. The table below shows the current measure number and the new measure number for all affected measures. The table also shows measures that the Commission proposed removing—these measures are discussed in more detail later.

| **Measure** | **Current Measure Number** | **New Measure Number** |
| --- | --- | --- |
| Traffic Lights | 3.1.4 | Deleted |
| LED Exit Signs | 3.1.5 | 3.1.4 |
| LED Channel Signage | 3.1.6 | 3.1.5 |
| LED Refrigeration Display Case Lighting | 3.1.7 | 3.1.6 |
| Fuel Switching: Electric Resistance Water Heaters to Gas / Oil / Propane | 3.4.4 | 3.4.3 |
| Fuel Switching: Heat Pump Water Heaters to Gas / Oil / Propane | 3.4.5 | Deleted |
| Controls: Evaporator Fan Controllers | 3.5.4 | 3.5.3 |
| Controls: Floating Head Pressure Controls | 3.5.5 | 3.5.4 |
| Controls: Anti-sweat Heater Controls | 3.5.6 | 3.5.5 |
| Controls: Evaporator Coil Defrost Control | 3.5.7 | 3.5.6 |
| Variable Speed Refrigeration Compressor | 3.5.8 | 3.5.7 |
| Strip Curtains for Walk-in Freezers and Coolers | 3.5.9 | 3.5.8 |
| Night Covers for Display Cases | 3.5.10 | 3.5.9 |
| Auto Closers | 3.5.11 | 3.5.10 |
| Door Gaskets for Walk-in and Reach-in Coolers and Freezers | 3.5.12 | 3.5.11 |
| Special Doors with Low or No Anti-sweat Heat for Low Temp Case | 3.5.13 | 3.5.12 |
| Suction Pipe Insulation for Walk-in Coolers and Freezers | 3.5.14 | 3.5.13 |
| Refrigerated Display Cases with Doors Replacing Open Cases | 3.5.15 | 3.5.14 |
| Adding Doors to Existing Refrigerated Display Cases | 3.5.16 | 3.5.15 |
| ENERGY STAR Refrigerated Beverage Machine | 3.7.5 | Deleted |
| ENERGY STAR Servers | 3.11.1 | 3.9.4 |
| Load Curtailment for Commercial and Industrial Programs | 5.1 | 3.12.1 |

## Removed Residential EE&C Protocols

Based on a review of the available research, the Commission proposed removing six residential EE&C measures and associated protocols. No stakeholder comments were received in response to these removals. As such, all six measures have been excluded from the Final 2021 TRM. The measures are: Section 2.2.8 – Programmable Thermostats, Section 2.2.9 – Residential Whole House Fans, Section 2.3.4 – Fuel Switching: Heat Pump Water Heater to Fossil Fuel Water Heater, Section 2.4.9 – ENERGY STAR Water Coolers, Section 2.5.1 – ENERGY STAR Televisions, and Section 2.7.1 – Pool Pump Load Shifting.

## Removed C&I EE&C Measure Protocols

Based on a review of the available research, the Commission proposed removing three C&I EE&C measures and associated protocols. No stakeholder comments were received in response to these removals. As such, all three measures have been excluded from the Final 2021 TRM. The measures are: Section 3.1.4 – Traffic Lights, Section 3.4.5 – Fuel Switching: Heat Pump Water Heaters to Gas/Oil/Propane, and Section 3.7.5 – ENERGY STAR Refrigerated Beverage Machines.

## Appendix C: Lighting Audit and Design Tool

The Commission proposed several revisions to the 2016 TRM Appendix C to increase customer usability while allowing for increased customization. These proposed changes included the following:

* Adjusting custom hours of use and coincidence factor module to accommodate dusk-to-dawn lighting;
* Adding an active link on Lighting Inventory tab to configure custom SVG values;
* Decrementing baseline incandescent lamp wattages for non-specialty lamps to be in compliance with EISA backstop;
* Correcting an error in which certain columns in the Lighting Inventory tab did not populate for new construction projects utilizing the Whole Building Method;
* Adding 36" and 96" linear LED options to the LED Fixture Builder;
* Expanding functionality to allow for multiple deemed space types (i.e., interior, exterior, refrigeration, and exit). This is facilitated by using either the Deemed or Mixed modes in General Information cell I26;
* Adjusting the energy savings algorithm to ignore the baseline SVG factor in the event that both the pre-retrofit and post-retrofit cases both employ either method of Daylighting controls. This proposed adjustment was made in order to correct the issue through which known photocell operating hours were further discounted by the Photocell SVG factor;
* Revising and expanding LED\_Codes named ranges to include LED Linear Fluorescent Tube Replacement Type in the Description and revising Code for same fixtures to append Type to the end of the Code (i.e., LTA, LTB, LTC);
* Adjusting LPD baseline values to be consistent with 2015 IECC;
* Revising hours of use and coincidence factors for consistency with the proposed updates to Section 3.1.1;
* Revising New Construction SVG Accountability % Req. assumptions for consistency with 2015 IECC 2015, as discussed in Section F.2; and
* Adding a Small Business Direct Install radio button input on the General Information worksheet. When Yes is selected, the T12 baseline adjustment will be disabled.

