Evaluation, Measurement, and Verification Report for Virginia Electric and Power Company (Dominion Energy)

Case No. PUR-2020-00274 (Virginia)
Docket No. E-22 Sub 604 (North Carolina)

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Date: June 15, 2022
Prepared by DNV Energy Insights USA Inc. (DNV)

APPENDIX F DOMINION ENERGY TECHNICAL REFERENCE MANUAL (FORMERLY STEP MANUAL) 2021

F.1 Dominion Energy Technical Reference Manual for Residential Programs 2021

F.2 Dominion Energy Technical Reference Manual for Non-Residential Programs 2021

Appendix F1 Technical Reference Manual (TRM) for Residential Programs

Dominion Energy Virginia and North Carolina

Protocols to Track Demand-Side Management Programs (DSM) Resource Savings

Version 2021-Report

Prepared by DNV Energy Insights USA Inc.

June 15, 2022

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List of Exhibits

1 INTRODUCTION

This manual is the Technical Reference Manual (TRM) for demand-side management (DSM) programs approved by State Corporation Commission of Virginia (SCC) Order and the North Carolina Utilities Commission's (NCUC) Orders. These protocols assess gross program impacts and resource savings, including annual electric energy and peak capacity savings, for technologies and measures supported by Virginia Electric and Power Company (Dominion, or the Company) in Virginia and North Carolina. Protocols to determine resource savings for each program are presented for each eligible measure and technology.

1.2 Purpose

This manual was developed to estimate resource savings from installed DSM technologies and measures and provide the primary estimates of annual energy savings and peak demand reductions for tracking, monitoring, and reporting. The consulting firm DNV, under contract with Dominion Energy, developed this manual using industry-standard approaches for estimating annual energy savings and peak demand reductions. This document references authoritative studies in Technical Reference Manuals (TRMs) issued by regulatory agencies in other states, primarily the Maryland/Mid-Atlantic TRM Version 10 (v10) and Mid-Atlantic TRM Versions 9 (v9) and earlier—all facilitated and managed by the Northeast Energy Efficiency Partnerships (NEEP) for its Mid-Atlantic partners of Maryland, Delaware, and the District of Columbia, with significant involvement by the respective states' Public Service Commissions (PSCs). Other reference sources include TRMs and impact study results from California, Connecticut, Maine, Massachusetts, New Jersey, New York, Michigan, North Carolina, Ohio, Pennsylvania, the Tennessee Valley Authority (TVA), and Vermont, as well as other engineering resources such as the American Society of Heating, Refrigeration & Air Conditioner Engineers (ASHRAE), the 2012 International Energy Conservation Code, the National Electrical Manufacturers Association (NEMA) Standards Publication Condensed MG 1-2007, ENERGY STAR®, the US Energy Information Administration Residential Energy Consumption Survey and Commercial Building Energy Consumption Survey, and the Energy Conservatory. Additionally, Dominion's Residential and Non-Residential Energy Use Survey 2019 – 2020, is leveraged for calculation inputs and assumptions.

This manual is not intended to be the final word on gross annual electric energy and peak demand reduction estimates. Rather, this manual serves as the foundation for ongoing program operations and as the basis for further refinement through evaluation, measurement & verification (EM&V). Savings estimates from this manual will be coupled with the results of actual EM&V activities to calibrate the annual energy and peak demand reductions estimates derived from to report population-level estimates.

This is the 2021 version of the manual. It is designed to estimate gross savings in concert with program tracking data received from Dominion through its business intelligence (BI) data system, which is populated by its program implementation vendors. Dominion has developed data specification requirements (listed in Table 1-1) for each of the programs. This manual is designed to leverage that data.

Table 1-1. Program Tracking Data Specifications

DSM Phase	Program	Virginia	North Carolina
Residential Programs			
4	Residential Income and Age Qualifying Home Improvement (DSM Phase IV)	1.20	1.20
7	Residential Home Energy Assessment, DSM Phase VII	7.14	7.14

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DSM Phase	Program	Virginia	North Carolina
7	Residential Efficient Product Marketplace, DSM Phase VII	Program: 7.14 Lighting: 4.00	Program: 7.14 Lighting: 4.00
7	Residential Appliance Recycling, DSM Phase VII	7.40	7.40
8	Residential Thermostat Purchase (Energy Efficiency) Program, DSM Phase VIII	8.40	
8	Residential Thermostat Behaviour (Energy Efficiency) Program, DSM Phase VIII	8.30	
8	Residential Customer Engagement Program, DSM Phase VIII	8.30	
8	Residential Energy Efficient Kits Program, DSM Phase VIII	8.30	
8	Residential Manufactured Housing Program, DSM Phase VIII	8.90	
8	Residential Home Retrofit Program, DSM Phase VIII	9.00	
8	Residential/Multifamily Program, DSM VIII	8.80	
8	Residential HB2789 (Heating and Cooling/Health and Safety), DSM Phase VIII	8.80	
8	Residential New Construction, DSM Phase VIII	8.40	
8	Electric Vehicle (EE) Program, DSM Phase VIII	8.10	
Non-Residential Programs			
3	Non-Residential Lighting Systems and Controls, DSM Phase III	4.00	2.00
7	Non-Residential Lighting Systems and Controls, DSM Phase VII	7.50	7.50
3	Non-Residential Heating and Cooling Efficiency, DSM Phase III	3.30	3.30
7	Non-Residential Heating and Cooling Efficiency, DSM Phase VII	7.60	7.60
3	Non-Residential Window Film, DSM Phase III	2.00	1.00
7	Non-Residential Window Film, DSM Phase VII	7.30	7.30
5	Non-Residential Small Business Improvement, DSM Phase V	3.30	3.30
6	Non-Residential Prescriptive, DSM Phase VI	6.40	6.40
7	Non-Residential Small Manufacturing, DSM Phase VII	3.40	3.40
7	Non-Residential Small Office, DSM Phase VII	7.30	7.30
8	Non-Residential Midstream Energy Efficient Products Program, DSM Phase VIII	8.60	
8	Non-Residential New Construction Program, DSM Phase VIII	8.50	
8	Non-Residential Small Business Improvement Enhanced, DSM Phase VIII	9.60	
8	Non-Residential Multifamily Program, DSM Phase VIII	8.70	
Peak-Shaving Programs			
1	Residential AC Cycling, DSM Phase I	2.00	2.00
2	Non-Residential Distributed Generation, DSM Phase II	Final	–
8	Electric Vehicle (DR) Program, DSM Phase VIII	8.10	
8	Thermostat (DR) Program, DSM Phase VIII	8.12	

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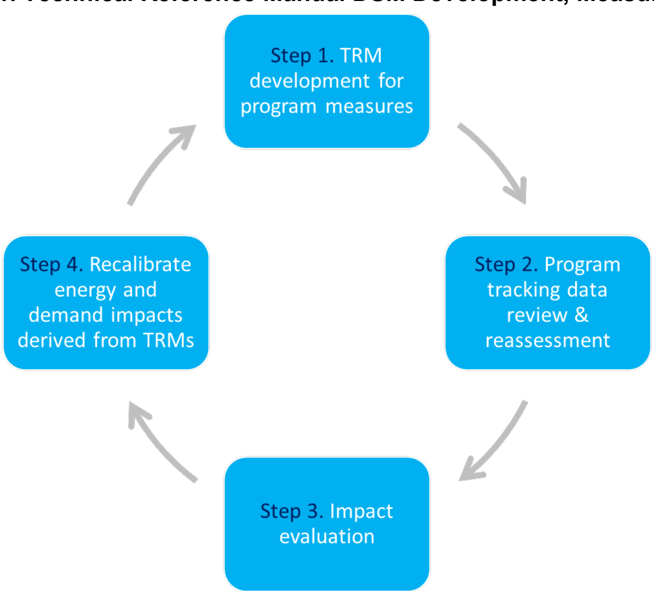
For Dominion, these protocols also serve the following purposes:

1. Establish a common resource for Dominion's gross annual energy and peak demand reductions estimates across business units.
2. Ensure all internal parties (e.g., Program Managers, implementation contractors, etc.) use the same protocols, input values, assumptions, and algorithms.
3. Assist in defining program data tracking elements in the change management process.
4. Serve as a basis to assess performance of program implementation progress.
5. Allow Dominion Program Managers and their implementation contractors to manage the programs to meet their annual energy savings (kWh/year) and peak demand (kW) reductions objectives.

Figure 1-1 shows how these protocols shall be updated regularly to reflect the addition of new programs, modifications to existing programs, updates based on measured data, regulatory requirements, and the results of future program evaluations. Some examples of key drivers to updating and revising this manual include the following:

- Updates of input factors based on primary research
- Updates of input approaches or input factors in source documents of secondary data or revised modeled outputs
- Added efficiency measures
- Corrections of errors in prior versions of the manual

Figure 1-1. Technical Reference Manual DSM Development, Measurement, and Update Cycle



This version of the manual (for the June 15, 2022, Virginia and North Carolina EM&V report filing) applies to the period from January 1 through December 31, 2021, in both states.

1.3 Algorithms

The algorithms calculate gross customer electric savings without counting line losses (from the generator to the customer), spillover, or persistence. A free-ridership assumption is specified for each program. For energy efficiency

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programs, the algorithms are driven by a change in efficiency level for the installed, energy-efficient (EE) measure compared to a baseline (base) level of efficiency. This change is reflected in both energy savings and demand reductions. The basic algorithms are presented below.

$$\text{Electric demand savings} = \Delta kW = kW_{base} - kW_{ee}$$

$$\text{Annual electric energy savings} = \Delta kWh = \Delta kW \times EFLH$$

$$\text{Electric summer coincident demand reduction} = \Delta kW_{summer} = \Delta kW \times CF_{summer}$$

$$\text{Electric winter coincident demand reduction} = \Delta kW_{winter} = \Delta kW \times CF_{winter}$$

Where:

kW_{base} = baseline connected load
kW_{ee} = energy-efficient connected load
EFLH = annual equivalent full load hours of operation for the installed measure
CF_{summer} = summer peak coincidence factor
CF_{winter} = winter peak coincidence factor

Algorithms for each of the program measures may incorporate additional factors to reflect specific conditions associated with a program or measure such as accounting for coincidence of multiple installations, or interaction between different measures.[1] In some cases, a savings factor is provided in place of the expanded algorithm if the factor is properly documented and applicable.

1.4 Measure Life

Measure lives are provided at the end of each section of this manual devoted to the measures offered as shown in Table 1-2. These are used for estimating lifetime savings for planning or in benefit/cost studies spanning more than one year. Measure lives are included in the initial planning assumptions as filed with the SCC and NCUC state regulatory commissions when each program was considered for approval. Program-level measure lives are a composite estimate of the associated measures that comprise the program. Programs no longer active are still included in this table if their measures are still delivering annual energy savings that are captured in the appendices within the annual report.

Table 1-2. Measure Life Assumptions by Program

DSM Phase	Program	Initial Participant Month	Final Participant Month	Final Savings Month	Effective Useful Measure Life[2] (Years)
Residential Programs					
1	Residential Lighting Program	May 2010	December 2011	April 2021	9.40, all measures

[1] Interactive effects include those from the installation of multiple measures at a single participant site. Where those interactive effects are accounted for in referenced technical reference manuals, they will also be documented in this Manual.

[2] Pre-DSM Phase VIII programs use program-wide, measure-savings-weighted effective useful life (EUL) values for calculating lifetime savings that are based upon program design assumptions; DSM Phase VIII programs and beyond use measure-specific EUL values, instead.

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DSM Phase	Program	Initial Participant Month	Final Participant Month	Final Savings Month	Effective Useful Measure Life[2] (Years)
1	Residential Low Income Program	April 2010	December 2014	May 2029	13.60, all measures
2	Residential Duct Testing and Sealing Program	October 2012	March 2017	February 2035	18.00
2	Residential Heat Pump Tune-Up Program	October 2012	March 2017	February 2022	5.00
2	Residential Heat Pump Upgrade Program	October 2012	March 2017	February 2032	15.00
2	Residential Home Energy Check-up Program	October 2012	March 2017	March 2027	10.00, all measures
4	Residential Appliance Recycling Program	September 2015	July 2017	June 2025	8.00, all measures
4	Residential Income and Age Qualifying Home Improvement Program	October 2015	June 2021	June 2036	14.00 (2015-2017) 15.00 (after 2018), all measures
5	Residential Retail LED Lighting Program	August 2017	December 2018	November 2038	20.00, all measures
7	Residential Appliance Recycling Program	September 2019	N/A	N/A	8.00, all measures
7	Residential Efficient Products Marketplace Program	August 2019	N/A	N/A	16.50, all measures
7	Residential Home Energy Assessment Program	January 2020	N/A	N/A	12.41, all measures
8	Residential Thermostat (Energy Efficiency) Program	February 2021	N/A	N/A	1.00–7.50
8	Residential Customer Engagement Program	July 2021	N/A	N/A	1.00
8	Residential Energy Efficient Kits Program	July 2021	N/A	N/A	1.71 – 15.00
8	Residential Manufactured Housing Program, DSM Phase VIII	December 2021	N/A	N/A	1.71–25.00
8	Residential Home Retrofit Program, DSM Phase VIII	July 2021	N/A	N/A	1.71–25.00
8	Residential Multifamily Program	December 2021	N/A	N/A	1.71–25.00
8	Electric Vehicle (EE) Program	July 2021	N/A	N/A	10.00
8	Residential HB2789 (Heating and Cooling/Health and Safety)	May 2021	N/A	N/A	5.00–25.00
8	Residential New Construction	May 2021	N/A	N/A	25.00

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DSM Phase	Program	Initial Participant Month	Final Participant Month	Final Savings Month	Effective Useful Measure Life[2] (Years)
Non-Residential Programs					
1	Commercial HVAC Upgrade Program	July 2010	October 2012	September 2027	15.00, all measures
1	Commercial Lighting Program	June 2010	November 2012	July 2022	10.00, all measures
2	Non-Residential Duct Testing and Sealing Program	November 2012	March 2017	February 2042	25.00
2	Non-Residential Energy Audit Program	May 2013	March 2017	February 2024	7.00, all measures
3	Non-Residential Heating and Cooling Efficiency Program	November 2014	March 2019	February 2034	15.00, all measures
3	Non-Residential Lighting & Controls Program	October 2014	March 2020	February 2029	9.00, all measures
3	Non-Residential Window Film Program	October 2014	February 2019	January 2029	10.00, all measures
5	Non-Residential Small Business Improvement Program	October 2016	February 2021	November 2033	14.00, all measures
6	Non-Residential Prescriptive Program	December 2017	N/A	N/A	6.30, all measures
7	Non-Residential Heating and Cooling Efficiency Program	May 2020	N/A	N/A	15.00, all measures
7	Non-Residential Lighting Systems & Controls Program	March 2020	N/A	N/A	10.59, all measures
7	Non-Residential Office Program	November 2020	N/A	N/A	7.00, all measures
7	Non-Residential Small Manufacturing Program	October 2021	N/A	N/A	12.24, all measures
7	Non-Residential Window Film Program	April 2020	N/A	N/A	10.00
8	Non-Residential Midstream Energy Efficient Products Program	October 2021	N/A	N/A	12.00–23.00
8	Non-Residential New Construction Program	-	-	-	8.00–25.00
8	Non-Residential Small Business Improvement Enhanced	May 2021	N/A	N/A	4.00–18.00
8	Non-Residential Multifamily Program	-	-	-	5.00–18.00
Peak-shaving Programs					
1	Residential AC Cycling Program	June 2010	N/A	N/A	1.00

DSM Phase	Program	Initial Participant Month	Final Participant Month	Final Savings Month	Effective Useful Measure Life[2] (Years)
2	Non-Residential Distributed Generation Program	June 2012	N/A	N/A	1.00
8	Thermostat (DR) Program	March 2021	-	-	1.00
8	Electric Vehicle (DR) Program	-	-	-	1.00

1.5 Data and Input Values

Input values and algorithms in the protocols and on the program application forms are based primarily on the best available and applicable data for Dominion's programs. In more detail, the input values are taken primarily from two sources: program application forms completed during enrolment, or from standard values based on measured or industry data. As stated earlier, this manual leverages the Maryland/Mid-Atlantic TRM v10 whenever possible.

Many input values, including site-specific data, are taken directly from program application forms, worksheets, and field tools. Site-specific data on the application forms are used for measures with important variations in one or more input values (e.g., delta watts, efficiency rating, capacity, etc.).

Standard input values are based on the best available measured or industry data, including metered data, measured data from prior evaluations (applied prospectively), field data and program results, and standards from industry associations. Many input values are based on evaluations of programs in other similar regions.

For the standard input assumptions for which metered or measured data were not available, the input values (e.g., delta watts, delta efficiency, equipment capacity, operating hours, and coincidence factors) were based on the best available industry data or standards. These input values were developed from a review of literature from industry organizations, equipment manufacturers, and suppliers.

Program evaluation will be used to assess key data and input values to either confirm that current values should continue to be used or update the values going forward.

1.6 Peak Definition

Gross coincident peak demand reduction or potential represents the average expected connected load over a peak period defined by the power system operators. In most cases, demand reductions are calculated using a CF, which represents the fraction of the annual average connected load expected to be coincident with the defined peak period.

Peak demand reduction calculations for individual measures in this document are based on the respective source TRM's demand reduction calculations, as referenced in each section. Depending on the TRM referenced and the jurisdiction that it applies to, peak demand reduction can be defined differently per TRM and thus per measure in this Manual. Table 1-3 lists the peak period definitions for TRMs referenced in this Manual.

The Maryland/Mid-Atlantic TRM v10 uses data and assumptions specific to the Mid-Atlantic region, wherever possible. For this reason, DNV leverages energy and demand calculations from the Maryland/Mid-Atlantic TRM v10 to the fullest extent possible. However, several assumptions and peak coincidence factors (CFs) originate in other regions because they are the most transferable resources available.[3] These other TRMs have some variation in peak performance period definition, geography, climate, and customer characteristics.

Table 1-3. Definition of Peak Demand in Reference TRMs

Peak period definition source	Dates[4]	Hours[5]	TRMs using this period
Dominion Summer Peak Demand	July summer peak day for the year	4:00 p.m.– 5:00 p.m.	Applied in this manual
Dominion Winter Peak Demand	Mondays in January	7:00 a.m.– 8:00 a.m.	Applied in this manual
PJM Summer Peak Performance Hours	June 1 – August 31	2 p.m. – 6 p.m.	All versions of the Mid-Atlantic and Maryland/Mid-Atlantic TRM (non-cooling measures) Pennsylvania TRM
Peak Performance Hours	June 1 – August 31	3 p.m.– 6 p.m. Summer: 3 p.m.– 6 p.m.	Pennsylvania TRM; 2017 Arkansas TRM
ISO New England Seasonal Peak Demand Savings	Summer: June 1 – August 31 Winter: December 1 – January 31	Summer: 1 p.m.– 5 p.m. Winter: 5 p.m.– 7 p.m.	2016 Maine Commercial TRM 2014 Massachusetts TRM
2015 Avoided Energy Supply Costs in New England Report	Summer: June to September Winter: October to May	7 a.m.– 11 p.m.	2015 Vermont TRM
Peak Performance Hours	Summer: June 1 – September 30 Winter: December 1 – March 31	Summer: 2 p.m.– 5 p.m. Winter: 6 a.m.– 8 a.m.	2016 TVA TRM
Summer Peak Period	Summer: June to August	Summer: 1 p.m.– 4 p.m.	2019 Wisconsin TRM
Peak Period	Summer: June – August (Non-weather sensitive) Summer: July 30 (Weather sensitive) Winter: October to May	Summer: 3 p.m.– 6 p.m. (non-weather sensitive) Summer: 6 p.m. (Weather sensitive)	2019 Iowa TRM
Summer System Peak	Mid-Atlantic TRM: Summer System Peak days (hottest summer weekdays)	5 p.m.	2014 Mid-Atlantic TRM (cooling measures)
	TVA TRM: Summer and Winter System Peak hours	Summer: 10 hottest hours Winter: 10 coldest hours	2013 TVA TRM (weather-sensitive measures)

3 For more discussion about the transferability of consumption data, see the EM&V Forum Report: Cataloguing Available End-Use and Efficiency Measure Load Data, October 2009 at http://www.neep.org/file/1010/download?token=XDUhN8Aq.

4 Excluding weekends and federal holidays

5 Local time zone

Peak period definition source	Dates[4]	Hours[5]	TRMs using this period
	New York TRM: hottest summer day in June – August	5 p.m.	2019 New York TRM
Coincident Peak	June 1 – September 30	2 p.m.– 6 p.m.	2018 Michigan Energy Measure Database
	June 1 – August 31	12 p.m.– 8 p.m.	2019 New Jersey Clean Energy Program Protocols to Measure Resource Savings
Coincident Summer Peak	June 1 – August 31	1 p.m.– 5 p.m.	2019 Illinois TRM

As this Manual provides deemed energy savings and peak demand, impact evaluations conducted on a regular basis can be used to adjust them for Dominion's needs. Dominion's summer peak demand period is defined as the hour ending at 1700 hour on Dominion's July summer peak day for that year. The winter peak demand period is Mondays in January at the hour ending at 0800 hour. Coincidence factor is defined as the ratio of this coincident peak load to annual (non-coincident) peak for that measure's load shape.

Gross coincident demand reduction results are used for comparison against Dominion's program goals for this same metric. They are also used for bidding energy efficiency resources in wholesale electric capacity markets operated by regional bulk power system operators, such as the PJM Reliability Pricing Model and the ISO New England Forward Capacity Market.

1.7 Participant Definitions

Participants may be counted differently as shown in Table 1-4, depending upon the program and/or application.

Table 1-4. Program Definitions of Participants

DSM Phase	Program	DNV Definition	IRP Definition
	Residential Programs		
4	Residential Income and Age Qualifying Home Improvement (DSM Phase IV)	Only the first instance of a Dominion-approved rebate associated with a given electric account ID is counted as a unique participant. It is counted as a participant in the month that their first rebate is approved. The savings associated with subsequent measure(s) for a repeated electric account ID will be attributed to the month of their Dominion-approved rebate but will not increase the participant tally for the program.	Single household
7	Residential Home Energy Assessment, DSM Phase VII		
7	Residential Efficient Product Marketplace, DSM Phase VII		
7	Residential Appliance Recycling, DSM Phase VII		
8	Residential Thermostat Purchase (Energy Efficiency) Program, DSM Phase VIII		
8	Residential Thermostat Behaviour (Energy Efficiency) Program, DSM Phase VIII		

DSM Phase	Program	DNV Definition	IRP Definition
8	Residential Customer Engagement Program, DSM Phase VIII		
8	Residential Energy Efficient Kits Program, DSM Phase VIII		
8	Residential Manufactured Housing Program, DSM Phase VIII		
8	Residential Home Retrofit Program, DSM Phase VIII		
8	Residential/Multifamily Program, DSM VIII		
8	Residential HB2789 (Heating and Cooling/Health and Safety), DSM Phase VIII		
8	Residential New Construction, DSM Phase VIII		
8	Electric Vehicle (EE) Program, DSM Phase VIII	Account ID, by charger	Single household
	Non-Residential Programs		
3	Non-Residential Lighting Systems and Controls, DSM Phase III	Only the first instance of a Dominion-approved rebate associated with a given electric account ID is counted as a unique participant. It is counted as a participant in the month that their first rebate is approved. The savings associated with subsequent measure(s) for a repeated electric account ID will be attributed to the month of their Dominion-approved rebate but will not increase the participant tally for the program.	Single building
7	Non-Residential Lighting Systems and Controls, DSM Phase VII		
3	Non-Residential Heating and Cooling Efficiency, DSM Phase III		
7	Non-Residential Heating and Cooling Efficiency, DSM Phase VII		
3	Non-Residential Window Film, DSM Phase III		Square footage of installed window film at one building
7	Non-Residential Window Film, DSM Phase VII		
5	Non-Residential Small Business Improvement, DSM Phase V		Single building
6	Non-Residential Prescriptive, DSM Phase VI		
7	Non-Residential Small Manufacturing, DSM Phase VII		
7	Non-Residential Small Office, DSM Phase VII		
8	Non-Residential Midstream Energy Efficient Products Program, DSM Phase VIII		
8	Non-Residential New Construction Program, DSM Phase VIII		
8	Non-Residential Small Business Improvement Enhanced, DSM Phase VIII		
8	Non-Residential Multifamily Program, DSM Phase VIII		

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DSM Phase	Program	DNV Definition	IRP Definition
	Peak-Shaving Programs		
1	Residential AC Cycling, DSM Phase I	A unique electric account ID	Single AC or HP unit
2	Non-Residential Distributed Generation, DSM Phase II	1 MW available to Dominion for dispatch	1 MW of generated energy
8	Residential Electric Vehicle (DR) Program, DSM Phase VIII	A unique electric account ID	Single charger
8	Residential Thermostat (DR) Program, DSM Phase VIII	A unique electric account ID, by thermostat	Single thermostat

1.8 Program-Specific Impacts Protocols

Sections 2 through 17 of this appendix provide descriptions of each program and the protocol for calculating energy savings and demand reductions for the measures under each residential program offered by Dominion. Measure information for Non-Residential programs is provided in Appendix F2.

For each measure, its section gives the energy savings and demand reduction algorithms, input values, default savings calculations, and sources for the protocols. Unless the states in which they are implemented are specifically listed below, the programs are implemented in both Virginia and North Carolina.

For program-specific measure descriptions and savings protocols, click on one of the section links that follow:

Section 2: Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV

Section 3: Residential AC Cycling Program, DSM Phase I

Section 4: Residential Appliance Recycling Program, DSM Phase VII

Section 5: Residential Home Energy Assessment Program, DSM Phase VII

Section 6: Residential Efficient Products Marketplace Program, DSM Phase VII

Section 7: Residential Thermostat (Energy Efficiency) Program, DSM Phase VIII

Section 8: Residential Thermostat Smart Rewards Demand Response Program, DSM Phase VIII

Section 9: Residential Customer Engagement Program, DSM Phase VIII

Section 10: Residential Energy Efficiency Kits Program, DSM Phase VIII

Section 11: Residential Manufactured Housing Program, DSM Phase VIII

Section 12: Residential Home Retrofit Program, DSM Phase VIII

Section 13: Residential/Non-Residential Multifamily Program, DSM Phase VIII

Section 14: Residential Electrical Vehicle (EE) Program, DSM Phase VIII

Section 15: Residential Electrical Vehicle (DR) Program, DSM Phase VIII

Section 16: Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII

Section 17: Residential New Construction Program

Section 18: References

Section 19: Sub-appendices

2 RESIDENTIAL INCOME AND AGE QUALIFYING HOME IMPROVEMENT PROGRAM, DSM PHASE IV

The Residential Income and Age Qualifying Home Improvement Program provides direct install energy efficiency improvements to age and income qualifying homeowners in order to reduce electric use. The measures offered through the program and the sections that contain the savings algorithms for each measure are presented in Table 2-1.

Table 2-1. Income & Age Qualifying Home Improvement Program Measure List

End Use	Measure	Section
Domestic Hot Water	Domestic Hot Water Pipe Insulation	Section 2.1.1
	Kitchen & Bathroom Aerator	Section 2.1.2
	Low-flow Showerhead	Section 2.1.3
HVAC	Building Insulation	Section 2.2.1
Lighting	LED Lighting	Section 2.3.1

The program has been offered in Virginia since 2015 and in North Carolina since 2016.

2.1 Domestic Hot Water End Use

2.1.1 Domestic Hot Water Pipe Insulation

2.1.1.1 Measure Description

This measure realizes energy savings by adding insulation to uninsulated domestic hot water piping. The measure assumes the pipe wrap is installed to the first elbow of the hot water carrying pipe. The baseline condition is uninsulated hot water copper piping.

This measure is offered through different programs listed in Table 2-2, and uses the impacts estimation approach described in this section.

Table 2-2. Programs that Offer Domestic Hot Water Pipe Insulation

Program Name	Section
Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 2.1.1
Residential Home Energy Assessment Program, DSM Phase VII	Section 5.2.1
Residential Energy Efficiency Kits Program, DSM Phase VIII	Section 10.2.1
Residential Manufactured Housing Program, DSM Phase VIII	Section 11.2.3
Residential Home Retrofit Program, DSM Phase VIII	Section 12.2.1
Residential/Non-Residential Multifamily Program, DSM Phase VIII	Section 13.2.1

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2.1.1.2 Impacts Estimation Approach

Per measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \frac{\left(\frac{1}{R_{base}} - \frac{1}{R_{ee}}\right) \times L \times C \times \Delta T \times HOU}{3{,}412 \frac{Btu/h}{kW} \times \eta_{DHW}}$$

Per measure, gross summer peak coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{\Delta kWh}{HOU} \times CF_{summer}$$

Per measure, gross winter peak coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh}{HOU} \times CF_{winter}$$

Where:

ΔkWSummer	= per measure gross summer peak coincident demand reduction
ΔkWWinter	= per measure gross winter peak coincident demand reduction
Rbase	= assumed R-value of existing uninsulated piping
Ree	= R-value of existing pipe plus installed insulation
L	= length of piping insulated
C	= circumference of piping
ΔT	= temperature difference between water at the inlet pipe and ambient air
HOU	= annual hours of use
ηDHW	= recovery efficiency of electric, domestic water heater with storage tank
CFsummer	= summer peak coincident factor
CFwinter	= winter peak coincident factor

2.1.1.3 Input Variables

Table 2-3. Input Values for Domestic Water Heater Pipe Insulation Savings Calculations

Component	Type	Value	Unit	Source(s)
R_{base}	Fixed	1.0	hour·°F·feet^2/Btu	Mid-Atlantic TRM v9, p. 186[6]
R_{ee}	Fixed	2.5	hour·°F·feet^2/Btu	Program design

[6] Mid-Atlantic TRM v9, p.186. Navigant Consulting Inc., April 2009; "Measures and Assumptions for Demand Side Management (DSM) Planning; Appendix C Substantiation Sheets," p. 77, presented to the Ontario Energy Board. http://www.ontarioenergyboard.ca/oeb/_Documents/EB-2008-0346/Navigant_Appendix_C_substantiation_sheet_20090429.pdf. Accessed 9/16/2019.

Component	Type	Value	Unit	Source(s)
L	Variable	See customer application	feet	Customer application
		Default = 1		Mid-Atlantic TRM v9, p. 187
C	Variable	See customer application	feet	Customer application
		Default = 0.13		Mid-Atlantic TRM v9, p. 187
ΔT	Fixed	65	°F	Mid-Atlantic TRM v9, p. 187[7]
η_{DHW}	Fixed	0.98	–	Mid-Atlantic TRM v9, p. 187[8]
HOU	Fixed	8,760	hour	Mid-Atlantic TRM v9, p. 187
CF_{summer}	Fixed	1.0	–	Mid-Atlantic TRM v9, p. 187[9]
CF_{winter}	Fixed	1.0	–	Mid-Atlantic TRM v9, p. 187[9]

2.1.1.4 Default Savings

If the proper values are not supplied, a default savings may be applied using conservative input values. The default per measure gross annual electric energy savings will be assigned according to the following calculation.

$$\Delta kWh = \frac{\left(\frac{1}{R_{base}} - \frac{1}{R_{ee}}\right) \times L \times C \times \Delta T \times HOU}{3{,}412 \frac{Btu/h}{kW} \times \eta_{DHW}}$$

$$= \frac{\left(\frac{1}{1.0} - \frac{1}{2.5}\right) \frac{Btu}{hr \cdot °F \cdot ft^2} \times 1\,ft \times 0.13\,ft \times 65\,°F \times 8{,}760\,hours}{3{,}412 \frac{Btu/h}{kW} \times 0.98}$$

$$= 13.3\,kWh$$

The default per measure gross summer peak coincident demand reductions will be assigned according to the following calculation:

$$\Delta kW_{summer} = \frac{\Delta kWh}{HOU} \times CF_{summer}$$

$$= \frac{13.3\,kWh}{8{,}760\,hours} \times 1.0$$

[7] Mid-Atlantic TRM v9, p. 187. Assumes 130°F water leaving the hot water tank and an average basement temperature of 65°F.

[8] Mid-Atlantic TRM v9, p. 187. Electric water heaters have a recovery efficiency of 98%. http://www.ahrinet.org/App_Content/ahri/files/Certification/GAMA/PG-CMW.pdf. Accessed 9/17/2019

[9] Mid-Atlantic TRM v9 does not provide a CF, therefore a CF of 1.0 is implied.

DNV

$$= 0.002\ kW$$

The default per measure gross winter peak coincident demand reductions will be assigned according to the following calculation:

$$\Delta kW_{winter} = \frac{\Delta kWh}{HOU} \times CF_{winter}$$

$$= \frac{13.3\ kWh}{8{,}760\ hours} \times 1.0$$

$$= 0.002\ kW$$

2.1.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 2-4.