### Comments

FirstEnergy recommends that the exterior hours of use of 3,604 are sourced from the Mid-Atlantic TRM, with reference to a Navigant interior hours of use study and suggests using non-daylight hours for Pittsburgh of 4,306. FirstEnergy requests clarification on where Table 3-10 is being applied in Appendix C. FirstEnergy notes that the formula looking up the allowed LPDs for the exterior areas was based on looking up interior areas and not functioning properly. FirstEnergy states that the allowed LPD for atriums in the Appendix C calculator does not match what is stipulated in the proposed 2021 TRM. FirstEnergy comments that the data validation range for lighting fixtures should be extended to row 1045. Finally, FirstEnergy requests that “Troffer LED Panel” be added to the “LED Code Builder” table on “Lookups” worksheet. FirstEnergy Comments at 14-15. PPL recommends modifying Appendix C to allow entry of different heating and cooling system types per space designation. PPL notes that unique cooling system types for each space designation are captured in the “General Information” tab, but Appendix C only allows one heating system type for the whole building. PPL Comments at 6-7.

### Disposition

The Commission acknowledges FirstEnergy’s recommendation on exterior hours of use but notes that a value of 4,305 would only be appropriate if the exterior lighting in question is photocell controlled and operates from dusk-to-dawn. EDCs may assume 4,305 hours of use where operation photocell control is present and 3,604 hours in other cases. Regarding FirstEnergy’s comment about the use of Table 3‑10 in Appendix C, this table is not explicitly used in the calculations and is intended to present default values where exact lamp data is unknown. The Commission accepts FirstEnergy’s remaining recommendations on Appendix C and has updated the calculator to remedy the identified issues. We also accept PPLs recommendation and have therefore updated Appendix C to allow specification of both heating and cooling equipment at the space type level.

## Appendix D: Motors and VFD Audit and Design Tool

The Commission proposed several updates to the 2016 TRM Appendix D calculator to increase usability and to align with the proposed algorithm revisions for VFD improvement measures. The 2016 TRM Appendix D calculator houses general project information on both the Summary tab and the measure-specific Motor Form and VFD Form. The Commission proposed consolidating all general project information including Facility Type and Weather Location, fields that are critical for populating default coincidence factors and hours of operation according to the TRM, onto a new General Information tab. The proposed format of this new tab aligns this calculator with the Appendix C Lighting Calculator.

The Commission also proposed to reformat the Motor Form tab, which houses the algorithms for Measure 3.3.1 Premium Efficiency Motors. The proposed formatting was designed to streamline the user experience and maintain consistency with TRM algorithms. In the 2016 TRM Appendix D calculator, baseline and post-retrofit motor information were entered in separate parts of the Motor Form worksheet. The proposed format provides a single worksheet row for each upgraded motor type. Formulas on this tab were modified to include the Commission’s proposed revision to default load factor values and to allow for the entry of custom hours of operation in accordance with the algorithm outlined in the TRM for this measure. Additionally, the Commission proposed to rename this form to 3.3.1 Premium Efficiency Motors to further clarify the relationship between the calculator and the TRM.

The Commission similarly proposed renaming the Appendix D VFD Form to 3.3.2 VFD Improvements and to further revise the calculator formulas for alignment with the proposed algorithms for Measure 3.3.2 Variable Frequency Drive (VFD) Improvements. To facilitate this alignment, the Commission proposed the addition of a new tab to the calculator, VFD Custom Load Profile, where users can review the Default HVAC Fan and HVAC Pump load profiles and define up to ten custom load profiles. Formulas on this tab were also modified to include the Commission’s proposed revisions to the default motor load factor value and to allow for the entry of custom hours of operation, in accordance with the algorithm outlined in the TRM.

### Comments

FirstEnergy comments that the default load factor for pumps in the Appendix D calculator (0.78) was not aligned with the default load factor for pumps in the TRM (0.79). FirstEnergy Comments at 5.

### Disposition

The Commission reviewed the references for this measure and agrees with FirstEnergy that 0.79 is the correct value.

## Appendix E: Eligibility Requirements for Solid State Lighting Products in Commercial and Industrial Applications

The Commission proposed some changes to the text of Appendix E to clarify the intent of instructions. References to several industry testing procedures were also updated.

### Comments

PECO flags the ambiguity in Appendix E regarding whether solid state lighting products must meet both the requirements of ENERGY STAR and Design Lights Consortium, or just one of the certifications. PECO recommends replacing “and/or” with “or” to maintain flexibility. PECO Comments at 7.

### Disposition

The Commission agrees with PECO’s recommendation and has updated the language in Appendix E to clarify that products must meet either the ENERGY STAR or the Design Lights Consortium standards to be eligible for program support.

# CONCLUSION

This Order represents the Commission’s continuing efforts in establishing a comprehensive TRM with a purpose of supporting both the AEPS Act and the EE&C Program provisions of Act 129. We extend our thanks to all who provided comments; **THEREFORE,**

**IT IS ORDERED:**

1. That the 2021 Technical Reference Manual update, as modified by this Order, is adopted and replaces all prior versions of the Technical Reference Manual as of June 1, 2021.

2. That a copy of this Order shall be served upon all electric distribution companies, the Office of Consumer Advocate, the Office of Small Business Advocate, the Commission’s Bureau of Investigation and Enforcement, the Pennsylvania Department of Environmental Protection and all parties who filed comments.

3. That the Secretary shall deposit a notice of this Order and the 2021 version of the Technical Reference Manual with the Legislative Reference Bureau for publication in the *Pennsylvania Bulletin*.

4. That this Order and the 2021 Technical Reference Manual update, as well its appendices be published on the Commission’s website at <http://www.puc.pa.gov/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx>.

**BY THE COMMISSION**

Rosemary Chiavetta

Secretary

(SEAL)