Table 2-4. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Energy Efficiency Kits Program, DSM Phase VIII	15.00	years	Mid-Atlantic TRM v9, p. 188
	Residential Manufactured Housing Program, DSM Phase VIII			
	Residential Home Retrofit Program, DSM Phase VIII			
	Residential/Non-Residential Multifamily Program, DSM Phase VIII			
VII	Residential Home Energy Assessment Program	12.41	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)
IV	Residential Income & Age Qualifying Home Improvement program	15.00	years	

2.1.1.6 Source(s)

The primary source for this deemed savings approach is the Mid-Atlantic TRM v9, pp. 186-188.

2.1.1.7 Update Summary

Updates to this section are described in Table 2-5.

Table 2-5. Summary of Update(s)

Version with Updates	Update Type	Description
2021	New table	Effective Useful Life (EUL) by program
	Equations	Added gross winter peak demand reduction equation
2020	None	No change
v10	Source	Updated page numbers / version of the Mid-Atlantic TRM
	Input Variable	Clarified default assumption value

2.1.2 Faucet Aerator

2.1.2.1 Measure Description

This measure realizes energy savings by installing a low-flow faucet aerator in a home's kitchen and/or bathroom. Doing so reduces overall water usage and, in particular, the need to heat water. Faucet aerators are changed from those that deliver an estimated 2.2 gallons per minute (gpm) to low-flow, ≤1.5-gpm aerators.

This measure is offered through various programs as listed in Table 2-6, and uses the Impacts estimation Approach described in this section.

Table 2-6. Programs that Offer Faucet Aerator

Program Name	Section
Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 2.1.2
Residential Home Energy Assessment Program, DSM Phase VI	Section 5.2.3
Residential Energy Efficiency Kits Program, DSM Phase VIII	Section 10.2.2
Residential Manufactured Housing Program, DSM Phase VIII	Section 11.2.4
Residential Home Retrofit Program, DSM Phase VIII	Section 12.2.2
Residential/Non-Residential Multifamily Program, DSM Phase VIII	Section 13.2.2

2.1.2.2 Impacts Estimation Approach

Per measure, gross annual water savings are calculated according to the following equation:

$$\Delta Water = [(Flow_{base} \times Throttle_{base}) - (Flow_{ee} \times Throttle_{ee})] \times Minutes_{faucet} \times Qty_{people} \times Flow_{drain} \times 365\ days$$

DNV

Per measure, gross annual electric energy savings[10] are calculated according to the following equation:

$$\Delta kWh = \frac{\Delta Water \times 8.3\, lb/gal \cdot Btu/lb/°F \times \Delta T \times ISR}{\eta_{DHW} \times 3{,}412 \frac{Btu/h}{kW}}$$

Per measure, gross summer peak coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{Summer} = \frac{\Delta kWh \times CF_{Summer}}{Minutes_{faucet} \times Qty_{people} \times \frac{1\, hour}{60\, min.} \times 365\, days}$$

Per measure, gross winter peak coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{Winter} = \frac{\Delta kWh \times CF_{Winter}}{Minutes_{faucet} \times Qty_{people} \times \frac{1\, hour}{60\, min.} \times 365\, days}$$

Where:

ΔWater	= per measure gross annual water savings per faucet
ΔkWh	= per measure gross annual electric energy savings per faucet
ΔkW_{Summer}	= gross summer peak coincident demand reductions
ΔkW_{Winter}	= gross winter peak coincident demand reductions
$Flow_{base}$	= baseline faucet flow rate
$Flow_{ee}$	= energy efficient (low-flow) faucet flow rate
Qty_{people}	= number of people per household
$Flow_{drain}$	= percentage of water flowing down drain
$Minutes_{faucet}$	= average length of use of faucet per person per day
$Throttle_{base}$	= baseline faucet throttling factor
$Throttle_{ee}$	= energy efficient (low-flow) faucet throttling factor
ΔT	= change in temperature of the water used for kitchen and bathroom faucets and temperature entering the house ($\Delta T = T_{faucet} - T_{in\text{-}house}$)
η_{DHW}	= recovery efficiency of electric, storage-tank water heater
CF	= peak coincidence factor
ISR	= installation rate
$Delivery_{type}$	= measure delivery type
$Room_{type}$	= location of faucet aerator
CF_{summer}	= summer peak coincident factor
CF_{winter}	= winter peak coincident factor

[10] Maryland/Mid-Atlantic TRM v10, p. 133. Note, the algorithm and variables are provided as documentation for the deemed savings result provided which should be claimed for all faucet aerator installations.

DNV

2.1.2.3 Input Variables

Table 2-7. Input Values for Faucet Aerators Savings Calculations

Component	Type	Value	Unit	Source(s)
$Flow_{base}$	Fixed	2.2	gallon/ minute	Maryland/Mid-Atlantic TRM v10, p. 177[11]
$Flow_{ee}$	Fixed	1.5	gallon/ minute	Program design[12]
Qty_{people}	Variable	See customer application	–	Customer application
		Default = 2.0		Dominion Residential Home Energy Use Survey 2019–2020 Appendix B, p. 100
$Flow_{drain}$	Variable	Kitchen: 0.5 Bathroom: 0.7	–	Maryland/Mid-Atlantic TRM v10, p. 134[13]
$Throttle_{base}$	Fixed	0.83	–	Maryland/Mid-Atlantic TRM v10, p. 134
$Throttle_{ee}$	Fixed	0.95	–	Maryland/Mid-Atlantic TRM v10, p. 134[14]
$Minutes_{faucet}$	Variable	Kitchen: 4.5 Bathroom: 1.6	minute/ person/ day	Maryland/Mid-Atlantic TRM v10, p. 134[15]
ΔT	Variable	Kitchen: 32.1 Bathroom: 25.1	°F	Maryland/Mid-Atlantic TRM v10, p. 134[16]
η_{DHW}	Fixed	0.98	–	Maryland/Mid-Atlantic TRM v10, p. 134[17]
CF_{Summer}	Fixed	0.00262	–	Maryland/Mid-Atlantic TRM v10, p. 135[18]
CF_{Winter}	Fixed	0.00262	–	Maryland/Mid-Atlantic TRM v10, p. 135[19]

[11] Maryland/Mid-Atlantic TRM v.10 , p. 133. In 1998, the Department of Energy adopted a maximum flow rate standard of 2.2 gpm at 60 psi for all faucets: 63 Fed. Reg. 13307; March 18, 1998.

[12] Based on program eligibility requirements.

[13] Maryland/Mid-Atlantic TRM v10 p. 133. Estimate consistent with Ontario Energy Board, "Measures and Assumptions for Demand Side Management Planning."

[14] Maryland/Mid-Atlantic TRM v10 , p. 134. Schultdt, Marc, and Debra Tachibana, "Energy Related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings," 2008, page 1-265.

[15] Maryland/Mid-Atlantic TRM v10 , p. 134. Cadmus and Opinion Dynamics Evaluation Team. Showerhead and Faucet Aerator Meter Study. For Michigan Evaluation Working Group. June 2013. If aerator location is known, use the corresponding kitchen/bathroom value. If unknown, use 3 min/person/day as the average length of use value, which is the total for the household: kitchen (4.5 min/person/day) + bathroom (1.6 min/person/day) = 6.1 min/person/day/2. Via Pennsylvania TRM.

[16] Maryland/Mid-Atlantic TRM v10 , p. 134. Navigant Consulting “EmPOWER Maryland Draft Final Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Residential Retrofit Programs.” April 4, 2014, Appendix E, page 66.

[17] Maryland/Mid-Atlantic TRM v10 , p. 134. Electric water heater has recovery efficiency of 98%. http://www.ahrinet.org/App_Content/ahri/files/Certification/GAMA/PG-CMW.pdf. Accessed 9/17/2019.

[18] Maryland/Mid-Atlantic TRM v10 , p. 134. “Calculated as follows: Assume 13% faucet use takes place during peak hours (based on http://s3.amazonaws.com/zanran_storage/www.aquacraft.com/ContentPages/47768067.pdf). 13% * 3.6 minutes per day (10.9 * 2.56 / 3.5 / 2.2 = 3.6) = 0.47 minutes = 0.47 / 180 (minutes in peak period) = 0.00262.” Website was provided in Mid-Atlantic TRM and could not be accessed when DNV attempted on 8/4/2016.

[19] The source TRM for this measure does not include a winter CF. We apply the summer CF for the coincident winter peak period as it is the best information available.

Component	Type	Value	Unit	Source(s)
ISR	Variable	Assigned by program:[20] Residential Income and Age Qualifying Home Improvement Program, Residential Manufactured Housing Program, Residential Home Retrofit Program, Residential/ Non-Residential Multifamily Program ISR = 1.0 Residential Energy Efficiency Kits Program ISR = 0.35	–	Pennsylvania Vol. 2 Res 2019, p. 84

2.1.2.4 Default Savings

If the proper values are not supplied, a default savings may be applied using conservative input values. The default per measure gross annual water savings will be assigned according to the following calculations.

Kitchen:

$$\Delta Water = [(Flow_{base} \times Throttle_{base}) - (Flow_{ee} \times Throttle_{ee})] \times Minutes_{faucet} \times Qty_{people} \times Flow_{drain} \times 365\ days$$

$$= [(2.2\ gpm \times 0.83) - (1.5\ gpm \times 0.95)] \times \frac{4.5\ min./person}{day} \times 2.0\ people \times 0.5 \times 365\ days$$

$$= 658\ \text{gallons}$$

Bathroom:

$$\Delta Water = [(Flow_{base} \times Throttle_{base}) - (Flow_{ee} \times Throttle_{ee})] \times Minutes_{faucet} \times Qty_{people} \times Flow_{drain} \times 365\ days$$

$$= [(2.2\ gpm \times 0.83) - (1.5\ gpm \times 0.95)] \times \frac{1.6\ min./person}{day} \times 2.0\ people \times 0.7 \times 365\ days$$

[20] The ISR is assigned by the implementation channel. Direct install programs have an ISR of 1.0 and other programs have a value of 0.35.

$$= 328 \text{ gallons}$$

The default per measure gross annual electric energy savings will be assigned according to the following calculations:

Kitchen:

$$\Delta kWh = \frac{\Delta Water \times 8.3\, lb/gal \cdot Btu/lb/°\text{F} \times \Delta T \times ISR}{\eta_{DHW} \times 3{,}412 \frac{Btu/h}{kW}}$$

$$= \frac{658\ gallons \times 8.3\, lb/gal \cdot Btu/lb/°\text{F} \times 32.1\ °\text{F} \times 1.0}{0.98 \times 3{,}412 \frac{Btu/h}{kW}}$$

$$= 52 \text{ kWh}$$

Bathroom:

$$\Delta kWh = \frac{\Delta Water \times 8.3\, lb/gal \cdot Btu/lb/°\text{F} \times \Delta T \times ISR}{\eta_{DHW} \times 3{,}412 \frac{Btu/h}{kW}}$$

$$= \frac{415\ gallons \times 8.3\, lb/gal \cdot Btu/lb/°\text{F} \times 25.1\ °\text{F} \times 1.0}{0.98 \times 3{,}412 \frac{Btu/h}{kW}}$$

$$= 20.5 \text{ kWh}$$

The default per measure gross summer peak coincident demand reductions will be assigned according to the following calculation:

Kitchen:

$$\Delta kW_{summer} = \frac{\Delta kWh \times CF_{summer}}{Minutes_{faucet} \times Qty_{people} \times \frac{1\ hour}{60\ min.} \times 365\ days}$$

$$= \frac{52\ kWh \times 0.00262}{4.5\ minutes \times 2.0\ people \times \frac{1\ hour}{60\ min.} \times 365\ days}$$

$$= 0.0025 \text{ kW}$$

Bathroom:

$$\Delta kW_{summer} = \frac{\Delta kWh \times CF_{summer}}{Minutes_{faucet} \times Qty_{people} \times \frac{1\ hour}{60\ min.} \times 365\ days}$$

$$= \frac{20.5\ kWh \times 0.00262}{1.6\ minutes \times 2.0\ people \times \frac{1\ hour}{60\ min.} \times 365\ days}$$

$$= 0.0028\ \text{kW}$$

The default per measure gross winter peak coincident demand reductions will be assigned according to the following calculation:

Kitchen:

$$\Delta kW_{winter} = \frac{\Delta kWh \times CF_{winter}}{Minutes_{faucet} \times Qty_{people} \times \frac{1\ hour}{60\ min.} \times 365\ days}$$

$$= \frac{52\ kWh \times 0.00262}{4.5\ minutes \times 2.0\ people \times \frac{1\ hour}{60\ min.} \times 365\ days}$$

$$= 0.0025\ \text{kW}$$

Bathroom:

$$\Delta kW_{winter} = \frac{\Delta kWh \times CF_{winter}}{Minutes_{faucet} \times Qty_{people} \times \frac{1\ hour}{60\ min.} \times 365\ days}$$

$$= \frac{20.5\ kWh \times 0.00262}{1.6\ minutes \times 2.0\ people \times \frac{1\ hour}{60\ min.} \times 365\ days}$$

$$= 0.0028\ \text{kW}$$

2.1.2.5 Effective Useful Life

The effective useful life of this measure is provided in Table 2-5.

Table 2-5. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Energy Efficiency Kits Program, DSM Phase VIII	10.00	years	Mid-Atlantic TRM 2018, p. 174
	Residential Manufactured Housing Program, DSM Phase VIII			
	Residential Home Retrofit Program, DSM Phase VIII			
	Residential/Non-Residential Multifamily Program, DSM Phase VIII			
VII	Residential Home Energy Assessment Program, DSM Phase VI	12.41	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)
IV	Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	15.00	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

2.1.2.6 Source(s)

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v10, pp.133-136.

2.1.2.7 Update Summary

Updates to this section are described in Table 2-8.

Table 2-8. Summary of Update(s)

Version	Update Type	Description
2021	Equation	• Added in-service rate to account for self-install program • Removed electric water heater variable as this measure is only eligible for electric water heaters • Added winter peak coincident demand reduction equation
	Inputs	Replaced the Mid-Atlantic TRM with the Dominion Residential Home Energy Use Survey 2019 – 2020 as the source of the number of people
	New table	Effective Useful Life (EUL) by program
2020	None	No change
v10	Source	Updated page numbers / version of the Mid-Atlantic TRM
	Input Variable	Updated kitchen values for ΔT and $Flow_{drain}$
	Equation	Updated equation for water savings

DNV

2.1.3 Low-Flow Showerhead

2.1.3.1 Measure Description

This measure realizes energy savings by replacing an existing showerhead with a low-flow showerhead. Doing so reduces overall water usage and, in particular, the need to heat water. Showerheads are changed from those that deliver an estimated 2.5 gpm to low-flow, ≤2.0-gpm aerators. The baseline condition is a showerhead with a flow rate of 2.5 gpm.

This measure is offered through different programs listed in Table 2-7 and uses the impacts estimation approach described in this section.

Table 2-9. Programs that Offer Low-Flow Showerhead

Program Name	Section
Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 2.1.3
Residential Home Energy Assessment Program, DSM Phase VII	Section 5.2.4
Residential Energy Efficiency Kits Program, DSM Phase VIII	Section 10.2.3
Residential Manufactured Housing Program, DSM Phase VIII	Section 11.2.5
Residential Home Retrofit Program, DSM Phase VIII	Section 12.2.4
Residential Multifamily Program, DSM Phase VIII	Section 13.2.3

2.1.3.2 Impacts Estimation Approach

Gross annual water savings per showerhead are calculated according to the following equation:

$$\Delta Water = \left[(Flow_{base} - Flow_{ee}) \times Qty_{people} \times Minutes_{shower} \times Showers_{daily} \times ISR \times days\right] \div Qty_{showerheads}$$

Gross annual electric energy savings per showerhead are calculated according to the following equation:

$$\Delta kWh = \frac{\Delta Water \times 8.3\, lb/gal \times 1\, Btu/lb/°F \times \Delta T}{\eta_{DHW} \times 3{,}412\, Btu/kWh}$$

Per measure, gross summer peak coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{\Delta kWh \times CF_{summer}}{Minutes_{shower} \times Qty_{people} \times Showers_{daily} \times \frac{1\ hour}{60\ min.} \times days}$$

Per measure, gross winter peak coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh \times CF_{winter}}{Minutes_{shower} \times Qty_{people} \times Showers_{daily} \times \frac{1\ hour}{60\ min.} \times days}$$

Where:

	= gross annual water savings per showerhead
ΔkWh	= gross annual electric energy savings per showerhead
ΔkW_{summer}	= gross summer peak coincident demand reduction per showerhead
ΔkW_{winter}	= gross summer peak coincident demand reduction per showerhead
$Flow_{base}$	= baseline showerhead flow rate
$Flow_{ee}$	= energy efficient (low-flow) showerhead flow rate
Qty_{people}	= number of people per household
$Minutes_{shower}$	= average shower duration
$Showers_{daily}$	= average showers per person per day
Qty_{shower}	= number of showers in home
ΔT	= change in temperature of the water used for shower and temperature entering the house ($\Delta T = T_{shower} – T_{in\ house}$)
η_{DHW}	= recovery efficiency of electric, storage-tank water heater
CF	= peak coincidence factor
ISR	=installation rate/ in service rate
CF_{summer}	= summer peak coincident factor
CF_{winter}	= winter peak coincident factor

2.1.3.3 Input Variables

Table 2-10. Input Values for Low-Flow Shower Head Savings Calculations

Component	Type	Value	Unit	Source(s)
$Flow_{base}$	Fixed	2.5	gpm	Maryland/Mid-Atlantic TRM v10, p. 137[21]
$Flow_{ee}$	Fixed	2.0	gpm	Program design
Qty_{people}	Variable	See customer application	–	Customer application
		Default = 2.0		Dominion Residential Home Energy Use Survey 2019 - 2020 Appendix B, p. 100
$Minutes_{shower}$	Fixed	7.8	minute/ shower	Maryland/Mid-Atlantic TRM v10, p. 137[22]

[21] The Energy Policy Act of 1992 (EPAct) established the maximum flow rate for showerheads at 2.5 gallons per minute (gpm).

[22] Maryland/Mid-Atlantic TRM v10, p. 137. Table 6. Cadmus and Opinion Dynamics Evaluation Team. Showerhead and Faucet Aerator Meter Study. For Michigan Evaluation Working Group. June 2013. The study compared shower length by single-family and multifamily populations, finding no statistical difference in showering times. For the energy-saving analysis, the study used the combined single-family and multifamily average shower length of 7.8 minutes. Per Pennsylvania TRM-2016.

Component	Type	Value	Unit	Source(s)
$Showers_{daily}$	Fixed	0.6	shower/ person/day	Maryland/Mid-Atlantic TRM v10, p. 138[23]
$Qty_{showerheads}$	Variable	See customer application[24]	showers/ home	Customer application
ΔT	Fixed	44.1	°F	Maryland/Mid-Atlantic TRM v10, p. 173:
η_{DHW}	Fixed	0.98	–	Maryland/Mid-Atlantic TRM v10, p. 138[25]
CF_{summer}	Fixed	0.00371	–	Maryland/Mid-Atlantic TRM v10, p. 139[26]
CF_{winter}	Fixed	0.00371	–	Maryland/Mid-Atlantic TRM v10, p. 139[27]
Days	Fixed	365	days, annual	Maryland/Mid-Atlantic TRM v10, p.138[28]
ISR	Variable	Assigned by program[29]: Residential Income and Age Qualifying Home Improvement Program, Residential Manufactured Housing Program, Residential Home Retrofit Program, Residential/Non-Residential Multifamily Program = 1.0 Energy Efficient Kits Program = 0.35	–	Pennsylvania TRM Vol2 2019, p. 84

[23] Maryland/Mid-Atlantic TRM v10, p. 138. Table 8. Cadmus and Opinion Dynamics Evaluation Team. Showerhead and Faucet Aerator Meter Study. For Michigan Evaluation Working Group. June 2013. For each shower fixture metered, the evaluation team knew the total number of showers taken, duration of time meters remained in each home, and total occupants reported to live in the home. From these values, average showers taken per day, per person was calculated. The study compared showers per day, per person by single-family and multifamily populations, finding no statistically significant difference between the values. For the energy-saving analysis, the study used the combined single-family and multifamily average showers per day, per person of 0.6. Per Pennsylvania TRM-2016.

[24] The number of showerheads in the household are assumed to be the same as the number of low-flow showerheads installed through the program.

[25] Maryland/Mid-Atlantic TRM v10, p. 138. Electric water heater has recovery efficiency of 98%. http://www.ahrinet.org/App_Content/ahri/files/Certification/GAMA/PG-CMW.pdf. Accessed 9/17/2019.

[26] Maryland/Mid-Atlantic TRM v10, p. 139. Calculated as follows: Assume 9% showers take place during peak hours (based on http://s3.amazonaws.com/zanran_storage/www.aquacraft.com/ContentPages/47768067.pdf). Accessed 9/18/2019. Nine percent x 7.8 minutes per day = 0.702 minutes; 0.702 / 180 (minutes in peak period) = 0.0039." Website that was provided in Mid-Atlantic TRM, however, could not be accessed when DNV attempted on the same date.

[27] Maryland/Mid-Atlantic TRM v10, p. 139. Calculated as follows: Assume 9% showers take place during peak hours (based on http://s3.amazonaws.com/zanran_storage/www.aquacraft.com/ContentPages/47768067.pdf). Accessed 9/18/2019. Nine percent x 7.8 minutes per day = 0.702 minutes; 0.702 / 180 (minutes in peak period) = 0.0039." Website that was provided in Mid-Atlantic TRM, however, could not be accessed when DNV attempted on the same date.

[28] The source TRM for this measure does not include a winter CF. We apply the summer CF for the coincident winter peak period as it is the best information available.

[29] The ISR is assigned by the implementation channel. Direct install programs have an ISR of 1.0 and other programs have a value of 0.35

DNV

2.1.3.4 Default Savings

If the proper values are not supplied, a default savings may be applied using conservative input values.

Assuming the quantity of showers is 1.0, the default per measure gross annual water savings will be assigned according to the following calculation:

$$\Delta Water = \left[(Flow_{base} - Flow_{ee}) \times Qty_{people} \times Minutes_{shower} \times Showers_{daily} \times ISR \times 365\ days\right] \div Qty_{shower}$$

$$= \left[(2.5\ gpm - 2.0\ gpm) \times 2.0\ people \times 7.8\ \frac{min.}{shower} \times 0.6\ \frac{showers}{day} \times 1.0 \times 365\ days\right] \div 1.0\ showers$$

$$= 1{,}708\ gallons$$

The default per measure gross annual electric energy savings will be assigned according to the following calculation:

$$\Delta kWh = \frac{\Delta Water \times 8.3\ lb/gal \cdot Btu/lb/°F \times \Delta T}{\eta_{DHW} \times 3{,}412\frac{Btu/h}{kW}}$$

$$= \frac{1{,}708\ gal \times 8.3\ lb/gal \cdot Btu/lb/°F \times 44.1\ °F}{0.98 \times 3{,}412\frac{Btu/h}{kW}}$$

$$= 187\ kWh$$

The default per measure summer peak gross coincident demand reductions will be assigned according to the following calculation:

$$\Delta kW_{summer} = \frac{\Delta kWh \times CF_{summer}}{Qty_{people} \times Minutes_{shower} \times Showers_{daily} \times \frac{1\ hour}{60\ min.} \times 365\ days}$$

$$= \frac{187\ kWh \times 0.0039}{2.0\ people \times 7.8\ \frac{min}{shower} \times 0.6\ \frac{shower}{day} \times \frac{1\ hour}{60\ min.} \times 365\ days}$$

$$= 0.013\ kW$$

The default per measure winter peak gross coincident demand reductions will be assigned according to the following calculation:

$$\Delta kW_{winter} = \frac{\Delta kWh \times CF_{winter}}{Qty_{people} \times Minutes_{shower} \times Showers_{daily} \times \frac{1\ hour}{60\ min.} \times 365\ days}$$

$$= \frac{187\ kWh \times 0.0039}{2.0\ people \times 7.8\ \frac{min}{shower} \times 0.6\ \frac{shower}{day} \times \frac{1\ hour}{60\ min.} \times 365\ days}$$

$$= 0.013\ kW$$

2.1.3.5 Effective Useful Life

The effective useful life of this measure is provided in Table 2-11.

Table 2-11. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential/Non-Residential Multifamily	10.00	years	Maryland/Mid-Atlantic TRM v10, p. 140
	Residential Home Retrofit Program			
	Residential Energy Efficient Kits Program			
	Residential Manufactured Housing Program			
VII	Residential Home Energy Assessment Program	12.40	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)
IV	Residential Income & Age Qualifying Home Improvement program	15.00	years	

2.1.3.6 Source(s)

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v10, pp.137-140 and Pennsylvania TRM Vol2 2019, p. 84.

2.1.3.7 Update Summary

Updates to this section are described in Table 2-12.

Table 2-12. Summary of Update(s)

Version with Updates	Update Type	Description
2021	Equation	- Added In-Service Rate (ISR) to account for self-installed programs - Added winter peak coincident demand reduction equation
	Inputs	Replaced the Mid-Atlantic TRM with the Dominion Residential Home Energy Use Survey 2019 – 2020 as the source of the number of occupants in household
	New table	Effective Useful Life (EUL) by program
2020	None	No change
v10	Source	Updated page numbers / version of the Mid-Atlantic TRM
	Input Variable	Updated Qty_{shower} to use customer application data when available

2.2 Building Envelope End Use

2.2.1 Building Insulation

2.2.1.1 Measure Description

This measure involves improving the R-value of building shell components which may include attics/roofs, above grade and below grade walls, and floors above crawlspaces. This measure requires that the implementer determine the baseline and post-case R-value of the assembly of the building shell component for which new insulation is added, and to determine the surface area of the newly insulated assembly. For above grade and below grade wall assemblies, the baseline will be determined by the implementer, but is most likely empty wall cavities, or no insulation. For floors above crawlspaces, the baseline will be determined by the implementer, but is most likely to be no insulation on any surfaces surrounding a crawlspace. For attics and roofs, the baseline will be determined by the implementer, but is most likely no or little attic/roof insulation.

This measure is offered through different programs listed in Table 2-13, and uses the impacts estimation approach described in this section.

Table 2-13. Programs that Offer Building Insulation Measure

Program Name	Section
Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 2.2.1
Residential Manufactured Housing Program, DSM Phase VIII	Section 11.1.2
Residential Home Retrofit Program, DSM Phase VIII	Section 12.1.2
Residential/Non-Residential Multifamily Program, DSM Phase VIII	Section 13.1.2
Residential HB 2789 HVAC Component Program, DSM Phase VIII	Section 16.1.2

DNV

2.2.1.2 Impacts Estimation Approach

Per measure, gross annual electric energy savings are calculated according to the following equations:

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat,\,electric} + \Delta kWh_{heating,\,FAF\,fan}$$

If space cooling is provided, then ΔkWh_{cool} follows the equation below, otherwise ΔkWh_{cool} is zero.

$$\Delta kWh_{cool} = \frac{\left(\frac{1}{R_{base}} - \frac{1}{R_{base} + R_{ee}}\right) \times CDD \times 24\frac{hour}{day} \times DUA \times Area \times \left(1 - Factor_{framing}\right) \times Adj_{cool}}{1{,}000\ Btu/kBtu \times SEER \times DE}$$

If electric heating is provided by a heat pump, then ΔkWh_{heat} follows the equation that follows; otherwise $\Delta kWh_{heat,electric}$ is zero.

$$\Delta kWh_{heat,electric} = \frac{\left(\frac{1}{R_{base}} - \frac{1}{R_{base} + R_{ee}}\right) \times HDD \times 24\frac{hour}{day} \times Area \times \left(1 - Factor_{framing}\right) \times Adj_{heat}}{3{,}412\ Btu/kWh \times COP \times DE}$$

If a forced-air furnace (FAF)[30] provides heat, fan energy savings are calculated. The $\Delta kWh_{heating,FAF\ fan}$ is calculated using the equation that follows; otherwise $\Delta kWh_{heating,FAF\ fan}$ is zero.

$$\Delta kWh_{heat,\,FAF\,fan} = \frac{\left(\frac{1}{R_{base}} - \frac{1}{R_{base} + R_{ee}}\right) \times HDD \times 24\frac{hour}{day} \times Area \times (1 - Factor_{framing}) \times Adj_{heat} \times ESF_{FAF}}{3{,}412\ Btu/kWh \times AFUE \times DE}$$

Per measure, summer gross coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{\Delta kWh_{cool}}{EFLH_{cool}} \times CF_{summer}$$

Per measure, summer gross coincident demand reduction is calculated for both electric heat and FAF according to the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh_{heat,electric} + \Delta kWh_{heat,\,FAF\,fan}}{EFLH_{heat}} \times CF_{winter}$$

Where:

ΔkWh	= per measure gross annual electric energy savings
ΔkW_{summer}	= per measure gross summer peak coincident demand reduction
ΔkW_{winter}	= per measure gross winter peak coincident demand reduction
ΔkWh_{cool}	= gross annual electric savings to cooling system, if cooling system is present and affected by measure

[30] FAF heating system type is assumed when the heating system type is not a heat pump and the heating fuel is indicated to be non-electric heating on the customer application.

DNV

$\Delta kWh_{heat,electric}$	= gross annual electric savings to heating system, if electric heating is present and affected by measure
$\Delta kWh_{heating,\ FAF\ fan}$	= gross annual electric savings to furnace air fan, if furnace air fan is present and affected by measure
R_{base}	= R-value of existing assembly and any existing insulation. This includes the thermal resistance of the earth in below grade wall applications.
R_{ee}	= R-value of new assembly with the new insulation. This includes the thermal resistance of the earth in below grade wall applications.
CDD	= Cooling Degree Days (base 65°F for conditioned basement sidewall, above-grade wall, ceiling/attic; base 75°F for unconditioned basement sidewall, floor above crawlspace)
DUA	= discretionary use adjustment (reflects the fact that people do not always operate their AC when conditions may call for it)
Area	= surface area of insulation applied
$Factor_{framing}$	= adjustment to account for area of framing
Adj_{cool}	= adjustment to account for engineering algorithm overclaiming cooling savings
SEER	= efficiency of cooling system, seasonal energy efficiency ratio of cooling system (SEER)
HDD	= heating degree days (base 60°F for conditioned basement sidewall, above-grade wall, ceiling/attic; base 50°F for unconditioned basement sidewall, floor above crawlspace)
Adj_{heat}	= adjustment to account for engineering algorithm overclaiming heating savings
COP	= efficiency of electric heating system, coefficient of performance (effective COP estimate = HSPF/3.413)
ESF_{FAF}	= furnace fan energy consumption as a percentage of annual fuel consumption
AFUE	= efficiency of gas furnace, Annual Fuel Utilization Efficiency
DE	= distribution Efficiency (accounts for duct leakage in systems with ducts)
$EFLH_{cool}$	= equivalent full load hours (cooling)
$EFLH_{heat}$	= equivalent full load hours (heating)
CF_{summer}	= Summer peak coincidence factor
CF_{winter}	= winter peak coincidence factor

2.2.1.3 Input Variables

Table 2-14. Input Variables for Measure Name

Component	Type	Value	Units	Source(s)
R_{base}	Variable	See Table 2-15. Rbase Values by Component Type	hr-°F-ft^2/Btu	Table 2-15. Rbase Values by Component Type
R_{ee}	Variable	See customer application	hr-°F-ft^2/Btu	Customer application

DNV

Component	Type	Value	Units	Source(s)
CDD	Variable	Location-dependent value using base 65°F for conditioned basement sidewall, above-grade wall, ceiling/attic; base 75°F for unconditioned basement sidewall, floor above crawlspace, See Table 19-4	CDD	Sub-Appendix F1-III: Cooling and Heating Degree Days and Hours
DUA	Fixed	0.75	–	IL TRM 2020 v8, Vol. 3. p. 324[31]
Area	Variable	See customer application	ft^2	Customer application
$Factor_{framing}$	Variable	See Table 2-16	–	See Table 2-16
Adj_{cool}	Fixed	0.8	–	IL TRM 2020 v8, Vol. 3. p. 300[32]
SEER[33]	Variable	See customer application	kBtu/kWh	Customer application
		Default: For residential programs see Table 19-9. Residential Baseline and Efficient HVAC Equipment Efficiency Ratings and Table 19-10 Room Air Conditioner Federal Standard and ENERGY STAR® Minimum Efficiency, If system type is unknown default type is air conditioning, split system For Non-Residential Programs see the Non-Residential Technical Reference Manual Sub-Appendix F2-III: Non-Residential HVAC Equipment Efficiency Ratings.		Sub-Appendix F1-V: Residential HVAC Equipment Efficiency Ratings Non-Residential Technical Reference Manual Sub-Appendix F2-III: Non-Residential HVAC Equipment Efficiency Ratings.
HDD	Variable	Location-dependent value using a base 60°F for conditioned basement sidewall, above-grade wall, ceiling/attic; base 50°F for unconditioned basement sidewall, floor above crawlspace	HDD	Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment
Adj_{heat}	Fixed	0.6[34]	–	IL TRM 2020 v8, Vol. 3., p. 302
COP	Variable	See customer application	–	Customer application

[31] IL TRM 2020 v8, Vol. 3. p. 324. Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p. 31

[32] IL TRM 2020 v8, Vol. 3. p. 300. Opinion Dynamics Memo "Results for AIC PY6 HPwES Billing Analysis", dated 2/20/15 found realization rate in ComEd PY6 of 0.23, and PY5 of 0.41. Negotiated TAC value was 0.80 based on large error bounds on realization rates.