ORDER ADOPTED: August 8, 2019

ORDER ENTERED: August 8, 2019

1. Order entered on October 3, 2005, at Docket No. M-00051865 (October 3, 2005 Order). [↑](#footnote-ref-2)
2. As of August 11, 2011, the Bureau of CEEP was eliminated and its functions and staff transferred to the newly created Bureau of Technical Utility Services (TUS). *See Implementation of Act 129 of 2008; Organization of Bureaus and Offices*, Final Procedural Order, entered August 11, 2011, at Docket No. M‑2008-2071852, at 4. [↑](#footnote-ref-3)
3. *See* October 3, 2005 Order at 13. [↑](#footnote-ref-4)
4. *See Energy Efficiency and Conservation Program* Implementation Order, at Docket No. M‑2008‑2069887, entered January 16, 2009 (Phase I Implementation Order), at 13. [↑](#footnote-ref-5)
5. *See Implementation of the Alternative Energy Portfolio Standards Act of 2004: Standards for the Participation of Demand Side Management Resources – Technical Reference Manual 2021 Update*, Tentative Order at Docket No. M-2019-3006867, entered April 11, 2019. [↑](#footnote-ref-6)
6. The PEG is chaired by staff of the Commission’s Bureau of Technical Utility Services and is comprised of representatives from the EDCs and the SWE for the purpose of encouraging discussion of EDC program-specific issues and associated evaluation, measurement, and verification. [↑](#footnote-ref-7)
7. National Solar Radiation Data Base. 1991 – 2005 Update: Typical Meteorological Year 3. Available at <https://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html>. [↑](#footnote-ref-8)
8. National Renewable Energy Laboratory, The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Chapter 2: Commercial and Industrial Lighting Evaluation Protocol (NREL/SR-7A30-53827), April 2013, pg. 109. [↑](#footnote-ref-9)
9. *Evaluation of the Weatherization Residential Assistance Partnership and Helps Programs (WRAP/Helps)* Middletown, CT: KEMA, 2010. Accessed July 30, 2015. Numbers are adjusted for relative HDD of Bridgeport/Hartford CT with the IL climate zones. [↑](#footnote-ref-10)
10. <http://mn.gov/commerce-stat/pdfs/card-report-energy-efficiency-behavorial-prog.pdf> [↑](#footnote-ref-11)
11. This was Section 2.2.3 of the tentative 2021 Manual. The Commission combined this measure protocol with Section 2.2.1 – Electric HVAC. [↑](#footnote-ref-12)
12. This was Section 2.6.4 of the tentative 2021 Manual. The Commission combined this measure protocol with Section 2.6.7 – Crawl Space Wall Insulation. [↑](#footnote-ref-13)
13. This was Section 2.7.3 in the tentative 2021 Manual. The Commission combined this measure protocol with Section 2.6.3 – Residential New Construction. [↑](#footnote-ref-14)
14. EPA ENERGY STAR Multifamily New Construction Program Decision Tree, Version 1.3. <https://www.energystar.gov/sites/default/files/asset/document/MFHR%20Flowchart_v1.3.pdf> [↑](#footnote-ref-15)
15. Per ASHRAE 62.2-2010, occupiable space is any enclosed space inside the pressure boundary and intended for human activities or continual human occupancy, including, but not limited to, areas for living, sleeping, dining, and cooking; and toilets, closets, halls, storage and utility areas, and laundry areas. [↑](#footnote-ref-16)
16. For mixed-use buildings, exclude the retail/commercial area when determining the square footage of the building. [↑](#footnote-ref-17)
17. At the time of publication, RESNET standards for multifamily inspection and sampling were still under development, though they are expected to be adopted before the 2021 TRM takes effect. See <http://conference2018.resnet.us/data/energymeetings/presentations/How%20Standards%20are%20Evolving%20to%20Better%20Address%20Multifamily%20Ratings%20.pdf> [↑](#footnote-ref-18)
18. See <https://appliance-standards.org/sites/default/files/Fact_Sheet_Who_Opposes_DOE_Light_Bulb_Rollback_Final1.pdf> [↑](#footnote-ref-19)
19. Cascade Energy, Prepared for Regional Technical Forum. Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors. November 2012. Load factor for air compressors and average motor efficiency. <https://rtf.nwcouncil.org/meeting/rtf-meeting-november-14-2012> [↑](#footnote-ref-20)