[33] For Equipment types that don't have SEER values, other efficiency values are applied. For room air conditioners use CEER. For Nonresidential equipment types IEER may be applied. If size is not available and system type is split system, assume it is larger than 45 kBtu/h.

[34] IL TRM 2020 v8, Vol. 3. p. 302. Opinion Dynamics Memo "Results for AIC PY6 HPwES Billing Analysis", dated 2/20/15 found realization rate in ComEd PY6 of 0.57, and PY5 of 0.33 for electric heat, and 0.39 and 0.34 for gas heat. Negotiated TAC value was 0.60 based on large error bounds on realization rates.

DNV

Component	Type	Value	Units	Source(s)
		See For residential programs see Table 19-9. Residential Baseline and Efficient HVAC Equipment Efficiency Ratings, if system type is unknown, default is indoor gas furnace For Non-Residential Programs see the Non-Residential Technical Reference Manual Sub-Appendix F2-III: Non-Residential HVAC Equipment Efficiency Ratings.		Sub-Appendix F1-V: Residential HVAC Equipment Efficiency Ratings Non-Residential Technical Reference Manual Sub-Appendix F2-III: Non-Residential HVAC Equipment Efficiency Ratings.
ESF_{FAF}	Fixed	0.0314[35]	–	IL TRM 2020 v8, Vol. 3. p. 289
AFUE	Variable	See Table 19-9	–	Baseline efficiencies in Sub-Appendix F1-V: Residential HVAC Equipment Efficiency Ratings
DE	Variable	Non-ducted systems (ductless or electric resistance heat): 1.0 Ducted systems[36]: 0.85	–	IL TRM 2020 v8, Vol. 3. p. 304[37]
		Default: Non-ducted systems (ductless or electric resistance heat): 1.0		Conservative estimate
$EFLH_{cool}$	Variable	For residential programs, see Section 19.3, Sub-Appendix F1-III: Cooling and Heating Degree Days and Hours For Non-Residential Programs, see the Non-Residential Technical Reference Manual Sub-Appendix F2-II: Non-Residential HVAC Equivalent Full Load Hours	hours	Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment Sub-Appendix F2-II: Non-Residential HVAC Equivalent Full Load Hours
$EFLH_{heat}$	Variable	For residential programs, see Section 19.3, Sub-Appendix F1-III: Cooling and Heating Degree Days and Hours For Non-Residential programs, see the Non-Residential Technical Reference Manual Sub-Appendix F2-II: Non-Residential HVAC Equivalent Full Load Hours	hours	Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment Non-Residential Technical Reference Manual Sub-Appendix F2-II: Non-Residential HVAC Equivalent Full Load Hour

35 IL TRM 2020 v8, Vol. 3. p. 289. According to IL TRM: "ESF_{FAF} is not one of the AHRI certified ratings provided for residential furnaces, but can be estimated from a calculation based on the certified values for fuel energy (E_f in MMBtu/yr.) and E_{ae} (kWh/yr.). An average of a 300-record sample (non-random) out of 1495 was 3.14%. This is, appropriately, ~50% greater than the ENERGY STAR version 3 criteria for 2% ESF_{FAF}"

36 Ducted systems are all system types other than ductless systems and electric resistance heating provided by the customer application

37 IL TRM 2020 v8, Vol. 3. p. 304. Also, average duct system efficiency for heating season for CZ4-5 is 0.854 according to this BPI document, accessed 10/13/20: http://www.bpi.org/sites/default/files/Guidance%20on%20Estimating%20Distribution%20Efficiency.pdf

Component	Type	Value	Units	Source(s)
CF_{summer}	Variable	0.69	–	Maryland/Mid-Atlantic TRM v10, p.93[38]
CF_{winter}	Variable	0.69	–	Maryland/Mid-Atlantic TRM v10, p.93[38]

Table 2-15. R_{base} Values by Component Type

Component type	R_{base}	Source
Roof/Attic	For Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV, R_{base} = 3.00 + Customer Application existing R-Value	Customer Application and IL TRM 2020 v8, Vol. 3, p. 323
	For all other programs: 3.00	IL TRM 2020 v8, Vol. 3, p. 323[39]
Above grade wall	5.00	IL TRM 2020 v8, Vol. 3, p. 315[40]
Below grade wall (basement)	7.97	IL TRM 2020 v8, Vol. 3, p. 301[41]
Floor above crawlspace	3.53	IL TRM 2020 v8, Vol. 3, p. 307[42]

Table 2-16. Framing Factor Values

Component type	Framing Factor[43]	Source
Roof/Attic	0.07	IL TRM 2020 v8, Vol. 3, p. 323
Above-grade wall	0.25	IL TRM 2020 v8, Vol. 3, p. 315
Below-grade wall (basement)	0.00	IL TRM 2020 v8, Vol. 3, p. 299
Floor, above crawlspace	0.12	IL TRM 2020 v8, Vol. 3, p. 307

2.2.1.4 Default Savings

If the values are not supplied, default input values may be applied using conservative assumptions.

38 The Maryland/Mid-Atlantic TRM v10 provides CF for room/wall AC and central AC systems in the ductless mini-split measure. In this section we use the generic value for central AC system. For other measures in the Maryland/Mid-Atlantic TRM v10, a utility-specific and equipment specific CF is provided. We use the more generic CF categories. There are no generic winter CF. Therefore, we apply summer CF.

39 IL TRM 2020 v8, Vol. 3. p. 323. According to IL TRM: "Component estimate of air film above and below, sheathing and sheet rock, (0.68+0.5+0.45+0.68 = 2.3) is rounded up to R-3"

40 IL TRM 2020 v8, Vol. 3. p. 315. According to IL TRM: "estimate based on review of Madison Gas and Electric, Exterior Wall Insulation, R-value for no insulation in walls, and NREL's Building Energy Simulation Test for Existing Homes (BESTEST-EX)"

41 IL TRM 2020 v8, Vol. 3. p. 301. According to IL TRM: "Adapted from Table 1, page 24.4, of the 1977 ASHRAE Fundamentals Handbook". Assumed average value of 1 through 8 feet.

42 IL TRM 2020 v8, Vol. 3. p. 307. According to IL TRM: "Based on 2005 ASHRAE Handbook – Fundamentals: assuming ¾" subfloor, ½" carpet with rubber pad, and accounting for a still air film above and below: 0.68 + 0.94 + 1.23 + 0.68 = 3.53"

43 IL TRM 2020 v8, Vol. 3. p.299. According to IL TRM: "Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP)," Table 7.1"

DNV

2.2.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 2-17.

Table 2-17. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Manufactured Housing Program, DSM Phase VIII	25.00	years	Iowa TRM 2019 Vol. 2 p. 283[44]
	Residential Home Retrofit Program, DSM Phase VIII			
	Residential/Non-Residential Multifamily Program, DSM Phase VIII			
	Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII			
IV	Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	15.00	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

2.2.1.6 Source

The primary source for this deemed savings approach is the IL TRM 2020 Ver. 8. Vol. 3, pp. 298-338. The source for the measure life is the Iowa TRM 2019 Vol. 2, p. 283.

2.2.1.7 Update Summary

Updates to this section are described in Table 2-18.

Table 2-18. Summary of Update(s)

Updates in Version	Update Type	Description
2021	Expanded Measure	This measure was expanded from only attic insulation to attics insulation, above grade and below grade walls, and floors above crawlspaces
	Input Variable	Assigned Non-ducted systems as the default for DE
	Equation	Added winter peak coincident demand reduction equation
	New table	Effective Useful Life (EUL) by program
2020	None	No change

[44] Iowa TRM 2016 Vol. 2 pp. 250 – 287. According to Iowa TRM: "Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007"

Updates in Version	Update Type	Description
v10	Source	Updated page numbers / version of the Mid-Atlantic TRM and ASHRAE Handbook Fundamentals
	Input Variable	Clarified default assumption values

2.3 Lighting End Use

2.3.1 LED Lighting

2.3.1.1 Measure Description

Existing incandescent light bulbs or minimum lighting efficacy EISA-compliant bulbs will be replaced with their respective equivalents LED bulbs.

This measure is offered through the programs listed in Table 2-19, and uses the impacts estimation approach described in this section. For the Residential Income and Age Qualified Program the quantity is limited to six. The other programs do not have a specified quantity limit.

Table 2-19. Programs that Offer LED Lighting

Program Name	Section
Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 2.3.1
Residential Home Energy Assessment Program, DSM Phase VII	Section 5.4.1
Residential Energy Efficiency Kits Program, DSM Phase VIII	Section 10.3.1
Residential Manufactured Housing Program, DSM Phase VIII	Section 11.4.1
Residential Home Retrofit Program, DSM Phase VIII	Section 12.6.1
Residential/Non-Residential Multifamily Program, DSM Phase VIII	Section 13.4.1

2.3.1.2 Impacts Estimation Approach

Per unit savings are multiplied by the number of total bulbs installed based on the program tracking data.

Per measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \frac{watts_{base} - watts_{ee}}{1{,}000\, W/kW} \times ISR \times HOU \times [WHFe_{heat} + (WHFe_{cool} - 1)]$$

Per measure, gross summer peak coincident demand reduction is calculated according to the following equation:

DNV

$$\Delta kW_{summer} = \frac{watts_{base} - watts_{ee}}{1{,}000\ W/kW} \times ISR \times WHFd_{summer} \times CF_{summer}$$

Per measure, gross winter peak coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{watts_{base} - watts_{ee}}{1{,}000\ W/kW} \times ISR \times WHFd_{winter} \times CF_{winter}$$

Where:

ΔkWh	= per measure gross annual electric energy savings
ΔkW_{summer}	= per measure gross summer peak coincident peak demand savings
ΔkW_{winter}	= per measure gross winter peak coincident peak demand savings
$watts_{base}$	= wattage of incandescent bulb being replaced
$watts_{ee}$	= wattage of new efficient LED bulb
ISR	= in service rate
HOU	= hours of use per year
$WHFe_{heat}$	= waste heat factor to account for electric heating increase due to reduced waste heat from efficient lighting
$WHFe_{cool}$	= waste heat factor to account for electric cooling savings due to reduced waste heat from efficient lighting
$WHF_{d,summer}$	= waste heat factor for summer coincident peak demand savings to account for cooling savings from efficient lighting
$WHF_{d,winter}$	= waste heat factor for summer coincident peak demand savings to account for cooling savings from efficient lighting
CF_{summer}	= summer peak coincidence factor
CF_{winter}	= winter peak coincidence factor

2.3.1.3 Input Variables

Table 2-20. Input Values for LED Lighting Savings

Component	Type	Value	Units	Sources
$watts_{base}$	Variable	For Residential Income and Age Qualifying Home Improvement program: 40 W 60 W	watts	Dominion Residential Income and Age Qualifying Home Improvement program requirements,
		For DSM VII and DSM VIII Programs: See Table 2-21		US EPA Energy Independence and Security Act of 2007 Frequently Asked Questions, p. 1

Component	Type	Value	Units	Sources
$watts_{ee}$	Variable	For Residential Income and Age Qualifying Home Improvement program: 9 (for 40 W base) or 14.5 (for 60 W base)	watts	Dominion Residential Income and Age Qualifying Home Improvement program assumptions
		For DSM VII and DSM VIII Programs: See Table 2-21		Dominion Residential Home Energy Assessment Program requirements
ISR	Fixed	0.965	–	Maryland/Mid-Atlantic TRM v10, p. 30-32
HOU	Variable	See Table 19-14 in Sub-Appendix F1-VII: Residential Lighting Factors Default = 760 for Unknown room location	hour/ year	Sub-Appendix F1-VII: Residential Lighting Factors
$WHFe_{heat}$	Variable	See Table 19-14 in Sub-Appendix F1-VII: Residential Lighting Factors Default = 0.899 for Unknown room location	–	Sub-Appendix F1-VII: Residential Lighting Factors
$WHFe_{cool}$	Variable	See Table 19-14 in Sub-Appendix F1-VII: Residential Lighting Factors Default = 1.077 for Unknown room location	–	Sub-Appendix F1-VII: Residential Lighting Factors
$WHFd_{summer}$	Variable	See Table 19-14 in Sub-Appendix F1-VII: Residential Lighting Factors Default = 1.17 for Unknown room location	–	Sub-Appendix F1-VII: Residential Lighting Factors
$WHFd_{winter}$	Variable	See Table 19-14 in Sub-Appendix F1-VII: Residential Lighting Factors Default = 1.17 for Unknown room location	–	Sub-Appendix F1-VII: Residential Lighting Factors
CF_{summer}	Variable	See Table 19-14 in Sub-Appendix F1-VII: Residential Lighting Factors Default = 0.058 for Unknown room location	–	Sub-Appendix F1-VII: Residential Lighting Factors
CF_{winter}	Variable	See Table 19-14 in Sub-Appendix F1-VII: Residential Lighting Factors Default = 0.124 for Unknown room location	–	Sub-Appendix F1-VII: Residential Lighting Factors

Table 2-21. LED Lighting Savings for Eligible Measures

Measure	$watts_{base}$	$watts_{ee}$
A-line LED 40 W Equivalent	29	5.0
A-line LED 60 W Equivalent	43	9.0
A-line LED 75 W Equivalent	53	12.0
A-line LED 100 W Equivalent	53	12.0
A-line LED 3 Way 75 W / 100 W / 150 W Equivalent	53	12.0
Decorative LED 25W Equivalent	25	2.7
Decorative LED 40W Equivalent	29	4.0
Globe LED 25W Equivalent	25	3.2
Globe LED 40W Equivalent	40	4.6
LED Downlight 50 W Equivalent	30	6.0
LED Downlight 65 W Equivalent	45	8.0
LED Downlight 75 W Equivalent	50	10.0
LED Downlight 85 W Equivalent	65	12.7
LED Downlight 90 W Equivalent	75	14.0

2.3.1.4 Default Savings

If the proper values are not supplied, a default savings may be applied using conservative input values. In the event that the install location is unavailable on the customer application, the savings are calculated using default values. The default gross annual electric energy savings will be assigned according to the equations that follow. This default calculation is for the Income and Age Qualifying Home Improvement Program. However, the same calculation applies to the other programs using the corresponding wattages in Table 2-21.

40 W LEDs

Per measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \frac{watts_{base} - watts_{ee}}{1{,}000\, W/kW} \times ISR \times HOU \times [WHFe_{heat} + (WHFe_{cool} - 1)]$$

$$= \frac{40 - 9}{1{,}000\, W/kW} \times 0.965 \times 760 \times [0.899 + (1.077 - 1)]$$

$$= 22.19\ kWh$$

Per measure, gross summer peak coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{watts_{base} - watts_{ee}}{1{,}000\, W/kW} \times ISR \times WHF_d \times CF_{summer}$$

$$= \frac{40 - 9}{1{,}000\, W/kW} \times 0.965 \times 1.17 \times 0.058$$

$$= 0.002\ kW$$

Per measure, gross winter peak coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{watts_{base} - watts_{ee}}{1{,}000\, W/kW} \times ISR \times WHF_d \times CF_{winter}$$

$$= \frac{40 - 9}{1{,}000\, W/kW} \times 0.965 \times 1.17 \times 0.124$$

$$= 0.004\ kW$$

60 W LEDs

Per measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \frac{watts_{base} - watts_{ee}}{1{,}000\, W/kW} \times ISR \times HOU \times [WHFe_{heat} + (WHFe_{cool} - 1)]$$

$$= \frac{60 - 14.5}{1{,}000\, W/kW} \times 0.965 \times 760 \times [0.899 + (1.077 - 1)]$$

$$= 32.6\ kWh$$

Per measure, gross coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{watts_{base} - watts_{ee}}{1{,}000\, W/kW} \times ISR \times WHFd \times CF_{summer}$$

$$= \frac{60 - 14.5}{1{,}000\, W/kW} \times 0.965 \times 1.17 \times 0.058$$

$$= 0.003\ kW$$

Per measure, gross winter peak coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{watts_{base} - watts_{ee}}{1{,}000\,W/kW} \times ISR \times WHF_d \times CF_{winter}$$

$$= \frac{60 - 14.5}{1{,}000\,W/kW} \times 0.965 \times 1.17 \times 0.124$$

$$= 0.006\,kW$$

2.3.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 2-22.

Table 2-22. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Energy Efficiency Kits Program	See Sub-Appendix F1-VII: Residential Lighting Factors Table 19-14	years	Maryland/Mid-Atlantic TRM v10, p. 42
	Residential Manufactured Housing Program			
	Residential Home Retrofit Program			
	Residential Multifamily Program			
VII	Residential Home Energy Assessment Program	12.41	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)
IV	Residential Income & Age Qualifying Home Improvement program	15.00	years	

2.3.1.6 Source(s)

The primary source for this deemed savings approach is the Mid-Atlantic TRM v9, pp. 21-42 and Maryland/Mid-Atlantic TRM v10, pp. 26-41. Wattage requirements for EISA-compliant bulbs come from the US EPA's Energy Independence and Security Act of 2007 Frequently Asked Questions, p1.[45]

2.3.1.7 Update Summary

Updates to this section are described in Table 2-23.

[45] Available at https://www.energystar.gov/ia/products/lighting/cfls/downloads/EISA_Backgrounder_FINAL_4-11_EPA.pdf

Table 2-23. Summary of Update(s)

Updates in Version	Update Type	Description
2021	New table	Effective Useful Life (EUL) by program
	Default Calculation	Updated default calculations with revised wattages.
	Equation	Added winter peak coincident demand reduction equation
2020	Inputs	Revised baseline wattages for Residential Home Energy Assessment Program to reflect the DOE's rollback of the EISA lighting efficiency standard that was scheduled to take effect in 2020 but did not. Updated default savings calculation with revised baseline wattages.
v10	Source	Updated page numbers / version of the Mid-Atlantic TRM

3 RESIDENTIAL AC CYCLING PROGRAM, DSM PHASE I

3.1 Heating Ventilation and Air Conditioning End Use

3.1.1 Residential AC Cycling

3.1.1.1 Measure Description

When AC cycling events are called by the program, a radiofrequency (RF) paging signal is broadcast throughout the Company's service area. The signal is received by load curtailment switches installed on central air conditioners and heat pumps of participating residential customers. The dispatch of the RF signal to the load curtailment switch reduces the duty cycle of the registered AC units up to 50% during an event. The objective of the program is to reduce kW demand during AC cycling events.

3.1.1.2 Evaluation History

At the conclusion of the 2014 program event season, DNV conducted an ex ante regression analysis to predict kW impacts per dispatched AC Cycling participant specific to hour of day and weather conditions. This ex ante value was derived by averaging historical ex-ante impacts over the 2011–2014 event seasons. In 2015, due to the elapsed time between 2011 and 2014, the decline in average connected load per participant, and other longitudinal factors, the 2015 ex ante model was based solely on 2015 ex post impacts. Since 2015, ex ante models are built on current year ex post impacts only.

3.1.1.3 Impacts Estimation Approach

The regression equation that DNV used to estimate the ex post kW impacts per participant in 2021 is derived by fitting a linear regression model for each event hour ending 16–18 with the temperature humidity index (THI) as a predictor variable. The event hours included in the ex post analysis is determined by the start and end of each event.[46]

Ex ante event day demand reduction is calculated according to the following equations:

$$Predicted\ Ex\ Ante\ kW\ Impact_{16:00,day} = \hat{\beta}_{0,16:00} + \hat{\beta}_{1,16:00} * (THI_{16:00})$$

$$Predicted\ Ex\ Ante\ kW\ Impact_{17:00,day} = \hat{\beta}_{0,17:00} + \hat{\beta}_{1,17:00} * (THI_{17:00})$$

$$Predicted\ Ex\ Ante\ kW\ Impact_{18:00,day} = \hat{\beta}_{0,18:00} + \hat{\beta}_{1,18:00} * (THI_{18:00})$$

Where:

$Predicted\ Ex\ Ante\ kW\ Impact_{hour}$ = estimated ex ante load impact estimate for hour

[46] The impact analysis follows protocols outlined in Miriam L. Goldberg & G. Kennedy Agnew. Measurement and Verification for Demand Response, National Forum on the National Action Plan on Demand Response, https://www.ferc.gov/industries/electric/indus-act/demand-response/dr-potential/napdr-mv.pdf.

$\hat{\beta}_{0,hour}$	= fixed estimate for the ex-ante kW impact
$\hat{\beta}_{1,hour}$	= increase to the ex ante kW impact estimate when THI increases by one
THI_{hour}	= THI value for a specific hour.

The Dominion peak condition for planning purposes is assumed to be 95°F, 43% relative humidity at hour ending 17:00. This corresponds with a THI of 83.4. Therefore, the gross coincident summer peak demand savings are calculated according to the following equations:

$$Predicted\ Ex\ Ante\ kW\ Impact_{17:00,day} = \hat{\beta}_{0,17:00} + \hat{\beta}_{1,17:00} * (83.4\ THI\ )$$

$$Predicted\ Ex\ Ante\ kW\ Impact_{17:00,day} = -1.75005 + 0.02738 * (83.4\ )$$

3.1.1.4 Input Variables

Table 3-1. Regression Parameters for the 2021 Residential AC Cycling Event Season

Component	Type	Value	Unit	Source
$\hat{\boldsymbol{\beta}}_{0,16:00}$	Fixed	-1.70749	kW	Dominion, 2021 AC Cycling Impact Analysis
$\hat{\boldsymbol{\beta}}_{0,17:00}$	Fixed	-1.75005	kW	
$\hat{\boldsymbol{\beta}}_{0,18:00}$	Fixed	-2.52862	kW	
$\hat{\boldsymbol{\beta}}_{1,16:00}$	Fixed	0.02632	kW	
$\hat{\boldsymbol{\beta}}_{1,17:00}$	Fixed	0.02738	kW	
$\hat{\boldsymbol{\beta}}_{1,18:00}$	Fixed	0.03745	kW	
$\boldsymbol{THI}_{16:00}$	Variable	–	THI	NOAA
$\boldsymbol{THI}_{17:00}$	Variable	–	THI	
$\boldsymbol{THI}_{18:00}$	Variable	–	THI	

3.1.1.5 Demand reduction

The kW impact per AC Cycling Program participant during Dominion's peak conditions for 2021 is 0.53 kW. DNV conducts a yearly impact analysis to support an ex ante model specification that is based on the ex post impacts for the same period.

Demand reduction is not deemed. All savings are taken from annual impact evaluations.

3.1.1.6 Effective Useful Life

The effective useful life of this measure is provided in Table 3-2.

Table 3-2. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
I	Residential AC Cycling Program	1.00	years	Program design assumption

3.1.1.7 Source

Local weather data are gathered from NOAA, National Centers for Environmental Information.

3.1.1.8 Update Summary

Updates to this section are described in Table 3-3.

Table 3-3. Summary of Update(s)

Version with Updates	Update Type	Description
2021	New table	Effective Useful Life (EUL) by program
	Regression model specification	Regression coefficients for 2021 taken from the 2021 AC Cycling Impact Analysis, DNV
2020	Regression model specification	Regression coefficients for 2020 taken from the 2020 AC Cycling Impact Analysis, DNV
2019	Regression model specification	Regression coefficients for 2019 taken from the 2020 AC Cycling Impact Analysis, DNV

4 RESIDENTIAL APPLIANCE RECYCLING PROGRAM, DSM PHASE VII

The Residential Appliance Recycling Program provides a financial incentive to residential customers to recycle aged refrigerators and/or freezers. Customers are limited to two units per electric account and eligible units must be at least 10 years old and operational.

4.1 Plug Load/Appliance End Use

4.1.1 Refrigerator and Freezer Recycling

4.1.1.1 Measure Description

Under this measure Dominion will remove older, less efficient refrigerators and/or freezers directly from customers' homes. Savings are realized through the decommissioning of secondary refrigerators or replacing older primary refrigerators with new units.

Baseline kWh is from a linear regression model and energy efficient kWh is a weighted average of the federal baseline maximum energy usage for the measure multiplied by a dummy variable equal to 1 if the unit will be replaced and 0 if not. The coefficients can be found in Table 4-2 and Table 4-3.

4.1.1.2 Impacts Estimation Approach

Per measure, gross energy savings for refrigerators and freezers are defined in the equations below.

Refrigerators:

$$\Delta kWh = kWh_{base} - kWh_{ee}$$

$$\begin{aligned} kWh_{ee} = \big(&(0.018333 \times Size + 0.5211) + (0.021573 \times Size + 0.6075) \\ &+ (4.619268 \times Size + 133.76988) + (0.11914 \times Size + 4.1692) \\ &+ (1.455825 \times Size + 52.1465) + (0.02268 \times Size + 1.04058) \\ &+ (2.05814 \times Size + 104.3048)\big) \times Replacement \end{aligned}$$

$$\begin{aligned} kWh_{base} = \Big[&0.80460 + (Age \times 0.02107) + (Pre1990 \times 1.03605) + (Size \times 0.05930) \\ &+ (SingleDoor \times -1.75138) + (SideBySide \times 1.11963) \\ &+ (Primary \times 0.55990) + \left(\frac{HDD}{365} \times Unconditioned \times -0.04013\right) \\ &+ \left(\frac{CDD}{365} \times Unconditioned \times 0.02622\right)\Big] \times 365 \times PUF \end{aligned}$$

Freezers:

$$\Delta kWh = kWh_{base} - kWh_{ee}$$

DNV

$$kWh_{ee} = (3.166988 \times Size + 83.87742) + (4.611654 \times Size + 68.19428) \times Replacement$$

$$kWh_{base} = \Big[-0.95470 + (Age \times 0.04536) + (Pre1990 \times 0.54341) + (Size \times 0.12023) + (ChestFreezer \times 0.29816) + \left(\frac{HDD}{365} \times Unconditioned \times -0.03148\right) + \left(\frac{CDD}{365} \times Unconditioned \times 0.08217\right)\Big] \times 365 \times PUF$$

Per-measure gross summer peak coincident peak demand reduction for both refrigerators and freezers are calculated according to the following equation:

$$\Delta kW_{summer} = \left(\frac{\Delta kWh}{8{,}760}\right) \times TAF_{summer} \times LSAF_{summer}$$

Per-measure gross winter peak coincident peak demand reduction for both refrigerators and freezers are calculated according to the following equation:

$$\Delta kW_{winter} = \left(\frac{\Delta kWh}{8{,}760}\right) \times CF_{winter}$$

Where:

ΔkW_{summer}	= per measure gross summer coincident peak demand savings
ΔkW_{winter}	= per measure gross winter coincident peak demand savings
kWh_{base}	= baseline annual electric energy consumption
kWh_{ee}	= annual electric energy consumption of efficient unit
Age	= age of refrigerator or freezer
Pre1990	= adjustment variables for refrigerators and freezers manufactured before 1990
Size	= size of refrigerator or freezer
Replacement	= dummy variable for if the recycled freezer or refrigerator will be replaced
SingleDoor	= adjustment factor for single-door refrigerators
SideBySide	= adjustment factor for side-by-side refrigerators
ChestFreezer	= adjustment factor for chest freezers
Primary	= adjustment factor for refrigerators or freezers that were primary units
HDD	= Heating Degree Days for location of appliance removal
CDD	= Cooling Degree Days for location of appliance removal
Unconditioned	= adjustment factor for refrigerators or freezers in unconditioned space
PUF	= Part-use Factor to account for units that do not run throughout the year
TAF_{summer}	= Temperature Adjustment Factor

DNV

$LSAF_{summer}$ = Load-shape Adjustment Factor
CF_{winter} = winter peak coincidence factor

4.1.1.3 Input Variables

Table 4-1. Input Values for Refrigerator and Freezer Recycling Input Values for Refrigerator and Freezer Recycling

Component	Type	Value	Unit	Source(s)
Age	Variable	See customer application	years	Customer application
		Default = 18.61, for refrigerators 23.79, for freezers		Maryland/Mid-Atlantic TRM v10, pp. 67 - 68[47]
Pre1990	Variable	See customer application	–	Customer application
		Default = 0.20 for refrigerators, 0.46 for freezers		Maryland/Mid-Atlantic TRM v10, pp. 67 - 68[47]
Size	Variable	See customer application	cubic feet	Customer application
		Default = 19.43, for refrigerators 15.86, for freezers		Maryland/Mid-Atlantic TRM v10, pp. 67 - 68[47]
SingleDoor	Variable	See customer application	–	Customer application
		Default = 0.02		Maryland/Mid-Atlantic TRM v10, p. 67[47]
SideBySide	Variable	See customer application	–	Customer application
		Default = 0.34		Maryland/Mid-Atlantic TRM v10, p. 67[47]
ChestFreezer	Variable	See customer application	–	Customer application
		Default = 0.21		Maryland/Mid-Atlantic TRM v10, p. 67[47]
Primary	Variable	See customer application	–	Customer application
		Default = 0.64		Maryland/Mid-Atlantic TRM v10, p. 67[47]
HDD	Variable	Location-dependent value using a base temperature of 65°F	Heating Degree Days (HDD)	Table 19-4 in Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment
CDD	Variable	Location-dependent value using a base temperature of 65°F	Cooling Degree Days (CDD)	Table 19-4 in Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment

[47] Using participation population mean values from BGE EY4

DNV

Component	Type	Value	Unit	Source(s)
Unconditioned	Variable	See customer application	–	Customer application
		Default = 0.22 for refrigerators, 0.55 for freezers		Maryland/Mid-Atlantic TRM v10, pp. 67 - 68
PUF	Variable	See customer application	–	Customer application
		Default = 0.95, for refrigerators 0.86, for freezers		Maryland/Mid-Atlantic TRM v10, pp. 67 - 68
TAF_{summer}	Fixed	1.23	–	Maryland/Mid-Atlantic TRM v10, p. 68
$LSAF_{summer}$	Fixed	1.066	–	Maryland/Mid-Atlantic TRM v10, p. 68
CF_{winter}	Fixed	0.418	–	California DEER2011 load profile for residential high efficiency refrigerator and freezer
Replacement	Variable	See customer application	–	Customer application

Table 4-2. Model Coefficients Used for Refrigerator-recycling Energy Savings

Independent Variable Description	Estimate Coefficient
Intercept	0.80460
Age (years)	0.02107
Pre-1990 (=1 if manufactured pre-1990)	1.03605
Size (cubic feet)	0.05930
Dummy: Single Door (=1 if single door)	-1.75138
Dummy: Side-by-Side (=1 side-by-side)	1.11963
Dummy: Primary Usage Type (=1 if primary unit)	0.55990
Interaction: Located in Unconditioned Space x HDD/365	-0.04013
Interaction: Located in Unconditioned Space x CDD/365	0.02622

Table 4-3. Model Coefficients Used for Freezer-recycling Energy Savings

Independent Variable Description	Estimate Coefficient
Intercept	-0.95470
Age (years)	0.04530
Pre-1990 (=1 if manufactured pre-1990)	0.54341
Size (cubic feet)	0.12023
Dummy: Chest Freezer Configuration (=1 if chest freezer)	0.29816
Interaction: Located in Unconditioned Space x HDD/365	-0.03148
Interaction: Located in Unconditioned Space x CDD/365	0.08217

4.1.1.4 Default Savings

Savings is calculated in the following manner if variable values are not provided in the data. These are established using default values provided in Table 4-1.