20. 2019 Illinois Statewide Technical Reference Manual for Energy Efficiency. Version 7. Volume 2: Commercial and Industrial Measures. September 2018. 4.8.9 High Frequency Battery Chargers. <http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_7/Final_9-28-18/IL-TRM_Effective_010119_v7.0_Vol_2_C_and_I_092818_Final.pdf> [↑](#footnote-ref-21)
21. *Id*. [↑](#footnote-ref-22)
22. Pacific Gas & Electric, “Emerging Technologies Program Application Assessment Report #0808,” Industrial Battery Charger Energy Savings Opportunities. May 29, 2009. See discussion below Table 7. [↑](#footnote-ref-23)
23. *See* Section 2.1.1 – ENERGY STAR Lighting of the 2016 TRM, page 17. [↑](#footnote-ref-24)
24. https://www1.eere.energy.gov/buildings/appliance\_standards/standards.aspx?productid=4 [↑](#footnote-ref-25)
25. See <https://appliance-standards.org/sites/default/files/Fact_Sheet_Who_Opposes_DOE_Light_Bulb_Rollback_Final1.pdf> [↑](#footnote-ref-26)
26. Reflector and other specialty lamp types were found in 42% of sockets in the 2018 Pennsylvania Residential Baseline Study. [↑](#footnote-ref-27)
27. U.S. DOE Appliance and Equipment Standards Rulemakings and Notices, <https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=4> [↑](#footnote-ref-28)
28. *See* Section 2.1.5 – Holiday Lights of the 2016 TRM, page 31. [↑](#footnote-ref-29)
29. *See* Section 2.2.1 – Electric HVAC of the 2016 TRM, page 34. [↑](#footnote-ref-30)
30. *See* Section 2.2.10 – Packaged Terminal Systems of the 2016 TRM, page 83. [↑](#footnote-ref-31)
31. *See* Section 2.2.3 – Ductless Mini-split Heat Pumps of the 2016 TRM, page 51. [↑](#footnote-ref-32)
32. *See* Section 2.2.4 – ENERGY STAR Room Air Conditioners of the 2016 TRM, page 57. [↑](#footnote-ref-33)
33. *See* Section 2.2.6 – Duct Sealing of the 2016 TRM, page 67. [↑](#footnote-ref-34)
34. *See* Section 2.3.1 – Heat Pump Water Heaters of the 2016 TRM, page 87. [↑](#footnote-ref-35)
35. *See* Section 2.3.2 – Solar Water Heaters of the 2016 TRM, page 93. [↑](#footnote-ref-36)
36. *See* Section 2.3.3 – Fuel Switching: Electric Resistance to Fossil Fuel Water Heater of the 2016 TRM, page 96. [↑](#footnote-ref-37)
37. *See* Section 2.3.6 – Water Heater Temperature Setback of the 2016 TRM, page 109. [↑](#footnote-ref-38)
38. *See* Section 2.3.7 – Water Heater Pipe Insulation of the 2016 TRM, page 112. [↑](#footnote-ref-39)
39. R-3 pipe insulation is equivalent to ¾” of fiberglass insulation on a ½” pipe, for reference. [↑](#footnote-ref-40)
40. *See* Section 2.3.8 – Low-flow Faucet Aerators of the 2016 TRM, page 114. [↑](#footnote-ref-41)
41. *See* Section 2.3.9 – Low-flow Showerheads of the 2016 TRM, page 120. [↑](#footnote-ref-42)
42. *See* Section 2.3.10 – Thermostatic Shower Restriction Valve of the 2016 TRM, page 125. [↑](#footnote-ref-43)
43. Using the associated algorithm this would actually equate to 18 years, though Act 129 savings can only be claimed for 15. [↑](#footnote-ref-44)
44. *See* Section 2.4.1 – ENERGY STAR Refrigerators of the 2016 TRM, page 129. [↑](#footnote-ref-45)
45. *See* Section 2.4.2 – ENERGY STAR Freezers of the 2016 TRM, page 137. [↑](#footnote-ref-46)
46. *See* Section 2.4.3 – Refrigerator / Freezer Recycling with and without Replacement of the 2016 TRM, page 141. [↑](#footnote-ref-47)
47. *See* Section 2.4.5 – ENERGY STAR Dryers of the 2016 TRM, page 152. [↑](#footnote-ref-48)
48. *See* Section 2.4.10 – ENERGY STAR Ceiling Fans of the 2016 TRM, page 166. [↑](#footnote-ref-49)
49. *See* Section 2.5.3 – Smart Strip Plug Outlets of the 2016 TRM, page 176. [↑](#footnote-ref-50)
50. *See* Section 2.6.1 – Ceiling / Attic and Wall Insulation of the 2016 TRM, page 180. [↑](#footnote-ref-51)
51. *See* Section 2.6.8 – Rim Joist Insulation of the 2016 TRM, page 212, and the approved Floor Insulation IMP. [↑](#footnote-ref-52)
52. *See* Section 2.6.2 – ENERGY STAR Windows of the 2016 TRM, page 187. [↑](#footnote-ref-53)
53. *See* <https://beopt.nrel.gov/home>. [↑](#footnote-ref-54)