Refrigerators that are not replaced, in Virginia:

$$\begin{aligned}\Delta kWh &= [0.80460 + (Age \times 0.02107) + \ (Pre1990 \times 1.03605 + (Size \times 0.05930) \\ &\quad + (SingleDoor \times -1.75138\ ) \ + (SideBySide \times 1.11963) \\ &\quad + (Primary \times 0.55990) \\ &\quad + (HDD/365 \times Unconditioned \times -0.04013) \\ &\quad + (CDD/365 \times Unconditioned \times 0.02622)] \times 365 \times PUF\end{aligned}$$

$$\begin{aligned}&= \Big[0.80460 + (18.61\ years \times 0.02107) + \ (0.20 \times 1.03605) \\ &\quad + (19.43\ cu.ft. \ \times 0.05930) + (0.02 \times -1.75138\ ) \\ &\quad + (0.34 \times 1.11963) + (0.64 \times 0.55990) \\ &\quad + \left(3{,}863 \frac{HDD}{365} \times 0.22 \times -0.04013\right) \\ &\quad + \left(1{,}436 \frac{CDD}{365} \times 0.22 \times 0.02622\right)\Big] \times 365 \times 0.95\end{aligned}$$

$$= 1{,}105.9\ kWh$$

Refrigerators that are replaced, in Virginia:

$$\begin{aligned}\Delta kWh &= [0.80460 + (Age \times 0.02107) + (Pre1990 \times 1.03605 + (Size \times 0.05930) \\ &\quad + (SingleDoor \times -1.75138) + (SideBySide \times 1.11963) \\ &\quad + (Primary \times 0.55990) \\ &\quad + (HDD/365 \times Unconditioned \times -0.04013) \\ &\quad + (CDD/365 \times Unconditioned \times 0.02622)] \times 365 \times PUF \\ &\quad - [(0.018333 \times Size + 0.5211) + (0.021573 \times Size + 0.6075) \\ &\quad + (4.619268 \times Size + 133.76988) + (0.11914 \times Size + 4.1692) \\ &\quad + (1.455825 \times Size + 52.1465) + (0.02268 \times Size + 1.04058) \\ &\quad + (2.05814 \times Size + 104.3048)] \times Replacement\end{aligned}$$

$$\begin{aligned}&= \Big[\Big[0.80460 + (18.61\ years \times 0.02107) + (0.20 \times 1.03605) \\ &\quad + (19.43\ cu.ft. \times 0.05930) + (0.02 \times -1.75138) \\ &\quad + (0.34 \times 1.11963) + (0.64 \times 0.55990) \\ &\quad + \left(3{,}863 \frac{HDD}{365} \times 0.22 \times -0.04013\right) \\ &\quad + \left(1{,}436 \frac{CDD}{365} \times 0.22 \times 0.02622\right)\Big] \times 365\Big] \\ &\quad - [[(0.018333 \times 19.43\ cu.ft. + 0.5211) \\ &\quad + (0.021573 \times 19.43\ cu.ft. + 0.6075) \\ &\quad + (4.619268 \times 19.43\ cu.ft. + 133.76988) \\ &\quad + (0.11914 \times 19.43\ cu.ft. + 4.1692) \\ &\quad + (1.455825 \times 19.43\ cu.ft. + 52.1465) \\ &\quad + (0.02268 \times 19.43\ cu.ft. + 1.04058) \\ &\quad + (2.05814 \times 19.43\ cu.ft. + 104.3048)] \times 1]\end{aligned}$$

$$= 1{,}105.9 - 458.1$$

$$= 647.8\ kWh$$

Refrigerators that are not replaced, in North Carolina:

$$\Delta kWh = \Big[0.80460 + (18.61 \times 0.02107) + (0.20 \times 1.03605) + (19.43 \times 0.05930) + (0.02 \times -1.75138) + (0.34 \times 1.11963) + (0.64 \times 0.55990) + \left(\frac{2{,}712}{365} \times 0.22 \times -0.04013\right) + \left(\frac{1{,}748}{365} \times 0.22 \times 0.02622\right)\Big] \times 365 \times 0.95$$

$$= 1{,}117.3\ kWh$$

Refrigerators that are replaced, in North Carolina:

$$\Delta kWh = \Big[\Big[0.80460 + (18.61 \times 0.02107) + (0.20 \times 1.03605) + (19.43 \times 0.05930) + (0.02 \times -1.75138) + (0.34 \times 1.11963) + (0.64 \times 0.55990) + \left(\frac{2{,}712}{365} \times 0.22 \times -0.04013\right) + \left(\frac{1{,}748}{365} \times 0.22 \times 0.02622\right)\Big] \times 365 \times 0.95\Big]$$
$$- [[(0.018333 \times 19.43\ cu.ft. + 0.5211) + (0.021573 \times 19.43\ cu.ft. + 0.6075) + (4.619268 \times 19.43\ cu.ft. + 133.76988) + (0.11914 \times 19.43\ cu.ft. + 4.1692) + (1.455825 \times 19.43\ cu.ft. + 52.1465) + (0.02268 \times 19.43\ cu.ft. + 1.04058) + (2.05814 \times 19.43\ cu.ft. + 104.3048)] \times 1]$$

$$= 1{,}117.3 - 458.1$$

$$= 659.2\ kWh$$

Freezers that are not replaced, in Virginia:

$$\Delta kWh = \Big[-0.95470 + (23.79 \times 0.04536) + (0.46 \times 0.54341) + (15.86 \times 0.12023) + (0.210.29816) + \left(\frac{3{,}863}{365} \times 0.55 \times -0.03148\right) + \left(\frac{1{,}436}{365} \times 0.55 \times 0.08217\right)\Big] \times 365 \times 0.86$$

$$= 734.0\ kWh$$

Freezers that are replaced, in Virginia:

$$\Delta kWh = \Big[\Big[-0.95470 + (23.79 \times 0.04536) + (0.46 \times 0.54341) + (15.86 \times 0.12023) + (0.21 \times 0.29816) + \left(\frac{3{,}863}{365} \times 0.55 \times -0.03148\right) + \left(\frac{1{,}436}{365} \times 0.55 \times 0.08217\right)\Big] \times 365 \times 0.86\Big] - \big[[(3.166988 \times 15.86 + 83.87742) + (4.611654 \times 15.86 + 68.19428)] \times 1\big]$$

$$= 734.0 - 275.4$$

$$= 458.6\ kWh$$

Freezers that are not replaced, in North Carolina:

$$\Delta kWh = \Big[-0.95470 + (23.79 \times 0.04536) + (0.46 \times 0.54341) + (15.86 \times 0.12023) + (0.21 \times 0.29816) + \left(\frac{2{,}712}{365} \times 0.55 \times -0.03148\right) + \left(\frac{1{,}748}{365} \times 0.55 \times 0.08217\right)\Big] \times 365 \times 0.86$$

$$= 763.3\ kWh$$

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Freezers that are replaced, in North Carolina:

$$\Delta kWh = \Bigg[\Bigg[-0.95470 + (23.79 \times 0.04536) + (0.46 \times 0.54341) + (15.86 \times 0.12023) + (0.21 \times 0.29816) + \left(\frac{2{,}712}{365} \times 0.55 \times -0.03148\right) + \left(\frac{1{,}748}{365} \times 0.55 \times 0.08217\right)\Bigg] \times 365 \times 0.86\Bigg] - \big[[(3.166988 \times 15.86 + 83.87742) + (4.611654 \times 15.86 + 68.19428)] \times 1\big]$$

$$= 763.3 - 275.4$$

$$= 487.8\ kWh$$

Summer per measure gross coincident peak demand savings for both refrigerators and freezers are calculated according to the following equations:

Refrigerators that are not replaced, in Virginia:

$$\Delta kW_{summer} = \left(\frac{\Delta kWh}{8{,}760}\right) \times TAF_{summer} \times LSAF_{summer}$$

$$= \left(\frac{1{,}105.9}{8{,}760}\right) \times 1.23 \times 1.066$$

$$= 0.166\ kW$$

Refrigerators that are replaced, in Virginia:

$$\Delta kW_{summer} = \left(\frac{647.8}{8{,}760}\right) \times 1.23 \times 1.066$$

$$= 0.097\ kW$$

Refrigerators that are not replaced, in North Carolina:

$$\Delta kW_{summer} = \left(\frac{1{,}117.3}{8{,}760}\right) \times 1.23 \times 1.066$$

$$= 0.167\ kW$$

DNV

Refrigerators that are replaced, in North Carolina:

$$\Delta kW_{summer} = \left(\frac{659.2}{8{,}760}\right) \times 1.23 \times 1.066$$

$$= 0.099\ kW$$

Freezers that are not replaced, in Virginia:

$$\Delta kW_{summer} = \left(\frac{734.0}{8{,}760}\right) \times 1.23 \times 1.066$$

$$= 0.110\ kW$$

Freezers that are replaced, in Virginia:

$$\Delta kW_{summer} = \left(\frac{458.6}{8{,}760}\right) \times 1.23 \times 1.066$$

$$= 0.069\ kW$$

Freezers that are not replaced, in North Carolina:

$$\Delta kW_{summer} = \left(\frac{763.3}{8{,}760}\right) \times 1.23 \times 1.066$$

$$= 0.114\ kW$$

Freezers that are replaced, in North Carolina:

$$\Delta kW_{summer} = \left(\frac{487.8}{8{,}760}\right) \times 1.23 \times 1.066$$

$$= 0.073\ kW$$

Winter per measure gross coincident peak demand savings for both refrigerators and freezers are calculated according to the following equations:

Refrigerators that are not replaced, in Virginia:

$$\Delta kW_{winter} = \left(\frac{\Delta kWh}{8{,}760}\right) \times CF_{winter}$$

$$= \left(\frac{1{,}105.9}{8{,}760}\right) \times 0.418$$

$$= 0.053\ kW$$

Refrigerators that are replaced, in Virginia:

$$\Delta kW_{winter} = \left(\frac{647.8}{8{,}760}\right) \times 0.418$$

$$= 0.031\ kW$$

Refrigerators that are not replaced, in North Carolina:

Units that are not replaced:

$$\Delta kW_{winter} = \left(\frac{1{,}117.3}{8{,}760}\right) \times 0.418$$

$$= 0.053\ kW$$

Refrigerators that are replaced, in North Carolina:

$$\Delta kW_{winter} = \left(\frac{659.2}{8{,}760}\right) \times 0.418$$

$$= 0.031\ kW$$

Freezers that are not replaced, in Virginia:

$$\Delta kW_{winter} = \left(\frac{734.0}{8{,}760}\right) \times 0.418$$

$$= 0.035\ kW$$

Freezers that are replaced, in Virginia:

$$\Delta kW_{winter} = \left(\frac{458.6}{8{,}760}\right) \times 0.418$$

$$= 0.022\ kW$$

Freezers that are not replaced, in North Carolina:

$$\Delta kW_{winter} = \left(\frac{763.3}{8{,}760}\right) \times 0.418$$

$$= 0.036\ kW$$

Freezers that are replaced, in North Carolina:

$$\Delta kW_{winter} = \left(\frac{487.8}{8{,}760}\right) \times 0.418$$

$$= 0.023\ kW$$

4.1.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 4-4.

Table 4-4. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VII	Residential Appliance and Freezer Recycling Program	8.00	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

4.1.1.6 Sources

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v10, pp. 57-61 and 65-69.

4.1.1.7 Update Summary

Updates to this section are described in Table 4-5.

Table 4-5. Summary of Update(s)

Version with Updates	Update Type	Description
2021	Source	Updated page numbers / version of the Mid-Atlantic TRM
	Equation	Added gross winter peak demand reduction equation
	New table	Effective Useful Life (EUL) by program
2020	None	No change
v10		Initial release

DNV

5 RESIDENTIAL HOME ENERGY ASSESSMENT PROGRAM, DSM PHASE VII

The Residential Home Energy Assessment Program provides energy efficiency measures to homeowners in order to reduce electric use. The measures offered through the program and the sections that contain the savings algorithms for each measure are presented in Table 5-1.

Table 5-1. Home Energy Assessment Program Measure List

End Use	Measure	Legacy Program	Manual Section
Envelope	Cool Roof	–	Section 5.1.1
Domestic Hot Water	Domestic Hot Water Pipe Insulation	Income & Age Qualifying Home Improvement Program	Section 2.1.1
	Heat Pump Domestic Hot Water Heater	–	Section 5.2.2
	Low-Flow Aerator	Income & Age Qualifying Home Improvement Program	Section 2.1.2
	Low-Flow Showerhead	Income & Age Qualifying Home Improvement Program	Section 2.1.3
	Water Heater Temperature Setback	–	Section 5.2.5
HVAC	HVAC Upgrades	–	Section 5.3.1
	HVAC Tune-Up	–	Section 5.3.2
	ECM Fan Motors	–	Section 5.3.3
	Duct Insulation	–	Section 5.3.4
	Duct Sealing	–	Section 5.3.5
Lighting	LED Lighting	Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 2.3.1

The program has been offered in Virginia since 2019.

5.1 Building Envelope End Use

5.1.1 Cool Roof

5.1.1.1 Measure Description

The cool roof measure involves the replacement of an existing roof with a roofing material that is designed to reduce the amount of heat absorbed through a home's roof. Cool roof materials have a higher solar reflectance and thermal emittance compared to typical residential roofing products. This reduces the overall heat gain within a home and thereby reduces the cooling load during warm seasons. On the other hand, the decrease in the amount of heat absorbed by the roof also increased the heating load during the cold seasons. Therefore, this measure yields significant energy savings during the warm seasons that are somewhat offset by increased energy usage during the cold season. As such, cool roofs are most beneficial in warm climates.

The baseline condition is the existing home's roofing material whereas the efficient condition is a material that has been rated by the Cool Roof Rating Council and meets ENERGY STAR® roof product performance specifications. Annual electric energy and demand savings are presented for cool roofs according to the rated 3-year reflectance of the installed cool roof product and the type of roof (low-slope, high-slope) on which it is installed.

This measure is offered through different programs listed in Table 5-6, and uses the impacts estimation approach described in this section.

Table 5-2. Programs that Offer Cool Roof

Program Name	Section
Residential Home Energy Assessment Program, DSM Phase VII	Section 5.1.1
Residential Manufactured Housing Program, DSM Phase VIII	Section 11.1.3

5.1.1.2 Impacts Estimation Approach

Deemed savings estimates for this measure are developed using BEopt™ 2.8, a program developed and maintained by the U.S. Department of Energy for modeling residential energy-efficiency measures using the EnergyPlus simulation engine. Savings will be calculated based on approved customer applications. The BEopt model uses the collected variables as provided in Table 5-3 and well as some default assumptions about the home's construction[48] to calculate the energy saved by installing a cool roof. The default assumptions will be informed by the applicant's house attributes (e.g., number of stories) and HVAC system(s) (e.g., heat pump system), but industry standards are assumed for those characteristics not gathered. The kWh term in the equations below is calculated from the results generated from the baseline- and efficient-case BEopt models. TMY3 weather station data will be assigned based upon the home's location.

Per roof gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh \quad = kWh_{base} - kWh_{ee}$$

Per roof gross summer coincident peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} \quad = kW_{base,summer} - kW_{ee,summer}$$

Per roof gross winter coincident peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} \quad = kW_{base,winter} - kW_{ee,winter}$$

48 Wilson, E., C. Engebrecht Metzger, S. Horowitz, and R. Hendron. "2014 Building America House Simulation Protocols," for National Renewable Energy Laboratory, NREL/TP-5500-60988, March 2014. (www.energy.gov/sites/prod/files/2014/03/f13/house_simulation_protocols_2014.pdf)

Where:

ΔkW_{summer}	= gross coincident summer peak demand reduction
ΔkW_{winter}	= gross coincident winter peak demand reduction
kWh_{base}	= gross annual energy consumption of the baseline case
kWh_{ee}	= gross annual energy consumption of the efficient case
$kW_{base,summer}$	= gross coincident summer peak demand of baseline case
$kW_{ee,summer}$	= gross coincident summer peak demand of efficient case
$kW_{base,winter}$	= gross coincident winter peak demand of baseline case
$kW_{ee,winter}$	= gross coincident winter peak demand of efficient case

5.1.1.3 Input Variable

The model inputs are based on the following customer application parameters:

Table 5-3. Input Parameters for BEopt Models of Cool Roof

Component	Type	Value	Units	Source(s)
Total Roof Area	Variable	See customer application	sq. ft.	Customer application
Cool Roof Area	Variable	See customer application	sq. ft.	Customer application
Conditioned Area	Variable	See customer application	sq. ft.	Customer application
Number of Floors	Variable	See customer application	floors	Customer application
Roof Type, Base	Variable	See customer application	–	Customer application
Roof Type, Efficient	Variable	See customer application	–	Customer application
Roof Color, Base	Variable	See customer application	–	Customer application
Roof Color, Efficient	Variable	See customer application	–	Customer application
Home Age	Variable	See customer application	years	Customer application
Ceiling Insulation R-value	Variable	See customer application	–	Customer application
Thermal Emittance, Base	Variable	Based on roof type, base	–	Customer application
Thermal Emittance, Efficient	Variable	Based on roof type, efficient	–	Customer application
Solar Reflectance, Base	Variable	Based of roof type, base	–	Customer application
Solar Reflectance, efficient	Variable	Based of roof type, efficient	–	Customer application
Above Sheathing Ventilation	Variable	See customer application	–	Customer application
Roof Pitch, Average	Variable	See customer application	–	Customer application
Radiant Barrier	Variable	See customer application	–	Customer application
Duct in Conditioned Space	Variable	See customer application	–	Customer application
Duct Leakage Tested and Sealed	Variable	See customer application	–	Customer application

5.1.1.4 Default Savings

If the proper values are not available, zero savings will be given for both the gross annual electric energy savings and the gross coincident peak demand reduction.

5.1.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 5-4.

Table 5-4. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Manufactured Housing Program, DSM Phase VIII	15.00	years	Texas TRM Residential Measures 2020, p. 283
VII	Residential Home Energy Assessment Program	12.41	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

5.1.1.6 Source(s)

The primary source for this deemed savings approach is the Texas TRM Residential Measures 2020, pp. 253-284.

5.1.1.7 Update Summary

Updates to this section are described in Table 5-5. Summary of Update(s).

Table 5-5. Summary of Update(s)

Updates in Version	Update Type	Description
2021	New table	Effective Useful Life (EUL) by program
	Equation	Added winter peak coincident demand reduction equation
2020		Initial release

5.2 Domestic Hot Water End Use

5.2.1 Domestic Hot Water Pipe Insulation

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV. The savings are determined using the methodology described in Section 2.1.1.

5.2.2 Heat Pump Domestic Water Heater

5.2.2.1 Measure Description

This measure involves replacing a electric storage water heater with a heat-pump water heater (HPWH) having an input power rating of less than or equal to 12 kW.[49] The baseline condition is a new electric storage water heater satisfying the minimum efficiency standards in effect since December 29, 2016 as provided in Table 5-8.[50,51] For this measure, the ENERGY STAR-qualified heat-pump water heater[52] is considered to be the efficient condition.

This measure is offered through different programs listed in Table 5-6, and uses the impacts estimation approach described in this section.

Table 5-6. Programs that Offer Heat Pump Domestic Water Heater

Program Name	Section
Residential Home Energy Assessment Program, DSM Phase VII	Section 5.2.2
Residential Manufactured Housing Program, DSM Phase VIII	Section 11.2.3
Residential Home Retrofit Program, DSM Phase VIII	Section 12.2.3

5.2.2.2 Impacts Estimation Approach

Per measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \left[Gallon_{day} \times 0.195 \frac{MMBtu\ day}{gallon} \times 293.1 \frac{kWh}{MMBtu} \times \left(\frac{1}{UEF_{base}} - \frac{1}{UEF_{ee}}\right)\right] + kWh_{cooling} - kWh_{heating}$$

The equation for calculating UEF_{base} uses the storage volume (V_s) as shown in Table 5-8.

The cooling savings are calculated for the reduction in cooling load—if the water heater is installed in conditioned space—using the equation that follows:[53]

[49] CFR 10 → Chapter II → Subchapter D → Part 430 → Subpart C → § 430.2. Maryland/Mid-Atlantic TRM v10, p. 149.

[50] Docket No. EERE-2015-BT-TP-0007. Maryland/Mid-Atlantic TRM v10, p. 149.

[51] The federal minimum standard for water heaters >55 gallon was increased to EF≥2.0, compared to an EF≥0.907 for water heaters ≤55 gallons. Since the standard went into effect, sales of the larger units have declined dramatically. Evaluators in Maryland hypothesize that customers are using a variety of strategies to avoid the higher efficiency standard including combining multiple smaller water heaters, increasing set points on smaller heaters, etc. To address this concern, some TRM stakeholders recommended that a common practice baseline be used for this measure rather than the minimum federal standard. To maintain consistency with other measures in the Maryland/Mid-Atlantic TRM, however, the decision was made to use the federal minimum efficiency for the standard baseline, recognizing that individual jurisdictions may depart from the federal standard baseline and use a common practice baseline instead (per Maryland/Mid-Atlantic TRM v10, p. 149).

[52] ENERGY STAR® v3.2 Program Requirements for Residential Water Heaters. Maryland/ Maryland/Mid-Atlantic TRM v10, p. 149.

[53] This algorithm calculates the heat removed from the air by subtracting the HPWH electric consumption from the total water heating energy delivered. This is then adjusted to account for the location of the HP unit and the coincidence of the waste with cooling requirements, the efficiency of the central cooling and latent cooling demands.

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$$kWh_{cooling} = \frac{Gallon_{day} \times 365\ days \times \gamma_{water} \times (T_{out} - T_{in}) \times 1.0 \frac{Btu}{lb \cdot °F} \times WMF_{cool} \times LF_{cool} \times Year_{cool}}{UEF_{ee} \times 3{,}412 \frac{Btu}{kWh} \times COP_{cool}}$$

The heating penalty is calculated for the space heating if the water heater is installed in a conditioned space and the heating fuel type is electric. For non-electric heating fuels there is no kWh penalty. The heating penalty is calculated using the following equation:

$$kWh_{heating} = \frac{Gallon_{day} \times 365\ days \times \gamma_{water} \times (T_{out} - T_{in}) \times 1.0 \frac{Btu}{lb \cdot °F} \times WMF_{heat} \times LF_{heat} \times Year_{heat}}{UEF_{ee} \times 3{,}412 \frac{Btu}{kWh} \times COP_{heat}}$$

Per measure, gross coincident summer peak demand reduction is fixed as follows:

For water heaters with a rated storage volume of 55 gallon or less:[54]

$$\Delta kW_{summer} = 0.09 \times UEF_{ee} / 3.41$$

For water heaters with a rated storage volume of greater than 55 gallons:[55]

$$\Delta kW_{summer} = 0.11 \times UEF_{ee} / 3.34$$

Per measure, gross coincident winter peak demand reduction is fixed as follows:

For water heaters with a rated storage volume of 55 gallon or less:[56]

$$\Delta kW_{winter} = CF_{winter} \times UEF_{ee} / 3.41$$

For water heaters with a rated storage volume of greater than 55 gallons:[57]

$$\Delta kW_{winter} = CF_{winter} \times UEF_{ee} / 3.34$$

Where:

ΔkW_{summer}	= per measure gross coincident summer peak demand savings
ΔkW_{winter}	= per measure gross coincident winter peak demand savings
Gallonday	= gallons per day of hot water use per person
UEF_{base}	= uniform energy factor (UEF) of electric storage water heater based on minimum federal standards

[54] Analysis of special study. Cadmus, "EmPOWER Maryland Heat Pump Water Heater Baseline and Market Analysis", February 2020. The study leveraged HPWH load shapes from "Field Testing of Pre-Production Prototype Residential Heat Pump Water Heaters" (https://www.energy.gov/sites/prod/files/2014/01/f7/heat_pump_water_heater_testing.pdf). Maryland/Mid-Atlantic TRM v10, p. 152

[55] Ibid.

[56] Analysis of special study. Cadmus, "EmPOWER Maryland Heat Pump Water Heater Baseline and Market Analysis", February 2020. The study leveraged HPWH load shapes from "Field Testing of Pre-Production Prototype Residential Heat Pump Water Heaters" (https://www.energy.gov/sites/prod/files/2014/01/f7/heat_pump_water_heater_testing.pdf). Maryland/Mid-Atlantic TRM v10, p. 152

[57] Ibid.

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UEF_{ee}	= uniform energy factor of efficient heat pump water heater
$kWh_{cooling}$	= cooling savings from conversion of heat in home to water heat
$kWh_{heating}$	= heating cost from conversion of heat in water to water heat (dependent on heating fuel)
$Year_{cool}$	= proportion of year typically requiring space cooling
$Year_{hot}$	= proportion of year typically requiring space heating
γ_{water}	= specific weight of water
T_{out}	= tank temperature
T_{in}	= incoming temperature from well or municipal system
LF_{cool}	= equipment installation location – is space conditioned or unconditioned for space cooling
LF_{heat}	= equipment installation location – is space conditioned or unconditioned for space heating
COP_{cool}	= coefficient of performance (COP) of central air conditioning
COP_{heat}	= coefficient of performance (COP) of electric heating system
WMF_{cool}	= water main factor to account for reduced DHW heating load during summer
WMF_{heat}	= water main factor to account for reduced DHW heating load during winter
V_s	= storage volume
CF_{winter}	= winter peak coincidence factor

5.2.2.3 Input Variables

Table 5-7. Input Values for the Heat Pump Domestic Hot Water Heater Savings Calculations

Component	Type	Value	Unit	Source(s)
$Gallon_{day}$	Variable	Based on tank capacity: ≤ 55 gallons = 42.6 > 55 gallons = 52.5	gallon/day	Maryland/Mid-Atlantic TRM v10, p. 150[58]
UEF_{base}	Variable	Calculated by customer application draw type and tank capacity, see Table 5-8	–	Maryland/Mid-Atlantic TRM v10, p. 153
		Default draw types: Tank capacity ≤50 gallons = Medium draw pattern, Tank capacity >50 gallons = high draw pattern		Maryland/Mid-Atlantic TRM v10, p. 154
UEF_{ee}	Variable	See customer application	–	Customer application
		For default see Table 5-8		Maryland/Mid-Atlantic TRM v10, p. 149[59]
V_s	Variable	See customer application		Customer application
		48.3		Dominion Residential Home Energy Use Survey 2019 - 2020 Appendix B, p. 37[60]
γ_{water}	Fixed	8.33	lb/gallon	Maryland/Mid-Atlantic TRM v10, p. 150
T_{out}	Fixed	125.0	°F	Maryland/Mid-Atlantic TRM v10, p. 150

58 EmPOWER heat pump water heater program participation in 2018-2019 and participant survey data. Mid-Atlantic TRM v10, p. 150
59 ENERGY STAR minimum qualifying requirements are used as the default value.
60 The weighted average tank volumes is used

Component	Type	Value	Unit	Source(s)
T_{in}	Fixed	60.9	°F	Maryland/Mid-Atlantic TRM v10, p. 150[61]
$Year_{cool}$	Fixed	0.35	–	Maryland/Mid-Atlantic TRM v10, p. 151
COP_{cool}	Variable	For Residential Home Energy Assessment Program, see customer application, Use SEER values and convert to COP using Equation 3 and Equation 7.	–	Customer application
		For Residential Manufactured Housing Program and Residential Home Retrofit Program, see Sub-Appendix F1-V: Residential HVAC Equipment Efficiency Ratings. Use EER values and convert to COP using Equation 7.		Customer application for cooling system type and the Federal Standard Efficiency Rating
		For default see Sub-Appendix F1-V: Residential HVAC Equipment Efficiency Ratings. Use split air conditioning >45 kBtu		Assumed equipment type and the Federal Standard Efficiency Rating
$Year_{heat}$	Fixed	0.47	–	Maryland/Mid-Atlantic TRM v10, p. 151
COP_{heat}	Variable	For Residential Home Energy Assessment Program, See customer application	–	Customer application
		For Residential Manufactured Housing Program and Residential Home Retrofit Program, see Sub-Appendix F1-V: Residential HVAC Equipment Efficiency Ratings		Customer application for cooling system type and the Federal Standard Efficiency Rating
		Default assumes non-electric heating equipment type		Assumed equipment type
LF_{cool}	Variable	See customer application, Conditioned space = 1.0, unconditioned =0.0, unknown = 0.65	–	Maryland/Mid-Atlantic TRM v10, p. 151
LF_{heat}	Variable	See customer application, Conditioned space = 1.0, unconditioned =0.0, unknown = 0.8	–	Maryland/Mid-Atlantic TRM v10, p. 151

[61] Navigant Consulting "EmPOWER Maryland Draft Final Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Residential Retrofit Programs." April 4, 2014, Appendix E, p. 66. Mid-Atlantic TRM v10, p. 150.

Component	Type	Value	Unit	Source(s)
WMF_{cool}	Fixed	0.82	–	Maryland/Mid-Atlantic TRM v10, p. 151
WMF_{heat}	Fixed	1.14	–	Maryland/Mid-Atlantic TRM v10, p. 151
CF_{winter}	variable	If $V_s \leq 55$ gallons = 0.167 If $V_s > 55$ gallons = 0.172	–	CA 2021 DEER load profile for 50-gallon and 65-gallon heat pump water heater[62]

Table 5-8. Consumer Electric Storage Water Heater Efficiency Criteria by Storage Volume

Standard	Baseline		Efficient	
	≥20 and ≤55 gallons	>55 gallons	≤55 gallons	>55 gallons
2017 Uniform Energy Factor (UEF) Standard	**Very small draw pattern** (first-hour rating <18 gal.; nom. 10 gal./day)			
	0.8808 -(0.00080 x V_s)	1.9236 -(0.00110 x V_s)	N/A	N/A
	Low draw pattern (first-hour rating ≥18 and <51 gal.; nom. 38 gal./day)			
	0.9254 -(0.00030 x V_s)	2.0440 -(0.00110 x V_s)	N/A	N/A
	Medium draw pattern (first-hour rating ≥51 and <75 gal.; nom. 55 gal./day)			
	0.9307 -(0.00020 x V_s)	2.1171 -(0.00110 x V_s)	2.0	2.2
	High draw pattern (first-hour rating ≥75 gal.; nom. 84 gal./day)			
	0.9349 -(0.00010 x V_s)	2.2418 -(0.00110 x V_s)	2.0	2.3

If first hour rating is unknown, assume medium draw pattern for electric storage water heaters having ≤ 50-gallon capacity and high draw pattern for those having > 50-gallon capacity.

5.2.2.4 Default Savings

If the proper values are not supplied, a default savings may be applied using conservative input values. The default gross annual electric energy savings will be assigned according to the sequence of equations that follow. The values used assume a water heater storage volume of 48.3 gallons and a medium draw pattern.

$$UEF_{base} = [0.9307 - (0.0002 \times V_s)]$$

$$= [0.9307 - (0.0002 \times 48.3)]$$

62 the CF_{winter} values are weighted for single family, multifamily and mobile homes. CA DEER building stock weights are applied.

$$= 0.921$$

The cooling savings due to using the heat in the house to heat the water is calculated according to the following equation:

$$kWh_{cooling} = \frac{Gallon_{day} \times 365\ days\ \times \gamma_{water} \times (T_{out} - T_{in}) \times 1.0 \frac{Btu}{lb \cdot °F} \times WMF_{cool} \times LF_{cool} \times Year_{cool}}{UEF_{ee} \times 3{,}412\ \frac{Btu}{kWh} \times COP_{cool}}$$

$$= \frac{46.2 \times 365 \times 8.33 \times (125 - 60.9) \times 1.0 \frac{Btu}{lb \cdot °F} \times 0.82 \times 0.65 \times 0.35}{2 \times 3{,}412\ \frac{Btu}{kWh} \times 3.08}$$

$$= 66.5\ kWh$$

The heating savings due to using the heat in the house to heat the water is calculated according to the following equation:

$$kWh_{heating} = \frac{Gallon_{day} \times 365\ days\ \times \gamma_{water} \times (T_{out} - T_{in}) \times 1.0 \frac{Btu}{lb \cdot °F} \times WMF_{heat} \times LF_{heat} \times Year_{heat}}{UEF_{ee} \times 3{,}412\ \frac{Btu}{kWh} \times COP_{heat}}$$

$$= \frac{46.2 \times 365 \times 8.33 \times (125 - 60.9) \times 1.0 \frac{Btu}{lb \cdot °F} \times 1.14 \times 0.80 \times 0.47}{2 \times 3{,}412\ \frac{Btu}{kWh} \times 2.04}$$

$$= 217.3\ kWh$$

Per measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \left[Gallon_{day} \times 0.195 \frac{MMBtu}{gallon} \times 293.1\ \frac{kWh}{MMBtu} \times \left(\frac{1}{UEF_{base}} - \frac{1}{UEF_{ee}}\right)\right] + kWh_{cooling} - kWh_{heating}$$

$$= \left[46.2\ \frac{gallon}{day} \times 0.195 \frac{MMBtu}{gallon} \times 293.1\ \frac{kWh}{MMBtu} \times \left(\frac{1}{0.921} - \frac{1}{2.00}\right)\right] + 66.5 - 217.3$$

$$= 1{,}396.6\ kWh$$

The default per measure gross summer peak coincident demand reductions will be assigned according to the following calculation. The values used assume a water heater with a tank capacity of 55 gallons or less.

$$\Delta kW_{summer} = 0.09 \times UEFee / 3.41$$

$$= 0.09 \times 2.00 / 3.41$$

$$= 0.0528 \text{ kW}$$

The default per measure gross winter peak coincident demand reductions will be assigned according to the following calculation. The values used assume a water heater with a tank capacity of 55 gallons or less.

$$\Delta kW_{winter} = CF_{winter} \times UEFee / 3.41$$

$$= 0.162 \times 2.00 / 3.41$$

$$= 0.0950 \text{ kW}$$

5.2.2.5 Effective Useful Life

The effective useful life of this measure is provided in Table 5-9.