54. *See* Section 2.6.3 – Residential New Construction of the 2016 TRM, page 190. [↑](#footnote-ref-55)
55. *See* Section 2.6.5 – ENERGY STAR Manufactured Homes of the 2016 TRM, page 198. [↑](#footnote-ref-56)
56. *See* Section 2.6.6 – Residential Air Sealing of the 2016 TRM, page 204. [↑](#footnote-ref-57)
57. *See* <https://beopt.nrel.gov/home>. [↑](#footnote-ref-58)
58. *See* Section 2.6.7 – Crawl Space Wall Insulation of the 2016 TRM, page 207. [↑](#footnote-ref-59)
59. *See* Section 3.1.1 – Lighting Improvements of the 2016 TRM, page 225. [↑](#footnote-ref-60)
60. See <https://appliance-standards.org/sites/default/files/Fact_Sheet_Who_Opposes_DOE_Light_Bulb_Rollback_Final1.pdf> [↑](#footnote-ref-61)
61. Missouri Division of Energy. March 31, 2017. Missouri Technical Reference Manual. Volume 2: Commercial and Industrial Measures. P.177. [↑](#footnote-ref-62)
62. *See* Section 3.1.2 – New Construction Lighting of the 2016 TRM, page 235. [↑](#footnote-ref-63)
63. *See* Section 3.1.5 – LED Exit Signs of the 2016 TRM, page 251. [↑](#footnote-ref-64)
64. *See* Section 3.1.6 – LED Channel Signage of the 2016 TRM, page 254. [↑](#footnote-ref-65)
65. *See* Section 3.2.1 – HVAC Systems of the 2016 TRM, page 260. [↑](#footnote-ref-66)
66. *See* Section 3.2.2 – Electric Chillers of the 2016 TRM, page 270. [↑](#footnote-ref-67)
67. *See* Section 3.2.4 – Ductless Mini-split Heat Pumps – Commercial < 5.4 Tons of the 2016 TRM, page 284. [↑](#footnote-ref-68)
68. *See* Section 3.2.5 – Fuel Switching: Small Commercial Electric Heat to Natural Gas / Propane / Oil Heat of the 2016 TRM, page 289. [↑](#footnote-ref-69)
69. *See* Section 3.2.6 – Small C&I HVAC Refrigerant Charge Correction of the 2016 TRM, page 294. [↑](#footnote-ref-70)
70. *See* Section 3.2.7 – ENERGY STAR Room Air Conditioner of the 2016 TRM, page 300. [↑](#footnote-ref-71)
71. See Section 3.2.9 – Controls: Economizer of the 2016 TRM, page 308. [↑](#footnote-ref-72)
72. See Section 3.3.1 – Premium Efficiency Motors of the 2016 TRM, page 313. [↑](#footnote-ref-73)
73. *See* Section 3.3.2 – Variable Frequency Drive (VFD) Improvements of the 2016 TRM, page 325. [↑](#footnote-ref-74)
74. *See* Section 3.3.3 – ECM Circulating Fan of the 2016 TRM, page 328. [↑](#footnote-ref-75)
75. *See* Section 3.3.4 – VSD on Kitchen Exhaust Fan of the 2016 TRM, page 332. [↑](#footnote-ref-76)
76. *See* Section 3.4.1 – Heat Pump Water Heaters of the 2016 TRM, page 335. [↑](#footnote-ref-77)
77. Department of Energy. Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Water Heating Equipment. April 2016. Table 7B.2.3, page 230. <https://www.regulations.gov/document?D=EERE-2014-BT-STD-0042-0016> [↑](#footnote-ref-78)
78. *See* Section 3.4.2 – Low-flow Pre-Rinse Sprayers for Retrofit Programs and Section 3.4.3 Low-flow Pre-Rinse Sprayers for Time of Sale / Retail Programs of the 2016 TRM, pages 344 and 349, respectively. [↑](#footnote-ref-79)
79. Impact Evaluation of Massachusetts Prescriptive Gas Pre-Rinse Spray Valve Measure, DNV-GL, 2014. Table 24. Page 6-12. <http://ma-eeac.org/wordpress/wp-content/uploads/Prescriptive-Gas-Pre-Rinse-Spray-Valve-Measure-Impact-Evaluation.pdf> [↑](#footnote-ref-80)
80. *See* Section 3.5.1 – High-efficiency Refrigeration / Freezer Cases of the 2016 TRM, page 369. [↑](#footnote-ref-81)
81. *See* Section 3.5.2 – High-efficiency Evaporator Fan Motors for Reach-in Refrigerated Cases of the 2016 TRM, page 373. [↑](#footnote-ref-82)
82. Commercial Refrigeration Loadshape Project, Northeast Energy Efficiency Partnerships, October 2015. Pages 71-72. <https://neep.org/commercial-refrigeration-loadshape-report-10-2015-0>. [↑](#footnote-ref-83)
83. Department of Energy. “Energy Savings Potential and Opportunities for High-Efficiency Electric Motors in Residential and Commercial Equipment.” December 2013. Motor efficiencies for the baseline motors are drawn from Table 2.1. <https://www.energy.gov/sites/prod/files/2014/02/f8/Motor%20Energy%20Savings%20Potential%20Report%202013-12-4.pdf> [↑](#footnote-ref-84)
84. *See* Section 3.5.4 – Controls: Evaporator Fan Controllers of the 2016 TRM, page 382. [↑](#footnote-ref-85)