Table 5-9. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Home Energy Assessment Program, DSM Phase VII	13.00	years	Mid-Atlantic TRM 2018, p. 191
	Residential Manufactured Housing Program, DSM Phase VIII			
VII	Residential Home Energy Assessment Program, DSM Phase VII	12.41	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

5.2.2.6 Source(s)

The primary sources for this deemed savings approach are the Maryland/Mid-Atlantic TRM v10, pp. 149-154 and Mid-Atlantic TRM v9, p. 196. The $kWh_{cooling}$ and $kWh_{heating}$ equations are missing the 365 days/yr in the Maryland/Mid-Atlantic TRM v10. Therefore, the equations used in this section are from the Maryland/Mid-Atlantic TRM v9. The other inputs and assumptions are from the Maryland/Mid-Atlantic v10.

5.2.2.7 Update Summary

Updates to this section are described in Table 5-10.

Table 5-10. Summary of Update(s)

Updates in Version	Update Type	Description
2021	Equations	Updated the energy savings, demand reduction equation and added winter demand equation
	Input Table	Updated default values of UEF_{base} and V_S
	Default Savings	Updated default energy savings and demand reduction values
	New table	Effective Useful Life (EUL) by program
2020		Initial release

5.2.3 Low-Flow Aerator

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV. The savings are determined using the methodology described in Section 2.1.2.

5.2.4 Low-Flow Showerhead

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV. The savings are determined using the methodology described in Section 2.1.3.

5.2.5 Water Heater Temperature Setback/Turndown

5.2.5.1 Measure Description

This measure relates to turning down an existing hot water tank thermostat setting that is at 130 degrees or higher. Savings are provided to account for the resulting reduction in standby losses. This is a retrofit measure.

The baseline condition is a hot water tank with a thermostat setting that is 130 degrees or higher. Note if there are more than one DHW tanks in the home at or higher than 130 degrees and they are all turned down, then the savings per tank can be multiplied by the number of tanks. The efficient condition is a hot water tank with the thermostat reduced to no lower than 120 degrees.

This measure is offered through different programs listed in Table 5-11, and uses the impacts estimation approach described in this section.

Table 5-11. Programs that Offer Water Heater Temperature Setback/Turndown

Program Name	Section
Residential Home Energy Assessment Program, DSM Phase VII	Section 5.2.5
Residential Manufactured Housing Program, DSM Phase VIII	Section 11.2.6
Residential Home Retrofit Program, DSM Phase VIII	Section 12.2.5

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Program Name	Section
Residential/Non-Residential Multifamily Program, DSM Phase VIII	Section 13.2.4

5.2.5.2 Impacts Estimation Approach

Per measure, gross annual electric energy savings are calculated according to the following equation:[63]

$$\Delta kWh = \frac{U \times A \times (T_{base} - T_{ee}) \times HOU}{3{,}412\ Btu/kWh \times \eta_{DHW}}$$

The Area is calculated according to the following equation[64]:

$$Area = -0.0017 \times capacity^2 + 0.437 \times capacity + 7.831$$

Per measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{\Delta kWh}{HOU} \times CF_{summer}$$

Per measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh}{HOU} \times CF_{winter}$$

Where:

ΔkWh = per measure gross annual electric energy savings
ΔkW_{summer} = per measure gross coincident summer peak demand savings
ΔkW_{winter} = per measure gross coincident winter peak demand savings
U = overall heat transfer coefficient of storage tank
Capacity = Tank storage volume
A = surface area of storage tank
T_{base} = temperature setting of storage water heater prior to measure
T_{ee} = temperature setting of storage water heater subsequent to measure
HOU = annual hours of use
η_{DHW} = recovery efficiency of electric, domestic hot water heater with storage tank
CF_{summer} = summer peak coincident factor
CFwinter = winter peak coincident factor

[63] For single family housing types, if the quantity of water heater temperature setback/turndown is ≥ 3 water heaters, a default quantity will be assigned to one instead. In such instances, it is assumed that the quantity was incorrectly documented as these water heater quantities are not expected to exceed 3 heat pumps per single family housing type.

[64] Mid-Atlantic TRM v10, p.141 provides areas for specific tank volume sizes. This equation is based on areas and tank volumes provided.

5.2.5.3 Input Variables

Table 5-12. Input Values for the Water Heater Temperature Setback Savings Calculations

Component	Type	Value	Unit	Source(s)
Capacity	Variable	See customer application	gallon	Customer application
		Default = 48.3		Dominion Residential Home Energy Use Survey 2019 - 2020 Appendix B, p. 37[65]
U	Fixed	0.083	Btu/hr· °F· ft^2	Maryland/Mid-Atlantic TRM v10, p. 161[66]
T_{base}	Fixed	135	°F	Maryland/Mid-Atlantic TRM v10, p. 161
T_{ee}	Fixed	120	°F	Maryland/Mid-Atlantic TRM v10, p. 161
HOU	Fixed	8,760	hours, annual	Maryland/Mid-Atlantic TRM v10, p. 161
η_{DHW}	Fixed	0.98	–	Maryland/Mid-Atlantic TRM v10, p. 160[67]
CF_{summer}	Fixed	1.0	–	Maryland/Mid-Atlantic TRM v10, p. 161[68]
CF_{winter}	Fixed	1.0	–	Maryland/Mid-Atlantic TRM v10, p. 161[68]

5.2.5.4 Default Savings

If the proper values are not supplied, a default savings may be applied using conservative input values. The default per measure gross annual electric energy savings will be assigned according to the following calculation:

$$Area = -0.0017 \times capacity^2 + 0.437 \times capacity + 7.831$$

$$= -0.0017 \times 48.3^2 + 0.437 \times 48.3 + 7.831$$

$$= 24.97\ ft^2$$

$$\Delta kWh = \frac{U \times A \times (T_{base} - T_{ee}) \times HOU}{3{,}412\ \frac{Btu/h}{kW} \times \eta_{DHW}}$$

65 The weighted average tank volumes is used

66 Assumed R-12

67 Electric storage water heaters have a minimum recovery efficiency of 98%: http://www.ahridirectory.org/ahridirectory/pages/home.aspx. Mid-Atlantic TRM v10, p. 161.

68 Mid-Atlantic TRM v10 does not provide a CF, therefore a CF is 1.0 is implied.

$$= \frac{0.083 \times 24.97\ ft^2 \times (135°F - 120°F) \times 8{,}760\ hr}{3{,}412\ Btu/kWh \times 0.98}$$

$$= 81.4\ kWh$$

The default per measure gross coincident summer peak demand reductions will be assigned according to the following calculation:

$$\Delta kW_{summer} = \frac{\Delta kWh}{8{,}760\ hr} \times CF_{summer}$$

$$= \frac{81.4\ kWh}{8{,}760\ hr} \times 1.0$$

$$= 0.009\ kW$$

The default per measure gross coincident winter peak demand reductions will be assigned according to the following calculation:

$$\Delta kW_{winter} = \frac{\Delta kWh}{8{,}760\ hr} \times CF_{winter}$$

$$= \frac{81.4\ kWh}{8{,}760\ hr} \times 1.0$$

$$= 0.009\ kW$$

5.2.5.5 Effective Useful Life

The effective useful life of this measure is provided in Table 5-13.

Table 5-13. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Manufactured Housing Program, DSM Phase VIII	2.00	years	Maryland/Mid-Atlantic TRM v10, p. 162
	Residential Home Retrofit Program, DSM Phase VIII			
	Residential/Non-Residential Multifamily Program, DSM Phase VIII			
	Residential Manufactured Housing Program, DSM Phase VIII			

DSM Phase	Program Name	Value	Units	Source(s)
VII	Residential Home Energy Assessment Program	12.41	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

5.2.5.6 Source(s)

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v10, pp. 160 – 162.

5.2.5.7 Update Summary

Updates to this section are described in Table 5-14.

Table 5-14. Summary of Update(s)

Updates in Version	Update Type	Description
2021	Source	Updated page numbers / version of the Maryland/Mid-Atlantic TRM
	Equation	• Added equation for calculating area instead of using look-up table to allow for more tank capacities • Added gross winter peak demand reduction equation
	Inputs	Used Dominion Residential Home Energy Survey as source for default tank storage capacity
	New Table	Effective Useful Life (EUL) by program
2020	None	No change
v10		Initial release

5.3 Heating, Ventilation, and Air Conditioning End Use

5.3.1 HVAC Upgrade

5.3.1.1 Measure Description

This measure is for the installation of high efficiency HVAC equipment. Equipment types include air-source heat pump, ductless mini-split heat pump, package terminal units (air conditioner and heat pump), and room air conditioners. High efficiency HVAC equipment deliver cooling and heating with between performance than standard equipment.

The baseline condition for the measure is a typical HVAC equipment that meets the minimum Federal standards. For most programs the baseline equipment type is the same as the high efficiency equipment. One exception to this is the Residential HB 2789 Program, which captures the existing heating system type. If the existing heating system type is electric resistance baseboard heat and is upgrade to a heat pump, the existing heating system type is the baseline.

This measure is offered through different programs listed in Table 5-15, and uses the impacts estimation approach described in this section.

Table 5-15. Programs that Offer HVAC Upgrade

Program Name	Section
Residential Home Energy Assessment Program, DSM Phase VII	Section 5.3.1
Residential Manufactured Housing Program, DSM Phase VIII	Section 11.3.6
Residential Home Retrofit Program, DSM Phase VIII	Section 12.4.1
Residential/Non-Residential Multifamily Program, DSM Phase VIII	Section 13.3.1
Residential HB 2789 Program, DSM Phase VIII	Section 16.3.1

5.3.1.2 Impacts Estimation Approach

Cooling Savings:

For air-source heat pump, ductless mini-split heat pump, package terminal units (air conditioner and heat pump) less than 65,000 Btu/h use the following equation:

$$\Delta kWh_{cool} = Size_{cool} \times \left(\frac{1}{SEER_{base}} - \frac{1}{SEER_{ee}}\right) \times EFLH_{cool} \times \frac{1\ kBtu/h}{1{,}000\ Btu/h}$$

For air-source heat pumps great than or equal to 65,000 Btu/h use the following equation:

$$\Delta kWh_{cool} = Size_{cool} \times \left(\frac{1}{IEER_{base}} - \frac{1}{IEER_{ee}}\right) \times EFLH_{cool} \times \frac{1\ kBtu/h}{1{,}000\ Btu/h}$$

For room air conditioners us the following equation:

$$\Delta kWh_{cool} = Size_{cool} \times \left(\frac{1}{CEER_{base}} - \frac{1}{CEER_{ee}}\right) \times EFLH_{cool} \times \frac{1\ kBtu/h}{1{,}000\ Btu/h}$$

Heating Savings:

Package terminal air conditioners and window air conditioners do not have heating savings.

$$\Delta kWh_{heat} = 0$$

For air-source heat pump, ductless mini-split heat pump, package terminal heat pumps less than 65,000 Btu/h use the following equation:

$$\Delta kWh_{heat} = Size_{heat} \times \left(\frac{1}{HSPF_{base}} - \frac{1}{HSPF_{ee}}\right) \times EFLH_{heat} \times \frac{1\ kBtu/h}{1{,}000\ Btu/h}$$

For air-source heat pumps great than or equal to 65,000 Btu/h use the following equation:

$$\Delta kWh_{heat} = Size_{heat} \times \left(\frac{1}{COP_{base}} - \frac{1}{COP_{ee}}\right) \times EFLH_{heat} \times \frac{1}{3{,}412\ Btu/kWh}$$

Per measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = Size_{cool} \times \left(\frac{1}{EER_{base}} - \frac{1}{EER_{ee}}\right) \times \frac{1\ kBtu/h}{1{,}000\ Btu/h} \times CF_{summer}$$

Package terminal air conditioners and window air conditioners do not have gross coincident winter peak demand reduction.

For air-source heat pump, ductless mini-split heat pump, package terminal heat pumps less than 65,000 Btu/h, the per measure gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = Size_{heat} \times \left(\frac{1}{HSPF_{base}} - \frac{1}{HSPF_{ee}}\right) \times \frac{1\ kBtu/h}{1{,}000\ Btu/h} \times CF_{winter}$$

For air-source heat pumps greater than or equal to 65,000 Btu/h the per measure, gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = Size_{heat} \times \left(\frac{1}{COP_{base}} - \frac{1}{COP_{ee}}\right) \times \frac{1}{3{,}412\ Btu/kWh} \times CF_{winter}$$

Where:

ΔkW_{summer}	= per measure gross coincident demand reduction
ΔkW_{winter}	= per measure gross coincident demand reduction
$Size_{cool}$	= cooling capacity of efficient heat pump
$Size_{heat}$	= heating capacity of efficient heat pump
$EFLH_{cool}$	= equivalent full load cooling hours
$EFLH_{heat}$	= equivalent full load heating hours
CF_{summer}	= summer peak coincidence factor
CF_{winter}	= winter peak coincidence factor
$SEER_{base}$	= seasonal energy efficiency ratio (SEER) of the existing or baseline air conditioning equipment. It is used for heat pumps and AC units that are smaller than 65,000 Btu/h.
$SEER_{ee}$	= seasonal energy efficiency ratio (SEER) of the installed air conditioning equipment. It is used for heat pumps and AC units that are smaller than 65,000 Btu/h.
$IEER_{base}$	= Integrated Energy Efficiency Ratio (IEER) of existing or baseline equipment.
$IEER_{ee}$	= Integrated Energy Efficiency Ratio (IEER) of installed equipment.
$CEER_{base}$	= Combined Energy Efficiency Ratio of baseline equipment.

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$CEER_{ee}$ = Combined Energy Efficiency Ratio of efficient equipment.

$HSPF_{base}$ = heating seasonal performance factor (HSPF) of existing or baseline heat pump. HSPF is used in heating savings for air source heat pumps.

$HSPF_{ee}$ = heating seasonal performance factor (HSPF) of installed heat pump. HSPF is used in heating savings for air source heat pumps.

COP_{base} = coefficient of performance (COP) of existing or baseline equipment.

COP_{ee} = coefficient of performance (COP) of installed equipment.

EER_{base} = energy efficiency ratio (EER) of existing or baseline air conditioning equipment. EER is used to analyze demand performance of heat pumps and AC units.

EER_{ee} = energy efficiency ratio (EER) of installed air conditioning equipment. EER is used to analyse performance of heat pumps and AC units.

5.3.1.3 Input Variables

Table 5-16. Input Values for Heat Pump Upgrade Savings Calculations

Component	Type	Value	Unit	Source(s)
$Size_{cool}$	Variable	See customer application	Btu/h	Customer application
$Size_{heat}$	Variable	See customer application[69]	Btu/h	Customer application
		Default = $Size_{cool}$		Customer-provided cooling size
$EFLH_{cool}$	Variable	For residential programs, see The location is assigned by the project's utility office code. For projects without an office code, a default location is assigned. The defaults are assigned based on the projects state. Projects in Virginia use a default location of Richmond, VA. Projects in North Carolina, use a default location of Elizabeth City, NC. in Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment For multifamily common areas, see the Non-Residential TRM Sub-Appendix F2-II: Non-Residential HVAC Equivalent Full Load Hours	hours, annual	Maryland/Mid-Atlantic TRM v10 and scaled from CDH by city
$EFLH_{heat}$	Variable	For residential programs, see Table 19-7 in Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment.	hours, annual	Maryland/Mid-Atlantic TRM v10 and scale from CDH by city

[69] When customer-provided heating system size is <80% or >156% of customer-provided cooling system size, a default value will be used, instead. In such instances, it is assumed that the heating system size was incorrectly documented. The acceptable range is based on a review of the AHRI database across numerous manufacturers and heat pump types.

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Component	Type	Value	Unit	Source(s)
		For multifamily common areas, see the Non-Residential TRM Sub-Appendix F2-II: Non-Residential HVAC Equivalent Full Load Hours		
SEER/IEER/ EER/HSPF/ COP_{base}	Variable	See Table 19-9 in Sub-Appendix F1-V: Residential HVAC Equipment Efficiency Ratings and the Non-Residential Technical Reference Manual, 13.3 Sub-Appendix F2-III: Non-Residential HVAC Equipment Efficiency Ratings . Assign baseline system to be the same as the efficient system type with exception for Residential HB 2789 Program. In this program, if the existing heat use existing heating equipment type for existing electric resistance baseboard, that is used as the baseline heating equipment. For other heating types the new heating equipment is used to determine the baseline efficiency. Use Equation 6 to convert from COP to HSPF if needed	kBtu/kWh (except COP is dimensionless)	10 CFR Ch. II (1-1-12 Edition) §430.32 Non-Residential Technical Reference Manual, 13.3 Sub-Appendix F2-III: Non-Residential HVAC Equipment Efficiency Ratings
$CEER_{base}$	Variable	See Table 19-10 in Sub-Appendix F1-V: Residential HVAC Equipment Efficiency Ratings	kBtu/kW-hour	Maryland/Mid-Atlantic TRM v10, p. 70
SEER/IEER/ CEER/EER/ $HSPF/COP_{ee}$	Variable	See customer application	kBtu/kWh (except COP is dimensionless)	Customer application
$CEER_{ee}$	Variable	See customer application	kBtu/kW-hour	Customer application
		Default see ENERGY STAR minimum qualifying values in Table 19-10 in Sub-Appendix F1-V: Residential HVAC Equipment Efficiency Ratings		Maryland/Mid-Atlantic TRM v10, p. 70
CF_{summer}	Variable	Room AC/Wall AC: 0.31 Ductless Mini-Split HP, package terminal air conditioning, package terminal heat pumps, central AC, and central HP: 0.69	–	Maryland/Mid-Atlantic TRM v10 p.93[70]
CF_{winter}	Variable	Ductless Mini-Split HP, package terminal heat pumps, and central HP: 0.69	–	Maryland/Mid-Atlantic TRM v10 p.93[70]

[70] The Maryland/Mid-Atlantic TRM v10 provides CF for room/wall AC and central AC systems in the ductless mini-split measure. In this section a generic value is used for each category. In other measures in the Maryland/Mid-Atlantic TRM v10 a utility-specific and equipment specific CF is provided. We use the more generic CF categories. It should be noted that ductless mini-split and package terminal units will likely have thermostats in each room, but we will consider these as a central unity. There are no generic winter CF. Therefore, we apply summer CF.

5.3.1.4 Default Savings

If the proper values are not available, zero savings will be given for both gross annual electric energy savings and gross demand energy savings.

5.3.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 5-17.

Table 5-17. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Manufactured Housing Program, DSM Phase VIII	Room AC use 12.00; all other types use 18.00	years	Maryland/Mid-Atlantic TRM v10, p.72, 79 and 85
	Residential Home Retrofit Program, DSM Phase VIII			
	Residential/Non-Residential Multifamily Program, DSM Phase VIII			
	Residential HB 2789 Program, DSM Phase VIII			
VII	Residential Home Energy Assessment Program, DSM Phase VII	12.41	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

5.3.1.6 Source(s)

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v10, pp. 70-71, 86, 120, 291; and Maryland/Mid-Atlantic TRM v9, p. 93.

5.3.1.7 Update Summary

Updates to this section are described in Table 5-18.

Table 5-18. Summary of Update(s)

Updates in Version	Update Type	Description
2021	New Table	Effective Useful Life (EUL) by program
	Equation	Added gross winter peak demand reduction equation
2020		Initial release

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5.3.2 HVAC Tune-Up

5.3.2.1 Measure Description

This measure realizes energy savings by tuning up an existing heat pump or regular air conditioning system. Tuning measures may include refrigerant charge correction, air flow adjustments, cleaning the condensate drain line, clean and straighten coils and fans, replace air filter, or repair damaged insulation.

This measure is offered through different programs listed in Table 5-19, and uses the impacts estimation approach described in this section.

Table 5-19. Programs that Offer HVAC Tune-Up

Program Name	Section
Residential Home Energy Assessment Program, DSM Phase VII	Section 5.3.2
Residential Manufactured Housing Program, DSM Phase VIII	Section 11.3.6
Residential Home Retrofit Program, DSM Phase VIII	Section 12.4.2
Residential/Non-Residential Multifamily Program, DSM Phase VIII	Section 13.3.2
Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII	Section 16.3.4

5.3.2.2 Impacts Estimation Approach

Per measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh \quad = \Delta kWh_{cool} + \Delta kWh_{heat}$$

$$\boldsymbol{\Delta kWh_{cool}} \quad = Size_{cool} \times \frac{1\ kBtu/h}{1{,}000\ Btu/h} \times \frac{EFLH_{cool}}{SEER} \times ESF$$

Heating savings are only applicable to heat pumps and calculated as follows:

$$\Delta kWh_{heat} \quad = Size_{heat} \times \frac{1\ kBtu/h}{1{,}000\ Btu/h} \times \frac{EFLH_{heat}}{HSPF} \times ESF$$

Per measure, gross coincident summer peak demand reductions are calculated according to the following equation:

$$\Delta kW_{summer} \quad = Size_{cool} \times \frac{1\ kBtu/h}{1{,}000\ Btu/h} \times \frac{1}{EER} \times DRF \times CF_{summer}$$

Per measure, gross coincident winter peak demand reductions are only applicable to heat pumps and calculated according to the following equation:

$$\Delta kW_{winter} = Size_{heat} \times \frac{1\ kBtu/h}{1{,}000\ Btu/h} \times \frac{1}{HSPF} \times DRF \times CF_{winter}$$

Where:

ΔkWh	= per measure gross annual electric energy savings
ΔkW_{summer}	= per measure gross coincident summer demand reductions
ΔkW_{winter}	= per measure gross coincident winter demand reductions
$Size_{cool}$	= cooling capacity of HVAC system
$Size_{heat}$	= heating capacity of heat pump
SEER	= seasonal energy efficiency ratio of the unit
EER	= energy efficiency ratio of the unit
HSPF	= heating seasonal performance factor of heat pump
$EFLH_{cool}$	= equivalent cooling full load hours
$EFLH_{heat}$	= equivalent heating full load hours
ESF	= annual energy savings factor attributed to tune-up
DRF	= demand reduction savings factor attributed to tune-up
CF_{summer}	= summer peak coincidence factor
CF_{winter}	= winter peak coincidence factor

5.3.2.3 Input Variables

Table 5-20. Input Values for Heat Pump Tune-Up Savings Calculations

Component	Type	Value	Unit	Source(s)
$Size_{cool}$	Variable	See customer application[71]	Btu/h	Customer application
$Size_{heat}$	Variable	See customer application[72] Default = $Size_{cool}$	Btu/h	Customer application
$EFLH_{cool}$	Variable	For residential programs see Table 19-7 in Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment For multifamily common areas see the Non-Residential Technical Reference Manual Sub-Appendix F2-II: Non-Residential HVAC Equivalent Full Load Hours	hours, annual	Maryland/Mid-Atlantic TRM v10 and scaled using cooling degree-hours (CDH) by city

[71] When customer-provided cooling system size is >5.4 tons, a default value will be assigned to zero tons instead. In such instances, it is assumed that the cooling system size was incorrectly documented as these residential heat pump systems are not expected to exceed 5.4 tons.

[72] When customer-provided heating system size is <80% or >156% of customer-provided cooling system size, a default value will be used, instead. In such instances, it is assumed that the heating system size was incorrectly documented. The acceptable range is based on a review of the AHRI database across numerous manufacturers and heat pump types.

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Component	Type	Value	Unit	Source(s)
EFLH$_{heat}$	Variable	For residential programs see The location is assigned by the project's utility office code. For projects without an office code, a default location is assigned. The defaults are assigned based on the projects state. Projects in Virginia use a default location of Richmond, VA. Projects in North Carolina, use a default location of Elizabeth City, NC. in Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment For multi-family common areas, see the Non-Residential Technical Reference Manual Sub-Appendix F2-II: Non-Residential HVAC Equivalent Full Load Hours	hours, annual	Maryland/Mid-Atlantic TRM v10 and scaled using CDH by city
SEER/EER/ HSPF	Variable	See customer application[73]	kBtu/kWh	Customer application
		Ssee Table 19-9 in Sub-Appendix F1-V: Residential HVAC Equipment Efficiency Ratings		10 CFR Ch. II (1-1-12 Edition) §430.32
ESF	Fixed	0.05	–	Maryland/Mid-Atlantic TRM v10, p. 316
DRF	Fixed	0.05	–	Maryland/Mid-Atlantic TRM v10, p. 316
CF$_{summer}$	Fixed	0.69	–	Maryland/Mid-Atlantic TRM v10, p. 93[74]
CF$_{winter}$	Fixed	0.69	–	Maryland/Mid-Atlantic TRM v10, p. 93[74]

5.3.2.4 Default Savings

If the proper values are not available, zero savings will be given for both gross annual electric energy savings and gross demand energy savings.

5.3.2.5 Effective Useful Life

The effective useful life of this measure is provided in Table 5-21.

[73] Customer application efficiency ratings are compared to acceptable ranges. If the provided value is outside the range a default value is applied. The acceptable ranges are based on AHRI rated equipment as follows: SEER 9.9 – 46.2, EER 7.92 – 22.11, HSPF 5.85 – 15.07

[74] The Maryland/Mid-Atlantic TRM v10 provides CF for central AC systems in the ductless mini-split measure. In other measures in the Maryland/Mid-Atlantic TRM v10 a utility-specific and equipment specific CF is provided. We use the more generic CF. There are no generic winter CF. Therefore, we apply summer CF.

Table 5-21. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Manufactured Housing Program, DSM Phase VIII	5.00	years	Maryland/Mid-Atlantic TRM v10, p. 316
	Residential Home Retrofit Program, DSM Phase VIII			
	Residential/Non-Residential Multifamily Program, DSM Phase VIII			
	Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII			
VII	Residential Home Energy Assessment Program, DSM Phase VII	12.41	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

5.3.2.6 Source(s)

The primary sources for this deemed savings approach is the Maryland/Mid-Atlantic TRM v10, pp. 315-316. This reference is for commercial applications. This has been adapted to residential applications using the residential equivalent full load hours and default efficiency values.

5.3.2.7 Update Summary

Updates to this section are described in Table 5-22.

Table 5-22. Summary of Update(s)

Updates in Version	Update Type	Description
2021	Equation	Added gross coincident winter peak demand reduction equation
	Inputs	Added acceptable customer application efficiency ranges
	New Table	Effective Useful Life (EUL) by program
	References	Updated the source TRM
2020		Initial release

5.3.3 ECM Fan Motor

5.3.3.1 Measure Description

Conventional natural-gas furnaces and air-conditioning systems that contain a permanent split capacitor (PSC) blower motor to deliver the conditioned air to the home are eligible to be replaced with a brushless DC motor, commonly called an electronically-commutated motor (ECM). The baseline condition is a furnace or air handler with a PSC motor at the fan; the efficient condition is an ECM motor in place of the PSC motor.

In the federal standard for residential furnaces have a required fan energy rating (FER) that would require an ECM motor for all new equipment. This became effective on July 3, 2019[75]. Therefore, this measure only applies to furnaces that were manufactured prior to that date.

This measure is offered through different programs listed in Table 5-23, and uses the impacts estimation approach described in this section.

Table 5-23. Programs that Offer ECM Fan Motor

Program Name	Section
Residential Home Energy Assessment Program, DSM Phase VII	Section 5.3.3
Residential Manufactured Housing Program, DSM Phase VIII	Section 11.3.4
Residential Home Retrofit Program, DSM Phase VIII	Section 12.4.4

5.3.3.2 Impacts Estimation Approach

Per measure, gross annual electric energy savings are calculated according to the following equation:

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

$$\Delta kWh_{cool} = EFLH_{cool} \times \Delta kW_{fan}$$

$$\Delta kWh_{heat} = EFLH_{heat} \times \Delta kW_{fan}$$

Summer per measure coincident peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \Delta kW_{fan} \times CF_{summer}$$

Summer per measure coincident peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \Delta kW_{fan} \times CF_{winter}$$

Where:

ΔkWh = per measure gross annual electric energy savings
ΔkW_{summer} = per measure gross coincident summer peak demand reduction
ΔkW_{winter} = per measure gross coincident winter peak demand reduction
$EFLH_{cool}$ = equivalent full-load hours for cooling
$EFLH_{heat}$ = equivalent full-load hours for heating

[75] CFR 10 → Chapter II → Subchapter D → Part 430 → Subpart C → § 430.216 CFR § 305.4, https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430, accessed 03/25/2022

ΔkW_{fan}	=	fan electric energy savings
CF_{summer}	=	summer peak coincidence factor
CF_{winter}	=	winter peak coincidence factor

5.3.3.3 Input Variables

Table 5-24. Input Values for ECM Fan Motors Savings Calculations

Component	Type	Value	Units	Sources
$EFLH_{cool}$	Variable	See The location is assigned by the project's utility office code. For projects without an office code, a default location is assigned. The defaults are assigned based on the projects state. Projects in Virginia use a default location of Richmond, VA. Projects in North Carolina, use a default location of Elizabeth City, NC. in Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment	hours, annual	Maryland/Mid-Atlantic TRM v10 and scaled using CDH by city
ΔkW_{fan}	Fixed	0.116	kW	Pennsylvania TRM Vol. 2 2019, p. 34
$EFLH_{heat}$	Variable	See Table 19-7 in Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment	hours, annual	Maryland/Mid-Atlantic TRM v10 and scaled using HDH by city
CF_{summer}	Fixed	0.69	–	Maryland/Mid-Atlantic TRM v10, p. 93[76]
CF_{winter}	Fixed	0.69	–	Maryland/Mid-Atlantic TRM v10, p. 93[76]

5.3.3.4 Default Savings

If the proper values are not supplied, a default savings may be applied using conservative input values. The default gross annual electric energy savings and the default coincident peak demand reduction will be assigned according to the following calculations, by system type and location.

In Virginia:

$$\Delta kWh = (EFLH_{cool} \times \Delta kW_{fan}) + (EFLH_{heat} \times \Delta kW_{fan})$$

[76] The same CF as the other HVAC measures are used for consistency. This measure is expected to have a similar savings profile. The Maryland/Mid-Atlantic TRM v10 provides CF for central AC systems in the ductless mini-split measure. In other measures in the Maryland/Mid-Atlantic TRM v10 a utility-specific and equipment specific CF is provided. We use the generic CF. There are no generic winter CF. Therefore, we apply summer CF.

$$= (842 \times 0.116) + (789 \times 0.116)$$

$$= 189.20\ kWh$$

The default summer coincident peak demand reduction will be assigned according to the following calculation:

$$\Delta kW_{summer} = \Delta kW_{fan} \times CF_{summer}$$

$$= 0.116 \times 0.69$$

$$= 0.08\ kW$$

The default winter coincident peak demand reduction will be assigned according to the following calculation:

$$\Delta kW_{winter} = \Delta kW_{fan} \times CF_{winter}$$

$$= 0.116 \times 0.69$$

$$= 0.08\ kW$$

In North Carolina:

$$\Delta kWh = (EFLH_{cool} \times \Delta kW_{fan}) + (EFLH_{heat} \times \Delta kW_{fan})$$

$$= (939 \times 0.116) + (744 \times 0.116)$$

$$= 195.23\ kWh$$

The default summer coincident peak demand reduction will be assigned according to the following calculation:

$$\Delta kW_{summer} = \Delta kW_{fan} \times CF_{summer}$$

$$= 0.116 \times 0.69$$

$$= 0.08\ kW$$

The default winter coincident peak demand reduction will be assigned according to the following calculation:

$$\Delta kW_{winter} = \Delta kW_{fan} \times CF_{winter}$$

$$= 0.116 \times 0.69$$

$$= 0.08\ kW$$

5.3.3.5 Effective Useful Life

The effective useful life of this measure is provided in Table 5-25.

Table 5-25. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Manufactured Housing Program, DSM Phase VIII	17.00	years	Maryland/Mid-Atlantic TRM v8, p. 74[77]
	Residential Home Retrofit Program, DSM Phase VIII			
VII	Residential Home Energy Assessment Program, DSM Phase VII	12.41	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

5.3.3.6 Source(s)

The primary source for this deemed savings approach is the Pennsylvania TRM Vol. 2 2019, p. 34, and Maryland/Mid-Atlantic TRM v10, p. 316.

5.3.3.7 Update Summary

Updates to this section are described in Table 5-26.

Table 5-26. Summary of Update(s)

Updates in Version	Update Type	Description
2021	Inputs	Changed the equation and calculated the default kWh savings with updated default values
	Equation	Added gross winter peak demand reduction equation
	New Table	Effective Useful Life (EUL) by program
2020		Initial release

[77] The Fan Energy Rating requirements in that became effecting in 2019 result in ECMs to be in new equipment. Therefore, the EUL will be the full equipment life minus the years since 2019. For equipment installed in 2021, the EUL will be 18 years (as provided in the Maryland/Mid-Atlantic TRM) minus 1 year (years since ECM were required in new equipment).

5.3.4 Duct Insulation

5.3.4.1 Measure Description

Energy and demand savings are realized through reductions in the home cooling and heating loads by insulating ductwork in unconditioned areas (e.g., attic with floor insulation, vented crawlspace, unheated garages). Basements shall be considered conditioned spaces.

The baseline condition is the existing uninsulated or poorly insulated ductwork in unconditioned spaces. The efficient condition is ductwork in unconditioned areas that has been insulated.

This measure is offered through different programs listed in Table 5-27, and uses the impacts estimation approach described in this section.

Table 5-27. Programs that Offer Duct Insulation

Program Name	Section
Residential Home Energy Assessment Program, DSM Phase VII	Section 5.3.4
Residential Home Retrofit Program, DSM Phase VIII	Section 12.4.5

5.3.4.2 Impacts Estimation Approach

Per measure, gross annual electric energy savings are calculated according to the following equation:

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

$$\Delta kWh_{cool} = \left(\frac{1}{R_{base}} - \frac{1}{R_{base} + R_{ee}}\right) \times Length \times Perimeter \times EFLH_{cool} \times \Delta T_{cool,avg.} \times \left(\frac{1}{1{,}000\ W/kW \times SEER}\right)$$

Heating savings are only calculated for heat pumps, central air conditioners with non-electric heating will not realize electric energy savings. Heating savings are calculated as follows:

$$\Delta kWh_{heat} = \left(\frac{1}{R_{base}} - \frac{1}{R_{base} + R_{ee}}\right) \times Length \times Perimeter \times EFLH_{heat} \times \Delta T_{heat,avg.} \times \left(\frac{1}{3{,}412\ Btu/kWh \times HSPF}\right)$$

Per measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{\Delta kWh_{cool}}{EFLH_{cool}} \times CF_{summer}$$

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Per measure, gross winter coincident peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh_{heat}}{EFLH_{heat}} \times CF_{winter}$$

Where:

ΔkW_{winter}	= per measure gross coincident winter peak demand reduction
R_{base}	= duct heat loss coefficient of existing duct and insulation
R_{ee}	= duct heat loss coefficient with new insulation
Area	= area of the duct surface exposed to the unconditioned space that has been insulated
$EFLH_{cool}$	= Equivalent Full Load Hours of cooling
$\Delta T_{cool,avg.}$	= average temperature difference during cooling season between outdoor air temperature, assuming 60°F supply air temperature
SEER	= Seasonal Energy Efficiency Ratio (SEER) of the cooling system
$EFLH_{heat}$	= Equivalent Full Load Hours of heating
$\Delta T_{heat,avg.}$	= Average temperature difference during heating season between outdoor air temperature, assuming 115°F supply air temperature
HSPF	= efficiency of the heating system
CF_{summer}	= summer system peak coincidence factor
CF_{winter}	= winter system peak coincidence factor

5.3.4.3 Input Variables

Table 5-28. Input Values for Duct Insulation Savings Calculations

Component	Type	Value	Units	Sources
R_{base}	Fixed	1.0 (minimum for uninsulated duct)	hr-°F-ft^2/Btu	Iowa 2019 Res TRM, p. 215
R_{ee}	Variable	See customer application	hr-°F-ft^2/Btu	See customer application
		Default: 6.0		Engineer estimate
Length	Variable	See customer application	ft	Customer application
		Default: 10		Engineer estimate
Perimeter	Fixed	1.57[78]	ft	Iowa 2019 Res TRM, p. 215
$EFLH_{cool}$	Variable	See Table 19-7 in Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment	hours	Maryland/Mid-Atlantic TRM v10 and scaled using CDH by city

[78] Based on an assumed circumference of 6 inches and circular duct (0.5 ft x 3.14 = 1.57)

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Component	Type	Value	Units	Sources
$\Delta T_{cool,avg.}$	Variable	Default: VA: 20.0 NC: 18.9	°F	Iowa 2019 Res TRM, p. 215. Values are derived from TMY data of Elizabeth City and Rocky Mount-Wilson (for NC), and Richmond (for VA), using 60°F supply temperature and an average OA temperature.[79]
SEER/HSPF	Variable	See customer application	kBtu/kWh	See customer application
		Default: Table 19-9 baseline efficiencies in Sub-Appendix F1-V: Residential HVAC Equipment Efficiency Ratings		10 CFR Ch. II (1-1-12 Edition) §430.32
$EFLH_{heat}$	Variable	See Table 19-7 in Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment	hours	Maryland/Mid-Atlantic TRM v10 and scaled using CDH by city
$\Delta T_{heat,avg.}$	Variable	Default: VA: 64.9 NC: 61.6	°F	Iowa 2019 Res TRM, pg. 215. Values are derived from TMY data of Elizabeth City and Rocky Mount-Wilson (for NC), and Richmond (for VA), using 115°F supply temperature and an average OA temperature.[80]
CF_{summer}	Fixed	0.69	–	Maryland/Mid-Atlantic TRM v10, p. 93[81]
CF_{winter}	Fixed	0.69	–	Maryland/Mid-Atlantic TRM v10, p. 93[81]

5.3.4.4 Default Savings

If the proper values are not supplied, a default savings may be applied using conservative input values.

The default per measure gross annual electric energy savings will be assigned according to the following calculation: (e.g., for residential homes in Virginia, with Central Air SEER=13, heat pump COP=2.0, and 10 ft. of uninsulated standard 6-inch round duct in an unconditioned space).

$$\Delta kWh_{cool} = \left(\frac{1}{R_{base}} - \frac{1}{R_{base} + R_{ee}}\right) \times Area \times EFLH_{cool} \times \Delta T_{cool.avg.} \times \left(\frac{1}{1{,}000\ W/kW \times \eta_{cool}}\right)$$

[79] Cooling season is estimated as May through August, only during 8 AM to 8 PM each day. See Iowa TRM pg. 215, footnote 568.

[80] Heating Season is estimated as September through April. See Iowa TRM, pg. 215, footnote 568.

[81] The same CF as the other HVAC measures are used for consistency. This measure is expected to have a similar savings profile. The Maryland/Mid-Atlantic TRM v10 provides CF for central AC systems in the ductless mini-split measure. In other measures in the Maryland/Mid-Atlantic TRM v10 a utility-specific and equipment specific CF is provided. We use the more generic CF. There are no generic winter CF. Therefore, we apply summer CF.

DNV

$$= \left(\frac{1}{1.0} - \frac{1}{1.0 + 6.0}\right) \times (\pi \times 0.5ft \times 10ft) \times 613\ hours \times 20.0°F \times \left(\frac{1}{1{,}000\ W/kW \times 13.0}\right)$$

$$= 12.7\ kWh$$

$$\Delta kWh_{heat} = \left(\frac{1}{R_{base}} - \frac{1}{R_{base} + R_{ee}}\right) \times Area \times EFLH_{heat} \times \Delta T_{avg,heat} \times \left(\frac{1}{3{,}412\ Btu/kWh \times \eta_{heat}}\right)$$

$$= \left(\frac{1}{1.0} - \frac{1}{1.0 + 6.0}\right) \times (\pi \times 0.5ft \times 10ft) \times 789\ hours \times 64.9°F \times \left(\frac{1}{3{,}412\ \ Btu/kWh \times 2.0}\right)$$

$$= 101.0\ kWh$$

The default summer per measure gross coincident peak demand reduction will be assigned according to the following calculation:

$$\Delta kW_{summer} = \frac{\Delta kWh_{cool}}{EFLH_{cool}} \times CF_{summer}$$

$$= \frac{12.7\ kWh}{613\ hours} \times 0.69$$

$$= 0.014\ kW$$

The default winter per measure gross coincident peak demand reduction will be assigned according to the following calculation:

$$\Delta kW_{winter} = \frac{\Delta kWh_{heat}}{EFLH_{heat}} \times CF_{winater}$$

$$= \frac{101.1\ kWh}{789\ hours} \times 0.69$$

$$= 0.089\ kW$$

5.3.4.5 Effective Useful Life

The effective useful life of this measure is provided in Table 5-29.

Table 5-29. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Home Retrofit Program, DSM Phase VIII	20.00	years	Iowa 2019 Res TRM, p. 214
VII	Residential Home Energy Assessment Program, DSM Phase VII	12.41	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

5.3.4.6 Source(s)

The primary source for this deemed savings approach is the Iowa TRM 2019, pp. 214-217. Other assumptions such as heating/cooling full load hours and temperature differences are based on NOAA TMY data estimations.

5.3.4.7 Update Summary

Updates to this section are described in Table 5-30.

Table 5-30. Summary of Update(s)

Updates in Version	Update Type	Description
2021	New table	Effective Useful Life (EUL) by program
	Equation	Added gross winter peak demand reduction equation
2020		Initial release

5.3.5 Duct Sealing

5.3.5.1 Measure Description

This measure realizes energy savings by identifying and sealing leaky duct work in unconditioned space using mastic sealant or metal tape.

Three methodologies for estimating the savings associated with sealing the ducts are provided. The first method requires the use of a blower door and the second requires the use of a duct blaster.

1. Modified Blower Door Subtraction - this technique is described in of the Energy Conservatory Blower Door Manual:

   http://energyconservatory.com/wp-content/uploads/2017/08/Blower-Door-Subtraction-Method.pdf

2. Total Leakage Test / Aerosol Test Equipment – this technique is described in detail on pp. 18 – 24 of the Energy Conservatory Duct Blaster Manual:

   https://energyconservatory.com/wp-content/uploads/2014/07/Duct-Blaster-Manual-Series-B-DG700.pdf

3. Duct Blaster Testing – this technique is described in detail on p. 16 of the RESNET Standard, Test 803.7:

   https://energyconservatory.com/wp-content/uploads/2014/09/RESNET-Standards-Chapter-8.pdf

4. Prescriptive – this method will make assumptions about the pre- and post-sealing leakage proportions. The energy savings and demand reductions are calculated using the Total Leakage Test method.

The existing baseline condition is leaky duct work within the unconditioned space. The efficient condition is sealed duct work throughout the unconditioned space in the home.

This measure is offered through different programs listed in Table 5-31, and uses the impacts estimation approach described in this section.

Table 5-31. Programs that Offer Duct Sealing

Program Name	Section
Residential Home Energy Assessment Program, DSM Phase VII	Section 5.3.5
Residential Manufactured Housing Program, DSM Phase VIII	Section 11.3.2
Residential Home Retrofit Program, DSM Phase VIII	Section 12.4.3
Residential/Non-Residential Multifamily Program, DSM Phase VIII	Section 13.3.3
Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII	Section 16.3.2

5.3.5.2 Impacts Estimation Approach

Per measure, gross annual electric energy savings are calculated according to duct leakage reduction and based on the methodology used:

Methodology 1: Modified Blower Door Subtraction Leakage

$$cfm50_{duct} = \left(cfm50_{whole\ house} - cfm50_{envelope\ only}\right) \times SCF$$

$$\Delta cfm25_{duct} = \left(cfm50_{duct,base} - cfm50_{duct,ee}\right) \times 0.64 \times (SLF + RLF)$$

Per measure, gross annual electric energy savings are calculated according to the following equations:

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

$$\Delta kWh_{cool} = \frac{\Delta cfm25_{duct} \times EFLH_{cool} \times 30\,\frac{Btu/h}{cfm}}{1{,}000\,\frac{W}{kW} \times SEER}$$

Heating savings are only calculated for heat pumps. Central air conditioners with non-electric heating and electric baseboard heating will not realize electric energy savings. Heating savings are calculated as follows:

$$\Delta kWh_{heat} = \frac{\Delta cfm25_{duct} \times EFLH_{heat} \times 30\,\frac{Btu/h}{cfm} \times 293.1\,\frac{kW}{MMBtu}}{1{,}000{,}000\,\frac{Btu}{MMBtu} \times COP}$$

Methodology 2: Total Leakage Test / Aerosol Test Equipment

$$\Delta cfm25_{duct} = \left(cfm25_{DL,base} - cfm25_{DL,ee}\right) \times DLF$$

Per measure, gross annual electric energy savings are calculated according to the following equations:

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

$$\Delta kWh_{cool} = \frac{\Delta cfm25_{duct} \times EFLH_{cool} \times 30\,\frac{Btu/h}{cfm}}{1{,}000\,\frac{W}{kW} \times SEER}$$

Heating savings are only calculated for heat pumps. Central air conditioners with non-electric heating will not realize electric energy savings. Heating savings are calculated as follows:

$$\Delta kWh_{heat} = \frac{\Delta cfm25_{duct} \times EFLH_{heat} \times 30\,\frac{Btu/h}{cfm} \times 293.1\,\frac{kW}{MMBtu}}{1{,}000{,}000\,\frac{Btu}{MMBtu} \times COP}$$

Methodology 3: Duct Blaster Testing

Per measure, gross annual electric energy savings are calculated according to the following equations:

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

$$\Delta kWh_{cool} = \frac{\left(cfm25_{duct,base} - cfm25_{duct,ee}\right) \times EFLH_{cool} \times 30\,\frac{Btu/h}{cfm}}{1{,}000\,\frac{W}{kW} \times SEER}$$

Heating savings are only calculated for heat pumps. Central air conditioners with non-electric heating and electric baseboard heating will not realize electric energy savings. Heating savings are calculated as follows:

$$\Delta kWh_{heat} = \frac{(cfm25_{duct,base} - cfm25_{duct,ee}) \times EFLH_{heat} \times 30\,\frac{Btu/h}{cfm} \times 293.1\,\frac{kW}{MMBtu}}{1{,}000{,}000\,\frac{Btu}{MMBtu} \times COP}$$

After obtaining gross annual electric energy savings from one of the above methods, per measure, gross coincident summer peak demand reductions are calculated according to the following equation:

$$\Delta kW_{summer} = \frac{\Delta kWh_{cool}}{EFLH_{cool}} \times CF_{summer}$$

per measure, gross coincident summer peak demand reductions are calculated according to the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh_{heat}}{EFLH_{heat}} \times CF_{winter}$$

Where:

ΔkWh_{heat}	= gross annual electric energy heating savings
ΔkW_{summer}	= per measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per measure gross coincident winter peak demand reduction
Size	= cooling/heating capacity of equipment in Btu/h (1 ton = 12,000 Btu/h)
$cfm50_{duct}$	= duct leakage, calculate base & efficient cfm50whole house and cfm50envelope only
$\Delta cfm25_{duct}$	= duct leakage reduction
$cfm25_{duct,base}$	= duct leakage in cfm25 as measured by duct blaster test before sealing
$cfm25_{duct,ee}$	= duct leakage in cfm25 as measured by duct blaster test after sealing
$cfm50_{whole\ house}$	= standard blower door test result finding cubic feet per minute at a 50 Pascal pressure differential
$cfm50_{envelope\ only}$	= blower door test result finding cubic feet per minute at 50 Pascal pressure differential with all supply and return registers sealed
SCF	= subtraction correction factor used to account for underestimation of duct leakage due to connections between duct system and the home. This value is determined by measuring pressure in duct system with registers sealed and using look up table provided by Energy Conservatory.
SLF	= supply loss factor; percentage of leaks sealed located in supply ducts x 182
RLF	= return loss factor; percentage of leaks sealed located in return ducts x 0.583
$EFLH_{cool}$	= equivalent cooling full load hours (EFLH)
$EFLH_{heat}$	= equivalent heating full load hours (EFLH)

[82] Mid-Atlantic TRM v9, p. 111. Assumes that for each percent of supply air loss there is one percent annual energy penalty. This assumes supply side leaks are direct losses to the outside and are not recaptured back to the house. This could be adjusted downward to reflect regain of usable energy to the house from duct leaks. For example, during the winter some of the energy lost from supply leaks in a crawlspace will probably be regained back to the house (sometimes 1/2 or more may be regained). More information provided in "Appendix E Estimating HVAC System Loss From Duct Airtightness Measurements" https://energyconservatory.com/wp-content/uploads/2014/07/Duct-Blaster-Manual-Series-B-DG700.pdf. Accessed 10/01/2019.

[83] Mid-Atlantic TRM v9, p. 111. Assumes that for each percent of return air loss there is a half percent annual energy penalty. Note that this assumes that return leaks contribute less to energy losses than do supply leaks. This value could be adjusted upward if there was reason to suspect that the return leaks contribute significantly more energy loss than "average" (e.g., pulling return air from a super-heated attic), or can be adjusted downward to represent significantly less energy loss (e.g. pulling return air from a moderate temperature crawl space). More information provided in "Appendix E Estimating HVAC System Loss From Duct Airtightness Measurements" from https://energyconservatory.com/wp-content/uploads/2014/07/Duct-Blaster-Manual-Series-B-DG700.pdf. Accessed 10/01/2019.

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SEER = seasonal energy efficiency ratio of air conditioning equipment
COP = coefficient of performance of heating equipment[84]
DLF = duct leakage to outside factor
CF_{summer} = summer system peak coincidence factor
CF_{winter} = winter system peak coincidence factor

5.3.5.3 Input Variables

Table 5-32. Input Values for Duct Sealing Savings Calculations

Component	Type	Value	Units	Sources
Size	Variable	See customer application	Btu/h	Customer application
$cfm50_{whole\ house}$	Variable	See customer application	cfm	Customer application
		Default for Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII $cfm50_{whole\ house,\ base}$ = 1,917 and for $cfm50_{whole\ house,\ ee}$ = 1,616		Dominion Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII participant data[85]
$cfm50_{envelope\ only}$	Variable	See customer application	cfm	Customer application
		Default for Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII $cfm50_{whole\ house,\ base}$ = 0 and for $cfm50_{whole\ house,\ ee}$ = 0		Dominion Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII participant data[86]
SCF	Variable	See Table 5-33. Correction Table for Blower Door Subtraction	–	Mid-Atlantic TRM v9, p. 110
		For default use house to duct pressure of 50 Pa		Conservative estimate
SLF	Fixed	0.50	–	Mid-Atlantic TRM v9, p. 111
RLF	Fixed	0.25	–	Mid-Atlantic TRM v9, p. 111
$cfm25_{duct,base}$	Variable	See customer application	cfm	Customer application

84 If the HSPF value is provided for residential split-system heat pump systems, convert to COP using COP = HSPF x 3.412.

85 A review of available participant data for 2021 was conducted. The average value is used based on 143 participants with a range of 1,072 cfm to 3,520 cfm.

86 A review of available participant data for 2021 was conducted. The $cfm50_{envelope\ only}$ measurements were not reliably reported. Therefore, these inputs are set to 0 for the base and ee cases. While a value of 0 is unreasonable, the assumption is that the envelope only leakage is the same for the base and efficient cases, and will have little effect on calculated change in duct leakage.

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Component	Type	Value	Units	Sources
		Default for Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII = 386 Prescriptive method default = 30% x size / (12,000 Btu/ton-h) x 400 cfm/ton		Dominion Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII participant data[87] Dominion Residential Duct Testing Program participant data[88]
$cfm25_{duct,ee}$	Variable	See customer application	cfm	Customer application
		Default for Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII = 286 Prescriptive method default = average of available $CFM25_{duct,ee}$ for similar contractor		Dominion Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII participant data[89] Dominion Residential Duct Testing Program participant data
$\Delta cfm25_{duct}$	Variable	See duct leakage calculations	cfm	Mid-Atlantic TRM v9, p. 111
$EFLH_{cool}$	Variable	For multifamily common areas see the Non-Residential TRM Sub-Appendix F2-II: Non-Residential HVAC Equivalent Full Load Hours	hours (annual)	Maryland/Mid-Atlantic TRM v10 and scale of CDH for different cities
$EFLH_{heat}$	Variable	For residential programs see Table 19-7 in Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment For multifamily common areas see the Non-Residential Technical Reference Manual Sub-Appendix F2-II: Non-Residential HVAC Equivalent Full Load Hours	hours (annual)	Maryland/Mid-Atlantic TRM v10 and scaled using CDH by city
SEER	Variable	See customer application	Btu/W-h	Customer application
		Default: see in Table 19-9 Sub-Appendix F1-V: Residential HVAC Equipment Efficiency Ratings		Mid-Atlantic TRM v9, pp. 111-112, based on Table C403.2.3(2) of 2012 IECC
COP	Variable	See customer application	–	Customer application
		Default: see in Table 19-9 Sub-Appendix F1-V: Residential HVAC Equipment Efficiency Ratings		Mid-Atlantic TRM v9, p. 114, which is based on Table C403.2.3(2) of 2012 IECC

87 A review of available participant data for 2021 was conducted. The average value is used based on 28 participants with a range of 163 cfm to 865 cfm.

88 DNV reviewed the customer application data on total leakage duct blaster method PreCFM25DL percentages in the Residential Duct Testing Program from program start dates through the end of 2014 (12/31/2014). The average pre-sealing duct leakage percentage (PreCFM25DL / (system size in tons x 400 CFM/ton)) was 30% for VA customers. There were no NC participants in this program at the end of 2014. To calculate customer specific PreCFM25DL, 30% was converted to 289 CFM for VA and 287 CFM for NC. For VA, the calculation = 28,903Btu/h 400CFM/ton x 30% / 12000 Btu/ton-hr, assuming a default of 28,903 Btu/h for Richmond, VA. These values were not updated for 2016 as average heat pump capacity varied little between 2014 and 2015.

89 A review of available participant data for 2021 was conducted, the average value is used based on 28 participants with a range of 126 cfm to 555 cfm.

Component	Type	Value	Units	Sources
DLF	Variable	Single-story houses: 0.75 Multi-story houses: 0.67	–	DEER Update Study (2004-2005), pp. 8-19[90]
CF_{summer}	Fixed	0.69	–	Maryland/Mid-Atlantic TRM v10, p.93[91]
CF_{winter}	Fixed	0.69	–	Maryland/Mid-Atlantic TRM v10, p. 93[91]

Table 5-33. Correction Table for Blower Door Subtraction[92]

House to Duct Pressure, Taped Off) (Pa)	Subtraction Correction Factor (SCF)	House to Duct Pressure, Taped Off) (Pa)	Subtraction Correction Factor (SCF)
50 (default)	1.00	**30**	2.23
49	1.09	**29**	2.32
48	1.14	**28**	2.42
47	1.19	**27**	2.52
46	1.24	**26**	2.64
45	1.29	**25**	2.76
44	1.34	**24**	2.89
43	1.39	**23**	3.03
42	1.44	**22**	3.18
41	1.49	**21**	3.35
40	1.54	**20**	3.54
39	1.60	**19**	3.74
38	1.65	**18**	3.97
37	1.71	**17**	4.23
36	1.78	**16**	4.51
35	1.84	**15**	4.83
34	1.91	**14**	5.20
33	1.98	**13**	5.63
32	2.06	**12**	6.12
31	2.14	**11**	6.71

[90] Itron prepared for SCE, Database for Energy Efficiency Resources (DEER) Update Study, Final Report (2004 – 2005), p. 8-19, http://deeresources.com/files/deer2005/downloads/DEER2005UpdateFinalReport_ItronVersion.pdf. Accessed 8/16/2016.

[91] The same CF as the other HVAC measures are used for consistency. This measure is expected to have a similar savings profile. The Maryland/Mid-Atlantic TRM v10 provides CF for central AC systems in the ductless mini-split measure. In other measures in the Maryland/Mid-Atlantic TRM v10 a utility-specific and equipment specific CF is provided. We use the more generic CF. There are no generic winter CF. Therefore, we apply summer CF.

[92] Table sourced from p.1 of the Energy Conservatory blower door manual – blower door subtraction method: http://energyconservatory.com/wp-content/uploads/2017/08/Blower-Door-Subtraction-Method.pdf. Accessed 10/1/2019.

5.3.5.4 Default Savings

No default savings will be awarded for this measure if pre- and post-duct testing values are not provided in the customer application.

5.3.5.5 Effective Useful Life

The effective useful life of this measure is provided in Table 5-34.

Table 5-34. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Manufactured Housing Program, DSM Phase VIII	20.00	years	Mid-Atlantic TRM v9, p. 119
	Residential Home Retrofit Program, DSM Phase VIII			
	Residential/Non-Residential Multifamily Program, DSM Phase VIII			
	Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII			
VII	Residential Home Energy Assessment Program, DSM Phase VII	12.41	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

5.3.5.6 Source(s)

The primary source for this deemed savings approach is the Mid-Atlantic TRM v9, pp. 106–119.

5.3.5.7 Update Summary

Updates to this section are described in Table 5-35. Summary of Update(s).

Table 5-35. Summary of Update(s)

Updates in Version	Update Type	Description
2021	New table	Effective Useful Life (EUL) by program
	Variable	Size is added (cooling/heating capacity)
	Defaults	Added program specific input defaults for Residential HB2789 Program based on program data review
	Equation	Added gross winter peak demand reduction equation

Updates in Version	Update Type	Description
2020	Inputs	For prescriptive approach (methodology 3) we changed the default for $cfm25_{duct,ee}$ to only be based on historical program participant data only and not compare to individual contractor's historical values
	Equation	• Removed size from the numerator and denominator of the kWh_{heat} and kWh_{cool} equations and added unit conversion. These values cancel out once units are accounted for. • Removed gross annual electric savings component for heating from equation for gross coincident demand reduction
V10		Initial release

5.4 Lighting End Use

5.4.1 LED Lighting

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV. The savings are determined using the methodology described in Section 2.3.1.

6 RESIDENTIAL EFFICIENT PRODUCTS MARKETPLACE PROGRAM, DSM PHASE VII

The Residential Efficient Products Marketplace Program provides residential customers with an incentive to purchase specific energy efficient appliances. The measures offered through the program and the sections that contain the savings algorithms for each measure are presented in Table 6-1.

Table 6-1: Residential Efficient Products Marketplace Program Measure List

End Use	Measure	Manual Section
Lighting	Lighting Lamps & Fixtures	Section 6.1.1
Plug Load/Appliance	Air Purifier	Section 6.2.1
	Clothes Washer	Section 6.2.2
	Clothes Dryer	Section 6.2.3
	Dehumidifier	Section 6.2.4
	Dishwasher	Section 6.2.5
	Freezer	Section 6.2.6
	Refrigerator	Section 6.2.7

6.1 Lighting End Use

6.1.1 Lighting Lamps & Fixtures

6.1.1.1 Measure Description

This measure describes savings from the purchase and installation of an ENERGY STAR® Integrated Screw Based SSL (LED) Lamp in place of an in-situ lamp. For time of sale, the baseline wattage is assumed to be that of an incandescent or EISA-compliant (where applicable) lamp installed in a screw-base socket. Note that the baseline will be EISA-compliant lamps for all categories to which EISA applies.

6.1.1.2 Impacts Estimation Approach

Per measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = (watts_{base} - watts_{ee}) \times ISR \times HOU \times NRS \times [WHFe_{heat} + (WHFe_{cool} - 1)] \times \frac{1\ kW}{1{,}000\ W} \times DCP$$

Per measure, gross summer coincident peak demand savings are calculated according to the following equation:

$$\Delta kW_{summer} = (watts_{base} - watts_{ee}) \times ISR \times NRS \times WHFd \times CF_{summer} \times \frac{1\ kW}{1{,}000\ W} \times DCP$$

Per measure, gross winter coincident peak demand savings are calculated according to the following equation:

$$\Delta kW_{winter} = (watts_{base} - watts_{ee}) \times ISR \times NRS \times WHFd \times CF_{winter} \times \frac{1\ kW}{1{,}000\ W} \times DCP$$

Where:

ΔkW_{winter}	= per measure gross coincident winter peak demand savings
$watts_{base}$	= assumed wattage of lamp being replaced based on lumens of LED
$watts_{ee}$	= wattage of efficient LED bulb
ISR	= in-service rate
HOU	= annual hours of use
NRS	= Non-Residential sales factor to account for lighting measures purchased by Non-Residential customers
$WHFe_{heat}$	= waste heat factor to account for electric heating increase due to reduced waste heat from efficient lighting
$WHFe_{cool}$	= waste heat factor to account for electric cooling savings due to reduced waste heat from efficient lighting
WHFd	= waste heat factor for summer coincident peak demand savings to account for cooling savings from efficient lighting
DCP	= Dominion customer proportion to account for leakage due to non-Dominion customers making in-store purchases
CF_{summer}	= summer peak coincidence factor
CF_{winter}	= winter peak coincidence factor

6.1.1.3 Input Variables

Table 6-2. Input Parameters for Lighting Lamps and Fixtures

Component	Type	Value	Units	Sources
ISR	Variable	0.965	–	Maryland/Mid-Atlantic TRM v10, pp. 30-32

Component	Type	Value	Units	Sources
$watts_{base}$	Variable	If product type = Multifaceted Reflector see customer application If base type of GU5.3, GX5.3, GU10, GU24 see customer application. "Retrofit Kit" or "Fixture" with lumens greater than 4,270 see customer application For all other product types and base types and lumen ranges see Table 6-3 If product type = “Parabolic Aluminized Reflector” and ENERYG STAR BULB type is unknown set = to PAR20. If ENERGY STAR Bulb Type is inconsistent with the Product Type, the Energy Star Bulb Type is used to define the product type.	watts	Customer application and Maryland/Mid-Atlantic TRM v10, p. 30
$watts_{ee}$	Variable	See customer application	watts	Customer application
HOU	Variable	See Table 19-14 in Sub-Appendix F1-VII: Residential Lighting Factors	hour/year	Maryland/Mid-Atlantic TRM v10, pp. 38-40[93]
		Default = unknown fixture location		
NRS	Variable	In-store purchase = 0.90	–	Final EM&V Report for the 2013 Energy Efficient Lighting Program[94]
		Online marketplace = 1.0		Program assumption
$WHFe_{heat}$	Variable	See Table 19-14 in Sub-Appendix F1-VII: Residential Lighting Factors	–	Mid-Atlantic TRM v9, p. 35
		Default = 0.899		
$WHFe_{cool}$	Variable	See Table 19-14 in Sub-Appendix F1-VII: Residential Lighting Factors	–	Mid-Atlantic TRM v9, p. 35
		Default = 1.077		
WHFd	Variable	See Table 19-14 in Sub-Appendix F1-VII: Residential Lighting Factors	–	Mid-Atlantic TRM v9, p. 36
		Default = 1.170		
CF_{summer}	Variable	See Table 19-14 in Sub-Appendix F1-VII: Residential Lighting Factors	–	Maryland/Mid-Atlantic TRM v10, p. 31, based on PJM Coincidence Factors
		Default = 0.058		

[93] Hours of use for Dining Room, Bedroom, Bathroom, Hallway, Living Room, and Kitchen are from Navigant, EM&V Report for the 2012 Energy Efficient Lighting Program, Duke Energy Progress, July 2013, p. 23. Hours of use for Indoor (“Residential Interior and in-unit Multi-Family”), Exterior, and Garage are from the 2019 Mid-Atlantic TRM p.36; SF hours (equivalent to "Indoors") and MF hours are from Mid-Atlantic TRM v10 p.38-40

[94] *Final EM&V Report for the 2013 Energy Efficient Lighting Program,* for Duke Energy Progress, by Navigant Consulting, Inc., August 13, 2014, p. 27.

Component	Type	Value	Units	Sources
CF_{winter}	Variable	See Table 19-14 in Sub-Appendix F1-VII: Residential Lighting Factors	–	Maryland/Mid-Atlantic TRM v10, p. 31, based on PJM Coincidence Factors
		Default = 0.124		
DCP	Variable	Varies by store location; See Table 19-15. in Sub-Appendix F1-VII: Residential Lighting Factors	–	Dominion
		Default = 1.0, for on-line purchases		On-line purchases by Dominion customers, exclusively

Table 6-3 is adapted from the Maryland/Mid-Atlantic TRM v10, with the addition of the right-most columns that maps the defining categories offered by the program. The “Product Types” are mapped to the “Lamp Types” most similar to the “Product Type” category and having the largest lumen range to accommodate a range of lighting types. The minimum and maximum lumen values are used in combination with “Product Type” to determine $watts_{base}$.