85. Commercial Refrigeration Loadshape Project, Northeast Energy Efficiency Partnerships, October 2015. Pages 73-74. <https://neep.org/commercial-refrigeration-loadshape-report-10-2015-0>. [↑](#footnote-ref-86)
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87. Database for UES Measures, Regional Technical Forum. Grocery Floating Head Pressure Controls for Single Compressor Systems, December 2016, V1.6. <https://rtf.nwcouncil.org/measure/floating-head-pressure-controls-single-compressor-systems> [↑](#footnote-ref-88)
88. *See* Section 3.5.6 – Controls: Anti-sweat Heater Controls of the 2016 TRM, page 389. [↑](#footnote-ref-89)
89. Commercial Refrigeration Loadshape Project, Northeast Energy Efficiency Partnerships, October 2015. Pages 74-75. <https://neep.org/commercial-refrigeration-loadshape-report-10-2015-0>. [↑](#footnote-ref-90)
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91. *See* Section 3.5.8 – Variable Speed Refrigeration Compressor of the 2016 TRM, page 396. [↑](#footnote-ref-92)
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94. *See* Section 3.5.11 – Auto Closers of the 2016 TRM, page 410. [↑](#footnote-ref-95)
95. *See* Section 3.5.14 – Suction Pipe Insulation for Walk-in Coolers and Freezers of the 2016 TRM, page 418. [↑](#footnote-ref-96)
96. *See* Section 3.5.15 – Refrigerated Display Cases with Doors Replacing Open Cases of the 2016 TRM, page 420. [↑](#footnote-ref-97)
97. *See* Section 3.5.16 – Adding Doors to Existing Refrigerated Display Cases of the 2016 TRM, page 422. [↑](#footnote-ref-98)
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99. *See* Section 3.6.1 – ENERGY STAR Clothes Washer of the 2016 TRM, page 424. [↑](#footnote-ref-100)
100. *See* Section 3.7.1 – High-efficiency Ice Machines of the 2016 TRM, page 432. [↑](#footnote-ref-101)
101. *See* Section 3.7.2 – Controls: Beverage Machine Controls of the 2016 TRM, page 437. [↑](#footnote-ref-102)
102. *See* Section 3.7.4 – ENERGY STAR Electric Steam Cooker of the 2016 TRM, page 442. [↑](#footnote-ref-103)
103. *See* FirstEnergy Comments at page 6 found at: <http://www.puc.pa.gov/pcdocs/1359168.pdf>. [↑](#footnote-ref-104)
104. *See* Section 3.8.1 – Wall and Ceiling Insulation of the 2016 TRM, page 450. [↑](#footnote-ref-105)
105. *See* Section 3.9.1 – ENERGY STAR Office Equipment of the 2016 TRM, page 455. [↑](#footnote-ref-106)
106. *See* Section 3.9.2 – Office Equipment – Network Power Management Enabling of the 2016 TRM, page 460. [↑](#footnote-ref-107)
107. *See* Section 3.9.3 – Advanced Power Strips of the 2016 TRM, page 463. [↑](#footnote-ref-108)
108. “RLPNC 17-3: Advanced Power Strip Metering Study,” Massachusetts Programs Administrators and Other Plug-EEAC, (Oct. 2018), <http://ma-eeac.org/wordpress/wp-content/uploads/RLPNC_173_APSMeteringReport_5OCT2018_Finalv2.pdf> [↑](#footnote-ref-109)
109. *See* Section 3.10.1 – Compressed Air Cycling Refrigerated Thermal Mass Dryer of the 2016 TRM, page 465. [↑](#footnote-ref-110)
110. Measure Life Study prepared for the Massachusetts Joint Utilities. Energy and Resource Solutions, 2005. <https://www.focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf> [↑](#footnote-ref-111)
111. *See* Section 3.10.2 – Compressed Air-entraining Air Nozzle of the 2016 TRM, page 468. [↑](#footnote-ref-112)
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113. *See* Section 3.10.3 – No-loss Condensate Drains of the 2016 TRM, page 472. [↑](#footnote-ref-114)
114. *See* Section 3.10.4 – Compressed Air-tanks for Loads / No Load Compressors of the 2016 TRM, page 477. [↑](#footnote-ref-115)
115. *See* Section 3.11.1 – ENERGY STAR Servers of the 2016 TRM, page 480. [↑](#footnote-ref-116)
116. *See* Section 4.1.3 – High-efficiency Ventilation Fans with and without Thermostats of the 2016 TRM, page 491. [↑](#footnote-ref-117)
117. *See* Section 4.1.5 – High Volume Low Speed Fans of the 2016 TRM, page 498. [↑](#footnote-ref-118)
118. *See* Section 5.1 – Load Curtailment for Commercial and Industrial Programs of the 2016 TRM, page 512. [↑](#footnote-ref-119)