Table 6-3. Baseline Wattage Determination

Mid-Atlantic v10 TRM Lamp Type	Lumen Range		Watts Base	Tracking Data Categories			
	Lower Bound	Upper Bound		Product Type	ENERGY STAR Bulb Type	Program Measure, 3-way Lamp	Program Measure, Base Type
Standard A-Type (medium base)	250	450	25	"A-Line"	A15, "A19", A21", "A23", "S14", " "	"No", " "	"E26 (Medium)", "E26D",
	450	800	29				
	800	1,100	43				
	1,100	1,600	53				
	1,600	2,600	72				
	2,600	3,000	150				
	3,000	4,000	200				
	4,000	6,000	300				
3-Way, bug, marine, rough service, infrared	250	450	25	"A-Line"	A15, "A19", A21", "A23", "S14", " "	"YES"	"E26 (Medium)", "E12 (Candelabra)", "E26D",
	450	800	40				
	800	1,100	60				
	1,100	1,600	75				
	1,600	2,000	100				
	2,000	2,550	125				
	2,550	3,000	150				
Standard	250	450	25	"A-Line"	A15, "A19", A21", "A23", "S14", " "	"No", " "	"E12 (Candelabra)"
	450	800	40				
	800	1,100	60				
	1,100	1,600	75				
	1,600	2,000	100				

Mid-Atlantic v10 TRM Lamp Type	Lumen Range		Watts Base	Tracking Data Categories			
A-Type (candelabra base)[95]	2,000	2,550	125				
	2,550	3,000	150				
Globe (any base < 500 lumens)	90	180	10	"Globe"	"G16.5", "G25", "G30", "G40", “ “	"NO", "YES", " "	"E26 (Medium)", "E12 (Candelabra)", "E26D",
	180	250	15				
	250	350	25				
	350	500	40				
Globe (medium base, > 499 lumens)	500	575	43				"E26 (Medium)"
	575	650	53				
	650	1,100	72				
	1,100	1,300	150				
Globe (candelabra or intermediate base, ≥ 500 lumens)	500	575	60				"E12 (Candelabra)", "E26D"
	575	650	75				
	650	1,100	100				
	1,100	1,300	150				
Decorative (Shapes B, BA, C, CA, DC, F, G, any base, < 500 lumens)	70	90	10	"Specialty", "ST", "Candelabra Base", "Candle"	"B10", "B11", "B13", "BA10", "BA11", "C11", "C7", "C9", "CA10", "F10", F15", "ST", "ST12", "ST18", "ST19", "S14"	NO, "YES", " "	E26 (Medium), "E12 (Candelabra)", "E26D"
	90	150	15				
	150	300	25				
	300	500	40				
Decorative (medium base, > 499 lumens)	500	1,050	43				"E26 (Medium)"

95 The Maryland/Mid-Atlantic v10 does not include a category for Standard A-Type with candelabra base, so it is added here. The bin ranges are the same as the “3-Way, bug, marine, rough service, infrared” Lamp Type,

Mid-Atlantic v10 TRM Lamp Type	Lumen Range		Watts Base	Tracking Data Categories			
Decorative (candelabra or intermediate base, ≥ 500 lumens)	500	1,050	60				"E12 (Candelabra)", "E26D"
Reflector with medium-screw bases w/ diameter ≤ 2.25"	200	300	20	"Reflector", "Parabolic Aluminized Reflector"	"PAR16", "R14", R16"	NO, "YES", " "	"E26 (Medium)"
	300	400	30				
	400	450	40				
	450	500	45				
	500	650	50				
	650	1,199	65				
R, PAR, ER, BR, BPAR or similar bulb shapes with medium screw bases w/ diameter > 2.26" and ≤ 2.5" (*see exceptions below)	200	300	20	"Parabolic Aluminized Reflector"	"PAR20"	NO, "YES", " "	"E26 (Medium)"
	300	540	30				
	540	630	40				
	630	720	45				
	720	1,000	50				
	1,000	1,200	65				
	1,200	1,520	75				
	1,520	1,730	90				
	1,730	2,190	100				
	2,190	2,900	120				
	2,900	3,850	150				
***R20**	200	300	20	"Reflector"	"R20"	NO, "YES", " "	"E26 (Medium)"
	300	400	30				
	400	450	40				

Mid-Atlantic v10 TRM Lamp Type	Lumen Range		Watts Base	Tracking Data Categories			
	450	850	45				
	850	1,180	50				
	1,180	1,420	65				
	1,420	1,790	75				
	1,790	2,050	90				
	2,050	2,580	100				
	2,580	3,430	120				
	3,430	4,270	150				
R, PAR, ER, BR, BPAR or similar bulb shapes with medium screw bases w/ diameter >2.5"	200	300	20	"Reflector", "Parabolic Aluminized Reflector"	"PAR30", PAR30L", PAR30S", "PAR38", "R40"	NO, "YES", " "	"E26 (Medium)"
	300	640	30				
	640	740	40				
	740	850	45				
	850	1,180	50				
	1,180	1,420	65				
	1,420	1,790	75				
	1,790	2,050	90				
	2,050	2,580	100				
	2,580	3,430	120				
	3,430	4,270	150				

Mid-Atlantic v10 TRM Lamp Type	Lumen Range		Watts Base	Tracking Data Categories			
BR30, BR40, or ER40	200	300	20	"Bulged Reflector", "Retrofit Kit", "Fixture"	"BR30", "BR40", "ER40", “Downlight Recessed”, “Downlight Solid State Retrofit”, “ “	NO, "YES", " "	"E26 (Medium)", "E12 (Candelabra)", "E26D"
	300	400	30				
	400	450	40				
	450	500	45				
	500	650	50				
	650	1,420	65				
	1,420	1,790	75				
	1,790	2,050	90				
	2,050	2,580	100				
	2,580	3,430	120				
	3,430	4,270	150				

6.1.1.4 Default Savings

No savings will be given when required information is missing.

6.1.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 6-4.

Table 6-4. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VII	Residential Efficient Products Marketplace Program, DSM Phase VII	16.50	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

6.1.1.6 Source

The primary source for this deemed savings approach include the Mid-Atlantic TRM v10, pp. 26-34.

6.1.1.7 Update Summary

Updates to this section are described in Table 6-5.

Table 6-5. Summary of Update(s)

Updates in Version	Update Type	Description
2021	Source	Updated page numbers / version of the Maryland/Mid-Atlantic TRM v10
	Table	Updated lighting baseline wattage table
	Equation	Added gross winter peak demand reduction equation
2020	Inputs	Revised baseline wattages for Residential Home Energy Assessment Program to reflect the DOE's rollback of the EISA lighting efficiency standard that was scheduled to take effect in 2020 but did not.
V10		Initial release

6.2 Plug Load/Appliance End Use

6.2.1 Air Purifier

6.2.1.1 Measure Description

An air purifier (cleaner) is a portable electric appliance that removes dust and fine particles from indoor air. This measure characterizes the purchase and installation of a unit meeting the energy efficiency specifications of ENERGY STAR in place of a baseline model.

The baseline equipment is assumed to be a conventional non-ENERGY STAR unit with the consumption estimates based upon EPA research on available models in 2011. The efficient equipment is defined as an air purifier that meets the specifications of ENERGY STAR as provided below:

The efficient equipment is defined as an air purifier that meets the specifications of ENERGY STAR as provided below:

- Maximum Standby Power Requirement: 1.0 watts for models without Wi-Fi capabilities, 2.0 watts for models with Wi-Fi capabilities
- Maximum ozone production: 50 parts per billion (ppb), per UL Standard 867 for models that emit ozone as a by-product of air cleaning.

The current ENERGY STAR minimum requirements are show in Table 6-6.

Table 6-6: ENERGY STAR Minimum Smoke CADR/W Requirements[96]

Product Size (cfm)	Smoke CADR/W
30 ≤ Smoke CADR < 100	1.90
100 ≤ Smoke CADR < 150	2.40
150 ≤ Smoke CADR	2.90

6.2.1.2 Impacts Estimation Approach

Per measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh \quad = \Delta kWh_{CADR}$$

Per measure, gross summer coincident peak savings are calculated according to the following equation:

$$\Delta kW_{summer} \quad = \frac{\Delta kWh}{HOU} \times CF_{summer}$$

[96] ENERGY STAR Version 2.0 current standards here: https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Version%202.0%20Final%20Room%20Air%20Cleaners%20Program%20Requirements.pdf , Accessed on 05/12/2021

Per measure, gross winter coincident peak savings are calculated according to the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh}{HOU} \times CF_{winter}$$

Where:

ΔkWh = per measure gross annual electric energy savings
ΔkW_{summer} = per measure gross coincident summer peak demand reduction
ΔkW_{winter} = per measure gross coincident winter peak demand reduction
ΔkWh_{CADR} = baseline annual electric energy usage
HOU = average annual hours of use
CF_{summer} = Summer Peak Coincidence Factor
CF_{winter} = Winter Peak Coincidence Factor

6.2.1.3 Input Variables

Table 6-7. Input Values for Air Purifier Savings Calculations

Component	Type	Value	Unit	Source(s)
kWh_{base}	Variable	See Table 6-5	kWh	Maryland/Mid-Atlantic TRM v10, p. 188, footnote 410
		Default use CADR 30-100		Conservative savings using smallest CADR category
HOU	Fixed	5,840	hours, annual	Maryland/Mid-Atlantic TRM v10, p. 189[97]
CF_{summer}	Fixed	0.67	–	Maryland/Mid-Atlantic TRM v10, p. 189[98]
CF_{winter}	Fixed	0.67	–	Maryland/Mid-Atlantic TRM v10, p. 189[99]

Table 6-8. Annual Electric Energy Usage by Clear Air Delivery Rate (CADR)[100]

Clean Air Delivery Rate (CADR)	ΔkWh_{CADR}
30 ≤ Smoke CADR < 100 (default)	39
100 ≤ Smoke CADR < 150	95
150 ≤ Smoke CADR < 200	173
200 ≤ Smoke CADR[101]	328

97 Assumes 16 hours/day, 365 days/year, consistent with ENERGY STAR Qualified Air Cleaner Calculator.
98 Assumes appliance just as likely to operate at night as during the day.
99 Maryland/Mid-Atlantic TRM v10 does not provide a Winter CF but based on the assumption that the appliance is as likely to be used any hour of the day, the same CF as summer is used for winter.
100 The CADR used for determined savings is smoke CADR. However, we use the application provided dust CADR as an approximation for smoke CADR. A review of current ENERGY STAR products indicates that the smoke CADR is slightly smaller than the dust CADR with a 0.98 R^2. Therefore, this assumption results in slightly conservative energy savings estimates,
101 If the customer application CADR is greater than 563, it is assumed that the wrong value was provided, and the default is assigned.

6.2.1.4 Default Savings

Default per measure gross annual electric energy savings is calculated according to the following equation, by assuming that the CADR < 100:

$$\Delta kWh = \Delta kWh_{CADW}$$

$$= 39\ kWh$$

Default per measure gross summer coincident peak savings is calculated according to the following equation, by assuming that CADR is < 100:

$$\Delta kW_{summer} = \frac{\Delta kWh}{HOU} \times CF_{summer}$$

$$= \frac{39\ kWh}{5{,}840\ hours} \times 0.67$$

$$= 0.004\ kW$$

Default per measure gross winter coincident peak savings is calculated according to the following equation, by assuming that CADR is < 100:

$$\Delta kW_{winter} = \frac{\Delta kWh}{HOU} \times CF_{summer}$$

$$= \frac{39\ kWh}{5{,}840\ hours} \times 0.67$$

$$= 0.004\ kW$$

6.2.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 6-9.

Table 6-9. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VII	Residential Efficient Products Marketplace	16.50	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

6.2.1.6 Source(s)

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v10, pp. 187-190.

6.2.1.7 Update Summary

Updates to this section are described in Table 6-10.

Table 6-10. Summary of Update(s)

Updates in Version	Update Type	Description
2021	References	Updated the source version
	New table	Effective Useful Life (EUL) by program
	Equations	Replaced kWh_{base} and kWh_{ee} with a single value, ΔkWh_{CADR}, as these values don't change. Added gross winter peak demand reduction equation
	Inputs	Removed the ENERGY STAR Version 1.2 savings values as Version 2.0 is now current.
2020		Initial release

6.2.2 Clothes Washer

6.2.2.1 Measure Description

This measure relates to the purchase (time of sale) and installation of a clothes washer exceeding either the ENERGY STAR/CEE Tier 1, ENERGY STAR Most Efficient/CEE Tier 2, or CEE Tier 3 minimum qualifying efficiency standards. This measure is offered through multiple programs, as listed in Table 6-11, and uses the impacts estimation approach described in this section.

Table 6-11. Programs that Offer Efficient Clothes Washers

Program Name	Section
Residential Efficient Products Marketplace Program, DSM Phase VII	Section 6.2.2
Residential Home Retrofit Program, DSM Phase VIII	Section 12.3.1
Residential/Non-Residential Multifamily Program, DSM Phase VIII	Section 13.5.1

6.2.2.2 Impacts Estimation Approach

Per measure, gross annual energy savings are calculated according to the following equation.

$$\begin{aligned}\Delta kWh \quad &= \Big[\big(Size \times 1/IMEF_{base} \times N_{cycle}\big) \\ &\qquad \times \ \big(CW_{base} + (DHW_{base} \times DHW_{electric}) + (Dryer_{base} \times Dryer_{electric})\big)\Big] \\ &\qquad - \Big[\big(Size \times 1/IMEF_{ee} \times N_{cycle}\big) \\ &\qquad \times \ \big(CW_{ee} + (DHW_{ee} \times DHW_{electric}) + (Dryer_{ee} \times Dryer_{electric})\big)\Big]\end{aligned}$$

Per measure, gross summer coincident peak savings are calculated according to the following equation.

$$\Delta kW_{summer} \quad = \Delta kWh/HOU \times CF_{summer}$$

Per measure, gross winter coincident peak savings are calculated according to the following equation.

$$\Delta kW_{winter} \quad = \Delta kWh/HOU \times CF_{winter}$$

Per measure, gross annual water savings are calculated according to the following equation.

$$\Delta Water \quad = Size \ \times (IWF_{base} - IWF_{ee}) \times N_{cycle}$$

Where:

ΔkWh	= per measure gross annual electric energy savings
ΔkW_{summer}	= per measure gross coincident summer peak demand savings
ΔkW_{winter}	= per measure gross coincident winter peak demand savings
ΔWater	= per measure gross annual water savings
Size	= clothes washer capacity
$IMEF_{base}$	= Integrated Modified Energy Factor of baseline unit
$IMEF_{ee}$	= Integrated Modified Energy Factor of efficient unit
N_{cycle}	= number of wash cycles per year
CW_{base}	= proportion of total energy consumption of baseline clothes washer operation
DHW_{base}	= proportion of total energy consumption for water heating of baseline unit
$Dryer_{base}$	= proportion of total energy consumption for baseline dryer operation
CW_{ee}	= proportion of total energy consumption for efficient clothes washer operation
DHW_{ee}	= proportion of total energy consumption for water heating of efficient unit
$Dryer_{ee}$	= proportion of total energy consumption for efficient dryer operation
$DHW_{electric}$	= proportion of DHW savings assumed to be electric
$Dryer_{electric}$	= proportion of dryer savings assumed to be electric
HOU	= annual hours of use of clothes washer
IWF_{base}	= integrated water factor of baseline clothes washer
IWF_{ee}	= integrated water factor of efficient clothes washer
CF_{summer}	= summer peak Coincidence Factor
CF_{winter}	= winter peak Coincidence Factor

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6.2.2.3 Input Variables

Table 6-12. Input Variables for Clothes Washer Savings Calculation

Component	Type	Value	Unit	Source(s)
Size	Variable	See customer application	feet^3	Customer application
		Default = 3.39		Maryland/Mid-Atlantic TRM v10, p. 164[102]
$IMEF_{base}$	Variable	See Table 6-13	–	Maryland/Mid-Atlantic TRM v10, p. 165,[103] the weighted average of front loading and top loading machine IMEF values is used.
		Default: If size ≤ 2.5 ft^3, $IMEF_{base}$ =1.84 If size > 2.5 ft^3, $IMEF_{base}$ =1.72		
$IMEF_{ee}$[104]	Variable	See customer application Table 6-13	–	Customer application
		For default see Table 6-13, If size ≤ 2.5 ft^3, $IMEF_{ee}$ = 2.07 If size > 2.5 ft^3, $IMEF_{ee}$ = 2.22		Maryland/Mid-Atlantic TRM v10, p. 165
N_{cycle}	Variable	If washer is located in residential space,[105] N_{cycle} = 254 If washer is located in multifamily common area, N_{cycle} = 1,241	–	Residential spaces: Maryland/Mid-Atlantic TRM v10, p. 165[106] and common areas: Minnesota TRM 2021, p. 173
CW_{base}	Variable	See Table 6-14	–	Maryland/Mid-Atlantic TRM v10, p. 165
		Default=0.07 (for all sizes)		
CW_{ee}	Variable	See Table 6-14	–	Maryland/Mid-Atlantic TRM v10, p. 165
		Default = 0.05 (for all sizes)		
DHW_{base}	Variable	See Table 6-14	–	Maryland/Mid-Atlantic TRM v10, p. 165
		Default = 0.28 (for all sizes)		
DHW_{ee}	Variable	See Table 6-14	–	Maryland/Mid-Atlantic TRM v10, p. 165
		Default = 0.32 (for all sizes)		
$Dryer_{base}$	Variable	See Table 6-14	–	Maryland/Mid-Atlantic TRM v10, p. 165
		Default = 0.65 (for all sizes)		
$Dryer_{ee}$	Variable	See Table 6-14	–	Maryland/Mid-Atlantic TRM v10, p. 165

[102] Maryland/Mid-Atlantic TRM v10, p. 164. Based on the average clothes washer volume of all units that are ENERGY STAR qualified as of 3/17/2020.

[103] The weighted average of front loading and top loading is used.

[104] ENERGY STAR Commercial Clothes Washers are rated in MEF instead of IMEF. However, for the purposes of calculating energy savings MEF is substituted for IMEF.

[105] All programs use washer location in residential space except the Nonresidential Multifamily program which uses the common number of cycles per year.

[106] Maryland/Mid-Atlantic TRM v10, p. 165. Metered data from Navigant Consulting “EmPOWER Maryland Draft Final Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Appliance Rebate Program.” March 21, 2014, p. 36.

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Component	Type	Value	Unit	Source(s)
		Default = 0.63 (for all sizes)		
$DHW_{electric}$	Variable	See Table 6-15	–	Maryland/Mid-Atlantic TRM v10, p. 166
		For default values, see Table 6-15		Dominion Residential Home Energy Use Survey 2019 – 2020, p. 19
$Dryer_{electric}$	Variable	See Table 6-16	–	Maryland/Mid-Atlantic TRM v10, p. 166
		For default, see Table 6-16		Dominion Residential Home Energy Use Survey 2019 – 2020 Appendix B, p. 112
HOU	Fixed	If washer is located in residential unit,[107] HOU = 265 If washer is located in multifamily common area, HOU = 1,241	hours, annual	Residential units: Maryland/Mid-Atlantic TRM v10, p. 166[108] Common areas: Minnesota TRM 2021, p. 173[109]
IWF_{base}	Variable	See Table 6-17	gal/ft^3	Maryland/Mid-Atlantic TRM v10, p. 168
IWF_{ee}	Variable	See customer application	gal/ft^3	Customer application
		See Table 6-17		Maryland/Mid-Atlantic TRM v10, p. 168
CF_{summer}	Fixed	0.029	–	Maryland/Mid-Atlantic TRM v10, p. 166[110]
CF_{winter}	Fixed	0.014	–	CA 2011 DEER load profile for residential clothes washer

For baseline IMEF, the weighted average is used regardless of the efficient case loading type.

Table 6-13. IMEF based on Efficiency Level and Loading Type

Efficiency Level	Loading Type		
	Front Loading	Top Loading	Weighted Average
Residential clothes washers > 2.5 ft^3			
Federal Standard (baseline)	1.84	1.57	1.72
ENERGY STAR (default)[111]	2.76	2.06	2.22
CEE Tier 1	2.76	2.06	2.22
CEE Tier 2	2.92	2.92	2.92
CEE Tier 3	3.10	3.10	3.10

107 All programs will use washer location in residential space with the exception of the Nonresidential Multifamily program which uses the common area HOU..

108 Maryland/Mid-Atlantic TRM v10, p. 166. Metered data from Navigant Consulting “EmPOWER Maryland Draft Final Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Appliance Rebate Program.” March 21, 2014, page 36.

109 Assumes 1 hours per cycle.

110 Ibid

111 If the application IMEF is lower than the ENERGY STAR Minimum the value provided is invalid and the ENERGY STAR Minimum is applied as a default.

Efficiency Level	Loading Type		
	Front Loading	Top Loading	Weighted Average
Residential clothes washers ≤ 2.5 ft^3			
Federal Standard (baseline)	1.84	1.57	1.84
ENERGYSTAR (default)	2.07	2.07	2.07
CEE Tier 1	2.07	2.07	2.07
CEE Tier 2	2.20	2.20	2.20
Commercial clothes washers			
Federal Standard (baseline) [112]	1.60	2.00	1.70
ENERGYSTAR (default)[113]			2.20

Table 6-14. Proportion of Total Energy Consumption based on Efficiency Level

Efficiency Level	Total Energy Consumption Proportions		
	Washer	Dryer	DHW
Federal Standard (baseline)	0.07	0.65	0.28
Clothes washers > 2.5 ft^3			
ENERGY STAR	0.05	0.63	0.32
CEE Tier 1	0.05	0.63	0.32
CEE Tier 2	0.10	0.87	0.03
CEE Tier 3	0.10	0.87	0.03
Clothes washers ≤ 2.5 ft^3			
CEE Tier 1	0.08	0.72	0.20
CEE Tier 2	0.08	0.72	0.20

Table 6-15. Proportion of Savings Assumed based on DHW Fuel

DHW Fuel	$DHW_{electric}$
Electric	1.00
Non-electric	0.00
Unknown (default)	0.57[114]

[112] Federal Standard baseline IMEF value is obtained from Code of Federal Regulation, Energy and water conservation standards table https://www.ecfr.gov/current/title-10/part-431

[113] ENERGY STAR Commercial Clothes Washers are rated in MEF instead of IMEF. However, for the purposes of calculating energy savings MEF is substituted for IMEF. https://www.energystar.gov/products/appliances/clothes_washers/key_product_criteria

[114] Dominion Energy Residential Home Energy Use Survey 2019 - 2020, p. 19, percent of homes with electric DHW.

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Table 6-16. Proportion of Savings Assumed based on Dryer Fuel

Dryer Fuel	$Dryer_{electric}$
Electric	1.00
Fossil Fuel	0.00
Unknown (default)	0.94[115]

Table 6-17. Integrated Water Factor (IWF) based on Efficiency Level and Loading Type

Efficiency Level	Loading Type		
	Front Loading	Top Loading	Weighted Average (Default)
Residential Clothes washers > 2.5 ft^3			
Federal Standard (baseline)	4.70	6.50	5.50
ENERGYSTAR (default)	3.20	4.30	4.00
CEE Tier 1	3.20	4.30	4.00
CEE Tier 2	3.20	3.20	3.20
CEE Tier 3	3.00	3.00	3.00
Residential Clothes washers ≤ 2.5 ft^3			
Federal Standard (baseline)		4.70	4.70
ENERGYSTAR (default)		4.20	4.20
CEE Tier 1		4.20	4.20
CEE Tier 2		3.70	3.70
Commercial clothes washers			
Federal Standard (baseline)	4.10	8.80	4.10[116]
ENERGYSTAR (default)		4.00	4.00[117]

115 Dominion Energy Residential Home Energy Use Survey 2019 – 2020 Appendix B. p. 112. Used the responses for gas and electric dyers that have been replaced in the past three to five years as a proxy for the number of gas and electric dryers in use.

116 Commercial clothes washer Integrated Water Factor (IWF) is obtained from https://www.ecfr.gov/current/title-10/part-431 and conservative value used for default savings calculation instead of weighted average

117 ENERGY STAR Commercial Clothes Washers Integrated Water Factor (IWF) is obtained from https://www.energystar.gov/products/appliances/clothes_washers/key_product_criteria and the value used for the conservative default savings calculation

6.2.2.4 Default Savings

Per measure gross annual energy savings, gross summer and winter coincident peak savings, and goss annual water savings respectively, are calculated according to the following equations when input parameter values are not provided.

If the clothes washer volume is > 2.5 ft^3, default savings are calculated as follows:

$$\begin{aligned}\Delta kWh &= \Big[\big(Size \times 1/IMEF_{base} \times N_{cycle}\big) \\ &\qquad \times \big(CW_{base} + (DHW_{base} \times DHW_{electric}) \\ &\qquad + (Dryer_{base} \times Dryer_{electric})\big)\Big] \\ &\qquad - \Big[\big(Size \times 1/IMEF_{ee} \times N_{cycle}\big) \\ &\qquad \times \big(CW_{ee} + (DHW_{ee} \times DHW_{electric}) \\ &\qquad + (Dryer_{ee} \times Dryer_{electric})\big)\Big]\end{aligned}$$

$$\begin{aligned}&= \Big[(3.39 \times 1/1.72 \times 254) \times \big(0.07 + (0.31 \times 0.28) + (0.68 \times 0.65)\big)\Big] \\ &\qquad - \Big[(3.39 \times 1/2.22 \times 254) \\ &\qquad \times \big(0.05 + (0.31 \times 0.32) + (0.68 \times 0.63)\big)\Big]\end{aligned}$$

$$= 75.74\ kWh$$

$$\Delta kW_{summer} = \Delta kWh/HOU \times CF_{summer}$$

$$= \frac{75.74\ kWh \times 0.029}{265\ hours}$$

$$= 0.00829\ \text{kW}$$

$$\Delta kW_{winter} = \Delta kWh/HOU \times CF_{winter}$$

$$= \frac{75.74\ kWh \times 0.014}{265\ hours}$$

$$= 0.00402\ \text{kW}$$

$$\Delta Water = Size\ \times (IWF_{base} - IWF_{ee}) \times N_{cycle}$$

$$= 3.39\ \times (5.50 - 4.00) \times 254$$

$$=1{,}291.59 \text{ gallons}$$

If clothes washer is ≤ 2.5 ft^3, default savings are calculated as follows:

$$\Delta kWh = \left[\left(Size \times 1/IMEF_{base} \times N_{cycle}\right) \times \left(CW_{base} + (DHW_{base} \times DHW_{electric}) + (Dryer_{base} \times Dryer_{electric})\right)\right] - \left[\left(Size \times 1/IMEF_{ee} \times N_{cycle}\right) \times \left(CW_{ee} + (DHW_{ee} \times DHW_{electric}) + (Dryer_{ee} \times Dryer_{electric})\right)\right]$$

$$= \left[(3.39 \times 1/1.84 \times 254) \times \left(0.07 + (0.31 \times 0.28) + (0.68 \times 0.65)\right)\right] - \left[(3.39 \times 1/2.07 \times 254) \times \left(0.05 + (0.31 \times 0.32) + (0.68 \times 0.63)\right)\right]$$

$$= 39.95\ kWh$$

$$\Delta kW_{summer} = \Delta kWh/HOU \times CF_{summer}$$

$$= \frac{39.95\ kWh \times 0.029}{265\ hours}$$

$$= 0.00437 \text{ kW}$$

$$\Delta kW_{winter} = \Delta kWh/HOU \times CF_{winter}$$

$$= \frac{39.95\ kWh \times 0.014}{265\ hours}$$

$$= 0.00212 \text{ kW}$$

$$\Delta Water = Size \times (IWF_{base} - IWF_{ee}) \times N_{cycle}$$

$$= 3.39 \times (4.70 - 4.20) \times 254$$

$$= 430.53 \text{ gallons}$$

6.2.2.5 Effective Useful Life

The effective useful life of this measure is provided in Table 6-18.

Table 6-18. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Manufactured Housing Program, DSM Phase VIII,	14.00	years	Maryland/Mid-Atlantic TRM v10, p. 169
	Residential Home Retrofit Program, DSM Phase VIII,			
	Residential/Non-Residential Multifamily Program, DSM Phase VIII			
VII	Residential Efficient Products Marketplace Program, DSM Phase VII	16.50	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

6.2.2.6 Sources

The primary sources for this deemed savings approach is the Maryland/Mid-Atlantic TRM v10, pp. 163-169, and the Minnesota TRM 2021, p. 173.

6.2.2.7 Update Summary

Updates to this section are described in Table 6-19.

Table 6-19. Summary of Update(s)

Updates in Version	Update Type	Description
2021	New table	• Effective Useful Life (EUL) by program • Added new table for Integrated Water Factor (IWF) variable
	Source	Updated page numbers / version of the Maryland/Mid-Atlantic TRM v10 and replaced some inputs with values from the Dominion Home Energy Use Survey 2019- 2020.
	Equation	• Added gross winter peak demand reduction equation • Added gross annual water savings equation
	Default Savings	Added default gross annual water savings value
	Input Table	• Expanded to accommodate multifamily common area locations • Added IWF_{base} and IWF_{ee} variables for water savings calculation
2020	Inputs Table	Adjusted CW_{ee}, DHW_{ee}, and $Dryer_{ee}$, $Dryer_{electric}$ and $DHW_{electric}$ from a fixed value to use customer application. The previous values are assigned as defaults if not provided by the application.
v10		Initial release

DNV

6.2.3 Clothes Dryer

6.2.3.1 Measure Description

This measure relates to the installation of a residential clothes dryer meeting the ENERGY STAR criteria. ENERY STAR qualified clothes dryers save energy through a combination of more efficient drying and reduced runtime of the drying cycle. More efficient drying is achieved through increased insulation, modifying operating conditions such as air flow and/or heat input rate, improving air circulation through better drum design or booster fans, and improving efficiency of motors. Reducing the runtime of dryers through automatic termination by temperature and moisture sensors is believed to have the greatest potential for reducing energy use in clothes dryers. ENERGY STAR provides criteria for both gas and electric clothes dryers.

This measure is offered through different programs listed in Table 6-20 and uses the impacts estimation approach described in this section.

Table 6-20. Programs that Offer Clothes Dryer

Program Name	Section
Residential Efficient Products Marketplace Program, DSM Phase VII	Section 6.2.3
Residential Home Retrofit Program, DSM Phase VIII	Section 12.3.2
Residential/Non-Residential Multifamily Program, DSM Phase VIII	Section 13.5.1

6.2.3.2 Impacts Estimation Approach

Per measure, gross annual electric energy savings are calculated according to the following equation.

$$\Delta kWh = \left(\frac{Load}{CEF_{base}} - \frac{Load}{CEF_{ee}}\right) \times N_{cycle} \times Dryer_{electric}$$

Per measure, gross summer coincident peak savings are calculated according to the following equation.

$$\Delta kW_{summer} = \Delta kWh / HOU \times CF_{summer}$$

Per measure, gross winter coincident winter peak savings are calculated according to the following equation.

$$\Delta kW_{winter} = \Delta kWh / HOU \times CF_{winter}$$

Where:

ΔkWh = gross annual electric energy savings
ΔkW_{summer} = gross coincident summer peak demand savings
ΔkW_{winter} = gross coincident winter peak demand savings
Load = the average total weight of clothes per drying cycle
CEF_{base} = Combined Energy Factor (CEF) of the baseline unit
CEF_{ee} = Combined Energy Factor (CEF) of the efficient unit

DNV

N_{cycle} = number of dryer cycles per year
$Dryer_{electric}$ = proportion of overall savings coming from electricity
HOU = annual hours of use of clothes dryer
CF_{summer} = summer peak coincidence factor for measure
CF_{winter} = winter peak coincidence factor for measure

6.2.3.3 Input Variables

Table 6-21. Input Variables for Clothes Dryer Savings Calculation

Component	Type	Value	Unit	Source(s)
Load	Variable	See customer application	lb	Customer application
		Default = 8.45		Maryland/Mid-Atlantic TRM v10, p. 177
CEF_{base}	Variable	See customer application	lb/kWh	Customer application
		Default product class is Vented or Ventless Electric, Standard (≥ 4.4 ft^3)		Maryland/Mid-Atlantic TRM v10, p. 177
CEF_{ee}	Variable	See customer application	lb/kWh	Customer application
		Default product class is Vented or Ventless Electric, Standard (≥ 4.4 ft^3)		Maryland/Mid-Atlantic TRM v10, p. 178
N_{cycle}	Fixed	If dryer is located in residential space,[118] N_{cycle} = 311 If dryer is located in multifamily common area,[119] N_{cycle} = 1,241	–	Residential spaces: Maryland/Mid-Atlantic TRM v10, p. 178; common areas: Minnesota TRM 2021, p. 173
$Dryer_{electric}$	Variable	See Table 6-24	–	Maryland/Mid-Atlantic TRM v10, p.178
		Default = 1.00		Program assumption
HOU	Fixed	If dryer is located in residential space,[118] HOU = 290 If dryer is located in multifamily common area, HOU = 1,241	hours, annual	Residential spaces: Maryland/Mid-Atlantic TRM v10, p. 179; common areas: Minnesota TRM 2021, p. 173[120]
CF_{summer}	Fixed	0.029	–	Maryland/Mid-Atlantic TRM v10, p. 179
CF_{winter}	Fixed	0.014	–	CA 2011 DEER load profile for residential clothes washer

118 All programs will use washer location in residential space with the exception of the Non-Residential Multifamily program which uses the common areas
119 The Source TRMs do not contain dryer cycles or HOU for multifamily common area applications. Therefore, the multifamily values use the same cycles and HOU as the clothes washer measure
120 Assumes 1 hour per cycle.

Table 6-22. Load Based on Dryer Size

Dryer Size	Default Load (lb)
Standard (default)	8.45
Compact	3.00

Table 6-23. CEF_{base} and CEF_{ee} based on Product Class

Product Class	Default CEF_{base} (lb/kWh)	Default CEF_{ee} (lb/kWh)
Vented or Ventless Electric, Standard (≥ 4.4 ft^3) (default)	3.11	3.93
Vented or Ventless Electric, Compact, 120V (< 4.4 ft^3)	3.01	3.80
Vented Electric, Compact, 240V (< 4.4 ft^3)	2.73	3.45
Ventless Electric, Compact, 240V (< 4.4 ft^3)	2.13	2.68
Vented Gas	2.84	3.48

Table 6-24. Proportion of Overall Savings from Dryer Based on Fuel Type

Clothes Dryer Fuel Type	$Fuel_{dryer}$
Electric (default)	1.00
Gas[121]	0.16

6.2.3.4 Default Savings

Per measure gross annual energy savings and gross summer coincident peak savings, respectively, are calculated according to the following equations when input parameter values are not provided.

$$\Delta kWh = \left(\frac{Load}{CEF_{base}} - \frac{Load}{CEF_{ee}}\right) \times N_{cycle} \times Fuel_{electric}$$

$$= \left(\frac{8.45\ lb}{3.11\ lb/kWh} - \frac{8.45\ lb}{3.93\ lb/kWh}\right) \times 311 \times 1.00$$

$$= 176.3\ kWh$$

121 Some electric savings are attributed to gas dryers resulting from electric al components (motors, controls, etc.). The Maryland/Mid-Atlantic TRM v10, p. 178 states "16% was determined using a ratio of the electric to total savings from gas dryers given by ENERGY STAR Draft 2 Version 1.0 Clothes Dryers Data and Analysis."

$$\Delta kW_{summer} = \Delta kWh/HOU \times CF_{summer}$$

$$= 176.3\ kWh/290\ hours \times 0.029$$

$$= 0.018\ kW$$

$$\Delta kW_{winter} = \Delta kWh/HOU \times CF_{winter}$$

$$= 176.3\ kWh/290\ hours \times 0.014$$

$$= 0.009\ kW$$

6.2.3.5 Effective Useful Life

The effective useful life of this measure is provided in Table 6-25.

Table 6-25. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential/ Non-Residential Multifamily	14.00	years	Mid-Atlantic TRM v8, p. 239
VII	Residential Efficient Products Marketplace Program	16.50	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

6.2.3.6 Sources

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v10, pp. 177-179.

6.2.3.7 Update Summary

Updates to this section are described in Table 6-26.

Table 6-26. Summary of Update(s)

Updates in Version	Update Type	Description
2021	Sources	Updated default values
	Equation	Added gross winter peak demand reduction equation
	New table	Effective Useful Life (EUL) by program

Updates in Version	Update Type	Description
2020	Input	Corrected error in the Load based on Dryer Size Table, fossil fuel was changed to compact
V10		Initial release

6.2.4 Dehumidifier

6.2.4.1 Measure Description

This measure relates to the purchase (time of sale) and installation of a dehumidifier meeting the minimum qualifying efficiency standard established by the current ENERGY STAR (Version 5.0) in place of a unit that meets the minimum federal standard efficiency.

6.2.4.2 Impacts Estimation Approach

Per measure, gross annual energy savings are calculated according to the following equation.

$$\Delta kWh = Capacity \times \frac{0.473\ L/pint}{24\ hr/day} \times HOU \times \left(\frac{1}{L/kWh_{base}} - \frac{1}{L/kWh_{ee}}\right)$$

Per measure, gross summer coincident peak savings are calculated according to the following equation.

$$\Delta kW_{summer} = \Delta kWh/HOU \times CF_{summer}$$

Per measure, gross winter coincident peak savings are zero for this measure as dehumidifiers typically operate between April through September.

$$\Delta kW_{winter} \quad 0.0$$

Where:

ΔkWh	= per measure gross annual electric energy savings
ΔkW_{summer}	= per measure gross coincident summer peak demand savings
ΔkW_{winter}	= per measure gross coincident winter peak demand savings
Capacity	= capacity of the unit
HOU	= annual hours of use
L/kWh_{base}	= liters of water per kWh consumed for the baseline unit
L/kWh_{ee}	= liters of water per kWh consumed for the energy efficient unit
CF_{summer}	= summer peak coincidence factor for measure

DNV

6.2.4.3 Input Variables

Table 6-27. Input Variables for Dehumidifier Savings Calculation

Component	Type	Value	Unit	Source(s)
Capacity	Variable	See customer application	pint/day	Customer application
		Default for portable dehumidifier: Capacity = 20		Portable dehumidifier is from Maryland/Mid-Atlantic TRM v10, p. 182
HOU	Fixed	1,632	hours, annual	Maryland/Mid-Atlantic TRM v10, p. 182
L/kWh_{base}	Variable	See Table 6-28	liter/kWh	Minimum federal standard criteria
L/kWh_{ee}	Variable	See customer application	liter/kWh	Customer application
		For default see Table 6-28		ENERGY STAR minimum qualifying criteria
CF_{summer}	Fixed	0.37	–	Maryland/Mid-Atlantic TRM v10, p. 183

Table 6-28. L/kWh_{base} and L/kWh_{ee} for Portable Dehumidifier based on Dehumidifier Capacity

Capacity Range (pint/day)	Minimum baseline (Federal standard) criteria, L/kWh_{base}	Minimum ENERGY STAR criteria, L/kWh_{ee} (Default)
≤ 25 (default)	1.30	1.57
> 25 and ≤ 50	1.60	1.80
> 50	2.80	3.30

6.2.4.4 Default Savings

Per measure gross annual energy savings and gross summer coincident peak savings, respectively, are calculated according to the following equations when input parameter values are not provided:

For portable dehumidifier:

$$\Delta kWh = Capacity \times \frac{0.473\ L/pint}{24\ hr/day} \times HOU \times \left(\frac{1}{L/kWh_{base}} - \frac{1}{L/kWh_{ee}}\right)$$

$$= 20\ \frac{pint}{day} \times \frac{0.473\ L/pint}{24\ hr/day} \times 1{,}632\ hours \times \left(\frac{1}{1.30\ L/kWh} - \frac{1}{1.57\ L/kWh}\right)$$

$$= 85.0\ kWh$$

$$\Delta kW_{summer} = \Delta kWh/HOU \times CF_{summer}$$

$$= {}^{85.0\ kWh}/_{1{,}632\ hours} \times 0.37$$

$$= 0.019\ kW$$

6.2.4.5 Effective Useful Life

The effective useful life of this measure is provided in Table 6-29.

Table 6-29. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII	12.00	years	Maryland/Mid-Atlantic TRM v10, p. 183
VII	Residential Efficient Products Marketplace Program, DSM Phase VII	16.50	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

6.2.4.6 Source

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v10, pp. 181-183.

6.2.4.7 Update Summary

Updates to this section are described in Table 6-30.

Table 6-30. Summary of Update(s)

Updates in Version	Update Type	Description
2021	Source	Updated the source page and values
2020	Inputs	• Clarified that I/kWh_{base} comes from Federal Standard rather than the customer application • Removed the default kWh_{ee} values referencing the previous version of ENERGY STAR requirements that were updated October 31, 2019
v10		Initial release

6.2.5 Dishwasher

6.2.5.1 Measure Description

A dishwasher meeting the efficiency specifications of ENERGY STAR is installed in place of a model meeting the federal standard. This measure is only for standard dishwashers and not compact dishwashers. A compact dishwasher is a unit that holds fewer than eight place settings with six serving pieces.

6.2.5.2 Impacts Estimation Approach

Per measure, gross annual energy savings are calculated according to the following equation.

$$\Delta kWh \quad = (kWh_{base} - kWh_{ee}) \times \left[Elec_{op} + (Elec_{heat} \times Elec_{DHW})\right]$$

Per measure, gross summer coincident peak savings are calculated according to the following equation.

$$\Delta kW_{summer} \quad = \Delta kWh / HOU \times CF_{summer}$$

Per measure, gross winter coincident peak savings are calculated according to the following equation.

$$\Delta kW_{winter} \quad = \Delta kWh / HOU \times CF_{winter}$$

Per measure, gross annual water savings are calculated according to the following equation.

$$\Delta Water \quad = Water_{base} - Water_{ee}$$

Where:

ΔkWh	= per measure gross annual electric energy savings
ΔkW_{summer}	= per measure gross coincident summer peak demand savings
ΔkW_{winter}	= per measure gross coincident winter peak demand savings
kWh_{base}	= kWh consumption per year of the baseline unit
kWh_{ee}	= kwh consumption per year of the energy efficient unit
$\Delta Water$	= per measure gross annual water savings
$Elec_{op}$	= percent of dishwasher energy consumption used for unit operation
$Elec_{heat}$	= percent of dishwasher energy consumption used for water heating
$Elec_{DHW}$	= percentage of DHW savings assumed to be electric
HOU	= annual hours of use
$Water_{base}$	= annual water consumption of baseline dishwasher
$Water_{ee}$	= annual water consumption of efficient dishwasher
CF_{summer}	= summer peak coincidence factor
CF_{winter}	= winter peak coincidence factor

DNV

6.2.5.3 Input Variables

Table 6-31. Input Variables for Dishwasher Savings Calculations

Component	Type	Value	Unit	Source(s)
kWh_{base}	Fixed	307	kWh	Maryland/Mid-Atlantic TRM v10, p. 191
kWh_{ee}	Fixed	270	kWh	Maryland/Mid-Atlantic TRM v10, p. 191
$Elec_{op}$	Fixed	0.44	–	Maryland/Mid-Atlantic TRM v10, p. 191
$Elec_{heat}$	Fixed	0.56	–	Maryland/Mid-Atlantic TRM v10, p. 192
$Elec_{DHW}$	Variable	See Table 6-15 in Section 6.2.2 For Default use unknown DHW fuel	–	Maryland/Mid-Atlantic TRM v10, p. 166
HOU	Fixed	210	hours, annual	Maryland/Mid-Atlantic TRM v10, p. 192
$Water_{base}$	Fixed	700[122]	gallons	Maryland/Mid-Atlantic TRM v10, p. 194
$Water_{ee}$	Fixed	490[123]	gallons	Maryland/Mid-Atlantic TRM v10, p. 194
CF_{summer}	Fixed	0.026	–	Maryland/Mid-Atlantic TRM v10, p. 192
CF_{winter}	Fixed	0.006	–	CA 2011 DEER load profile for residential dishwasher

6.2.5.4 Default Savings

Per measure gross annual energy savings, gross summer and winter coincident peak savings, and gross annual water savings respectively, are calculated according to the following equations for all dishwashers.

$$\Delta kWh = (kWh_{base} - kWh_{ee}) \times \left[Elec_{op} + (Elec_{heat} \times Elec_{DHW})\right]$$

$$= (307\ kWh - 270\ kWh) \times \left(0.44 + (0.56 \times 0.57\ )\right)$$

$$= \ 28.09\ kWh$$

122 Assuming 5 gallons/cycle (maximum allowed) and 140 cycles per year based on a weighted average of dishwasher usage in the Mid-Atlantic Region derived from the 2009 RECs data; http://205.254.135.7/consumption/residential/data/2009/

123 Assuming 3.50 gallons/cycle (maximum allowed) and 140 cycles per year based on a weighted average of dishwasher usage in the Mid-Atlantic Region derived from the 2009 RECs data; http://205.254.135.7/consumption/residential/data/2009/

$$\Delta kW_{summer} = \Delta kWh/HOU \times CF_{summer}$$

$$= 28.75\ kWh/210\ hours \times 0.0260$$

$$= 0.0034\ kW$$

$$\Delta kW_{winter} = \Delta kWh/HOU \times CF_{winter}$$

$$= 28.75\ kWh/210\ hours \times 0.006$$

$$= 0.0008\ kW$$

$$\Delta Water = Water_{base} - Water_{ee}$$

$$= 700 - 490$$

$$= 210\ \text{gallons}$$

6.2.5.5 Effective Useful Life

The effective useful life of this measure is provided in Table 6-32.

Table 6-32. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VII	Residential Efficient Products Marketplace	16.50	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

6.2.5.6 Source

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v10, pp. 191-194.

6.2.5.7 Update Summary

Updates to this section are described in Table 6-33.

Table 6-33. Summary of Update(s)

Updates in Version	Update Type	Description
2021	Source	Updated source references only

Updates in Version	Update Type	Description
	Equation	• Added gross winter peak demand reduction equation • Added gross annual water savings equation
	Input Variable	Added $Water_{base}$ and $Water_{ee}$ constants for water savings calculation
	Default Savings	Added default gross annual water savings value
2020	Inputs	Adjusted $Elec_{DHW}$ and $Fuel_{DHW}$ from fixed values to use customer application
v10		Initial release

6.2.6 Freezer

6.2.6.1 Measure Description

This measure relates to the upstream promotion of residential freezers meeting the ENERGY STAR criteria through the Energy Star Retail Products Program. In the measure, a freezer meeting the efficiency specifications of ENERGY STAR is installed in place of a model meeting the federal standard (NAECA).

6.2.6.2 Impacts Estimation Approach

Per measure, gross annual energy savings are calculated using one of the following equations, depending on what inputs are available

$$\Delta kWh \quad = kWh_{base} - kWh_{ee}$$

Per measure, gross summer coincident peak savings are calculated according to the following equation.

$$\Delta kW_{summer} \quad = (\Delta kWh/8{,}760) \times TAF \times LSAF$$

Per measure, gross summer coincident peak savings are calculated according to the following equation.

$$\Delta kW_{winter} \quad = (\Delta kWh/8{,}760) \times CF_{winter}$$

Where:

ΔkWh	= per measure gross annual electric energy savings
ΔkW_{summer}	= per measure gross coincident peak demand savings
ΔkW_{winter}	= per measure gross coincident peak demand savings
kWh_{base}	= annual baseline electric energy consumption per year
kWh_{ee}	= annual ENERGY STAR electric energy consumption
TAF	= Temperature Adjustment Factor
LSAF	= Load Shape Adjustment Factor
CF_{winter}	= winter peak coincident factor

DNV

6.2.6.3 Input Variables

Table 6-34. Input Variables for Freezer Savings Calculations

Component	Type	Value	Unit	Source(s)
TAF	Fixed	1.23	–	Maryland/Mid-Atlantic TRM v10, p. 56
LSAF	Fixed	1.15	–	Maryland/Mid-Atlantic TRM v10, p. 56
CF_{winter}	Fixed	0.418	–	CA 2011 DEER load profile for residential high efficiency refrigerator and freezer
$kWh_{base, calculated}$	Fixed	See customer application or ENERGY STAR Qualified Product List value for US Federal Standard, if value is unavailable see Table 6-35 and apply by Freezer type	kWh	Customer application
		For default see Table 6-35 = 313.0		Maryland/Mid-Atlantic TRM v10, p. 56
kWh_{ee}	Variable	See customer application	kWh	See customer application
		For default see Table 6-35 = = 281.0		Maryland/Mid-Atlantic TRM v10, p. 56

Table 6-35. Savings Based on Product Category Defaults

Freezer Type	$Volume_{adj.}$	kWh_{base}	kWh_{ee}	Weighting if Unknown Freezer Type (default)	ΔkWh	ΔkW_{summer}	ΔkW_{winter}
Upright Freezer	24.4	438.6	394.8	0.37	43.8	0.007	0.002
Chest Freezer	18.0	239.0	215.1	0.63	23.9	0.004	0.001
Unknown (default)	–	313.0	282.0	–	31.0	0.005	0.001

6.2.6.4 Default Savings

Per measure gross annual energy savings and gross summer coincident peak savings, respectively, are calculated according to the following equations when input parameter values are not provided.

$$\Delta kWh = kWh_{base} - kWh_{ee}$$

$$= 313.0 - 282.0$$

$$= 31\ kWh$$

$$\Delta kW_{summer} = (\Delta kWh/8{,}760) \times TAF \times LSAF$$

$$= 31/8{,}760 \times 1.23 \times 1.15$$

$$= 0.005\ kW$$

$$\Delta kW_{winter} = (\Delta kWh/8{,}760) \times CF_{winter}$$

$$= 31/8{,}760 \times 0.418$$

$$= 0.001\ kW$$

6.2.6.5 Effective Useful Life

The effective useful life of this measure is provided in Table 6-36.

Table 6-36. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VII	Residential Efficient Products Marketplace	16.50	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

6.2.6.6 Source

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v10, pp. 54-56.

6.2.6.7 Update Summary

Updates to this section are described in Table 6-37.

Table 6-37. Summary of Update(s)

Updates in Version	Update Type	Description
2021	Inputs	Use the application ENERGY STAR QPL kWh_{base} values when available
	Source	Updated page numbers / version of the Maryland/Mid-Atlantic TRM v10
	Equation	Added gross winter peak demand reduction equation
2020	None	No change

Updates in Version	Update Type	Description
v10		Initial release

6.2.7 Refrigerator

6.2.7.1 Measure Description

This measure relates to the purchase and installation of a new refrigerator meeting either ENERGY STAR or Consortium for Energy Efficiency (CEE) Tier 2 or Tier 3 specifications (defined as consuming ≥ 10%, ≥ 15%, or ≥ 20% less energy than an equivalent unit meeting federal standard requirements, respectively).

The baseline condition is a new refrigerator meeting the minimum federal efficiency standard. The efficient condition is a new refrigerator meeting either the ENERGY STAR or CEE TIER 2 or TIER 3 efficiency standards.

Table 6-38. Programs that Offer Refrigerator

Program Name	Section
Residential Efficient Products Marketplace Program, DSM Phase VII	Section 6.2.7
Residential Manufactured Housing Program, DSM Phase VIII	Section 11.4.1
Residential Home Retrofit Program, DSM Phase VIII	Section 12.5.1
Residential/Non-Residential Multifamily Program, DSM Phase VIII	Section 13.4.1

6.2.7.2 Impacts Estimation Approach

Per measure, gross annual energy savings are calculated according to the following equation.

$$\Delta kWh \quad = kWh_{base} \times ESF$$

Per measure, gross summer coincident peak savings are calculated according to the following equation.

$$\Delta kW_{summer} \quad = (\Delta kWh/HOU) \times TAF \times LSAF$$

Per measure, gross summer coincident peak savings are calculated according to the following equation.

$$\Delta kW_{winter} \quad = (\Delta kWh/HOU) \times CF_{winter}$$

Where:

ΔkWh	= per measure gross annual electric energy savings
ΔkW_{summer}	= per measure gross coincident summer peak demand savings
ΔkW_{winter}	= per measure gross coincident winter peak demand savings
kWh_{base}	= kWh consumption per year of the baseline unit

ESF	= energy savings factor of efficient unit
TAF	= temperature adjustment factor
HOU	= hours of use
LSAF	= load shape adjustment factor
CF_{winter}	= winter peak coincident factor

6.2.7.3 Input Variables

Table 6-39. Input Variables for Refrigerator Savings Calculation

Component	Type	Value	Unit	Source(s)
$Volume_{adj.}$	Variable	See customer application	feet^3	Customer application
kWh_{base}	Variable	See customer application	kWh	Customer application
		For default use Table 19-12 in Sub-Appendix F1-VI: Residential Refrigeration Factors		Pennsylvania TRM 2019, pp. 95-102
HOU	Fixed	Default= 8,760	hour, annual	Maryland/Mid-Atlantic TRM v10, p. 60
ESF	Variable	See customer application, ENERGY STAR Qualified Product List or Table 6-40	–	Customer application, Maryland/Mid-Atlantic TRM v10, p. 58 or ENERGY STAR Qualified Product List
		For default use efficiency tier is ENERGY STAR in Table 6-40		Results in most conservative savings
TAF	Fixed	1.23	–	Maryland/Mid-Atlantic TRM v10, p. 60
LSAF	Fixed	1.15	–	Maryland/Mid-Atlantic TRM v10, p. 60
CF_{winter}	Fixed	0.418	–	California DEER2011 load profile for residential high-efficiency refrigerator and freezer

Table 6-40. Energy Savings Factor Based on Efficiency Tier

Tier	ENERGY STAR	CEE Tier 2	CEE Tier 3
Energy Savings Factor (ESF)	0.10	0.15	0.20

DNV

6.2.7.4 Default Savings

No default savings will be awarded for this measure if the proper values are not provided in the customer application.

6.2.7.5 Effective Useful Life

The effective useful life of this measure is provided in Table 6-41.

Table 6-41. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Manufactured Housing Program, DSM Phase VIII	12.00	years	Maryland/Mid-Atlantic TRM v10, p. 61
	Residential Home Retrofit Program, DSM Phase VIII			
	Residential/Non-Residential Multifamily Program, DSM Phase VIII			
VII	Residential Efficient Products Marketplace Program, DSM Phase VII	16.50	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

6.2.7.6 Sources

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v10, pp. 57-69, and Pennsylvania Residential TRM 2019, pp. 95-102.

6.2.7.7 Update Summary

Updates to this section are described in Table 6-42.

Table 6-42. Summary of Update(s)

Updates in Version	Update Type	Description
2021	Reference	Updated the reference TRMs
	Equation	Added gross winter peak demand reduction equation
	Inputs	Removed default for adjusted volume since this input will always be available
2020	None	No changes
v10		Initial release

7 RESIDENTIAL THERMOSTAT (ENERGY EFFICIENCY) PROGRAM, DSM PHASE VIII

There are three components of the smart thermostat energy efficiency program: purchase, optimization, and behavior.

Thermostat Purchase and Upgrade

Participants are given a rebate to purchase a qualified ENERGY STAR smart thermostat. The purchaser must buy and activate an ENERGY STAR certified smart thermostat connected to a heat pump. Current eligible manufacturers include ecobee, Emerson, Google Nest and Honeywell Home.

- The thermostat must be in a single-family home (house, townhouse, mobile home).
- The purchaser must be the homeowner or the person responsible for the electric bill.
- The home must have a heat pump (air source, ductless mini-split, or geothermal).
- Rebate application must be submitted within 90 days of purchase.

Smart Thermostat Behavior – System Optimization

The WeatherSmart℠ Program adds external controls to account for local weather and automatically adjusts the thermostat settings to optimize the interior temperature and as a result, energy consumption. Thermostat optimization has the same eligibility criteria as thermostat purchase.

- The thermostat must be in a single-family home (house, townhouse, mobile home).
- The purchaser must be the homeowner or the person responsible for the electric bill.
- The home must have a heat pump (air source, ductless mini-split or geothermal).

Smart Thermostat Behavior – HVAC O&M Reports

All customers enrolled in thermostat optimization and the thermostat demand response program receive email or paper reports with recommendations for behavior and operations and maintenance (O&M) actions that encourage energy efficiency.

This measure applies to all residential applications and may be a time of sale or retrofit measure.

Table 7-1. Programs that Offer/Involve Thermostat Upgrades

End Use	Measure	Legacy Program	Manual Section
HVAC	Thermostat Purchase and Upgrade	–	Section 7.2.1
	Smart Thermostat Behavior – System Optimization	–	Section 7.2.2
	Smart Thermostat Behavior- HVAC O&M Reports	–	Section 7.2.3

7.2 Heating, Ventilation and Air Conditioning End Use

7.2.1 Thermostat Purchase and Upgrade

7.2.1.1 Measure Description–Smart and Programable Thermostats

The smart thermostat is the purchase or replacement of a manually operated or conventional programmable thermostat with a smart thermostat that meets or exceeds the ENERGY STAR® requirements.[124] A "smart" or communicating thermostat allows remote set point adjustment and control via remote application. The system requires an outdoor air temperature algorithm in the control logic to operate heating and cooling systems

The baseline is a mix of manual and programmable thermostats; the efficient condition is a smart thermostat that has earned ENERGY STAR certification.

The programable thermostat retrofit measure involves the replacement of a manually operated thermostat with a programable thermostat. Energy savings are calculated as a percentage of household heating load.

This smart thermostat and programable thermostat measures are offered in the programs listed in Table 7-2. Energy savings are calculated as a percentage of household heating and cooling loads using the impacts estimation approach described in this section.

Table 7-2. Programs that Offer/Involve Thermostat Upgrades

Program Name	Thermostat Type	Section
Residential Thermostat (Energy Efficiency) Program, DSM Phase VIII	Smart Thermostat	Section 7.2.1
Residential Manufactured Housing Program, DSM Phase VIII	Smart Thermostat	Section 11.3.8
Residential Home Retrofit Program, DSM Phase VIII	Smart Thermostat	Section 12.4.6
Residential/Non-Residential Multifamily Program, DSM Phase VIII	Smart Thermostat	Section 13.3.4
Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII	Programmable Thermostat	Section 16.3.5

7.2.1.2 Impacts Estimation Approach

Gross annual electric energy savings per household is calculated according to the following equation: Per account, the gross annual electric energy savings are calculated according to the following equation:

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

[124] The key product criteria for Smart thermostats can be found at https://www.energystar.gov/products/heating_cooling/smart_thermostats/key_product_criteria; Savings methodology is taken from the Maryland/Mid-Atlantic TRM v10. Heating and cooling consumption are taken from customer specific consumption data. The savings percent savings assumptions are locked down for three years from June 1, 2020 through May 31, 2023.

If the heating system type is non-electric or electric resistance baseboard there are no heating savings. For heat pump heating systems, the heating savings are calculated as follows:

$$\Delta kWh_{heat} = ESF_{heat} \times kWh_{heat}$$

$$\Delta kWh_{cool} = ESF_{cool} \times kWh_{cool}$$

The gross coincident demand reduction is assumed to be zero.

Where:

ΔkWh = gross annual electric energy savings

ΔkWh_{heat} = gross annual electric energy heating savings

ΔkWh_{cool} = gross annual electric energy cooling savings

ESF_{heat} = energy savings factor for heating energy

ESF_{cool} = energy savings factor for cooling energy

kWh_{heat} = annual baseline energy consumption for heating

kWh_{cool} = annual baseline energy consumption for cooling

The calculation inputs are based on the default savings percentages from the Maryland/Mid-Atlantic TRM v10 and the heating and cooling kWh consumption derived from a billing analysis of monthly customer energy consumption prior to the purchase of the thermostat.

7.2.1.3 Input Variables

Table 7-3. Input Variables for Thermostat

Component	Type	Value	Units	Source(s)
ESF_{heat}	Variable	See Table 7-4	–	For smart thermostat: Maryland/Mid-Atlantic TRM v10, p. 104 For programable thermostat Illinois TRM 2020, p. 137
		For default smart thermostat use segment = all other cases		
ESF_{cool}	Variable	See Table 7-4	–	Maryland/Mid-Atlantic TRM v10, p. 104
		For default smart thermostat use segment = all other cases		
kWh_{heat}	Variable	Customer-specific heating load	kWh	Customer billing data
		For default see Sub-Appendix F1-VIII: Residential Account Normalized Annual Consumption, Table 19-17		Annual heating load from billing data
kWh_{cool}	Variable	Customer-specific heating load	kWh	Customer billing data
		For default see Sub-Appendix F1-VIII: Residential Account Normalized Annual Consumption, Table 19-17		Annual cooling load from billing data

Table 7-4, provides a summary of the ESFs. The customer application will indicate if the existing thermostat is being replaced because it was broken or if the smart thermostat is being installed concurrently with a new HVAC unit. For all other cases the default value is used.

Table 7-4. Electric Heating and cooling ESF

Thermostat Type	Segment	Heat Pump		Air Conditioning	
		ESF_{heat}	ESF_{cool}	ESF_{heat}	ESF_{cool}
Smart Thermostat	Existing smart thermostat is broken	0.030	0.035	–	0.035
	New HVAC equipment is installed with thermostat	0.030	0.035	–	0.035
	All other cases (default)	0.060	0.070	–	0.070
Programable Thermostat[125]		0.062	–	–	–

7.2.1.4 Default Savings

If the proper values are not supplied, a default savings may be calculated. The default per measure gross annual electric energy savings will be assigned according to the following calculation:[126]

Smart Thermostat:

Default savings are calculated assuming a heat pump is used for space conditioning with a smart thermostat, as follows:[127]

$$\Delta kWh_{heat} = ESF_{heat} \times kWh_{heat}$$

$$= 0.07 \times 4{,}352$$

$$= 304.6\ kWh$$

$$\Delta kWh_{cool} = ESF_{cool} \times kWh_{cool}$$

$$= 0.06 \times 3{,}060$$

$$= 183.6\ kWh$$

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

125 The referenced Illinois TRM 2020 only attributes savings to heating for programable thermostats.
126 Virginia specific defaults are in development and this section will be updated when the defaults are available.
127 Method 3, Maryland/Mid-Atlantic TRM v.10, p. 105.

$$= 304.6 + 183.6$$

$$= 488.2 \ kWh$$

There is no default per measure gross coincident demand reduction.

Programable Thermostat:

Default savings are calculated assuming a heat pump is used for space conditioning with a programmable thermostat.

$$\Delta kWh_{heat} = ESF_{heat} \times kWh_{heat}$$

$$= 0.062 \times 4{,}352$$

$$= 269.8 \ kWh$$

There are no cooling savings for programable thermostat. There is no peak coincident demand reduction for this measure.

7.2.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 7-5.

Table 7-5. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Thermostat (Energy Efficiency) Program, DSM Phase VIII	7.50	years	Maryland/Mid-Atlantic TRM v10, pp. 103–106
	Residential Manufactured Housing Program, DSM Phase VIII			
	Residential Home Retrofit Program, DSM Phase VIII			
	Residential/Non-Residential Multifamily Program, DSM Phase VIII			
	Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII			

7.2.1.6 Source

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v10, pp. 103–106.

7.2.1.7 Update Summary

Updates to this section are described in Table 7-6.

Table 7-6. Summary of Update(s)

Updates in Version	Update Type	Description
2021		Initial release

7.2.2 Smart Thermostat Behavior – System Optimization

7.2.2.1 Measure Description

Smart thermostat-system optimization is a behavior measure. System optimization is a passive algorithmic optimization of wi-fi thermostat setpoints to reduce customers' annual heating and cooling consumption. Qualified customers can opt into the program and have their thermostat setpoints optimized to maintain their thermal comfort while reducing their energy consumption.[128] The Program is open to several thermostat manufacturers, makes, and models that meet or exceed the ENERGY STAR requirements and have communicating technology.

The baseline efficiency is a customer with a smart thermostat that is not participating in the temperature optimization program. The high efficiency is a customer participating in the temperature optimization program.

Smart thermostat “home energy reports” are sent to customers participating in the thermostat system optimization and demand response thermostat programs. In contrast to traditional home energy reports, the smart thermostat home energy report emphasizes behavior and O&M actions that encourage HVAC energy efficiency. The HVAC O&M Reports are considered a separate measure in Section 7.2.3, however, the impacts are included in the energy savings factor for smart thermostat-system optimization.

7.2.2.2 Impacts Estimation Approach

Gross annual electric energy savings per household is calculated according to the following equation: Per account, the gross annual electric energy savings are calculated according to the following equation:

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

If the heating system type is non-electric or electric resistance baseboard there are no heating savings. For heat pump heating systems, the heating savings are calculated as follows:

[128] From Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures 2019 Plan-Year, May 2020, D.P.U. 20-50, p. 37.

$$\Delta kWh_{heat} = ESF_{heat} \times kWh_{heat}$$

$$\Delta kWh_{cool} = ESF_{cool} \times kWh_{cool}$$

Per measure, gross summer coincident peak reduction is calculated according to the following equation.

$$\Delta kW_{summer} = \Delta kWh_{cool} \times DR_{summer}$$

Per measure, gross summer coincident peak reduction is calculated according to the following equation.

$$\Delta kW_{winter} = \Delta kWh_{heat} \times DR_{winter}$$

Where:

ΔkWh	= gross annual electric energy savings
ΔkWh_{heat}	= gross annual electric energy heating savings
ΔkWh_{cool}	= gross annual electric energy cooling savings
ΔkW_{summer}	= gross annual electric energy heating savings
$\Delta kW_{wintert}$	= gross annual electric energy heating savings
ESF_{heat}	= energy savings factor for heating energy
ESF_{cool}	= energy savings factor for cooling energy
kWh_{heat}	= annual baseline energy consumption for heating
kWh_{cool}	= annual baseline energy consumption for cooling
DR_{summer}	= summer demand ratio converting kWh savings to demand reduction
DR_{winter}	= winter demand ratio adjustment converting kWh savings to demand reduction

The calculation inputs are based on the default savings percentages from the Maryland/Mid-Atlantic TRM v10 and the heating and cooling kWh consumption derived from a billing analysis of monthly customer energy consumption prior to the purchase of the thermostat.

7.2.2.3 Input Variables

Table 7-7. Input Variables for Measure Smart Thermostat-Optimization

Component	Type	Value	Units	Source(s)
ESF_{heat}	Fixed	0.030	–	DNV Judgment[129]
ESF_{cool}	Fixed	0.035	–	DNV Judgment[129]

[129] DNV reviewed impact evaluations for similar programs. Based on this review a value of 3.0% and 3.5% were determined to be reasonable for the ESF_{heat} and ESF_{cool}, respectively.

DNV

Component	Type	Value	Units	Source(s)
kWh_{heat}	Variable	Customer-specific heating load	kWh	Annual heating load from billing data.[130]
		For default see Sub-Appendix F1-VIII: Residential Account Normalized Annual Consumption, Table 19-17		Average Virginia annual heating load from billing data
kWh_{cool}	Variable	Customer-specific cooling load	kWh	Annual cooling load from billing data, methodology is described in the Sub-Appendix F1-IX: Billing Analysis
		For default see Sub-Appendix F1-VIII: Residential Account Normalized Annual Consumption, Table 19-17		Average Virginia annual cooling load from billing data
DR_{summer}	Fixed	0.00166	kW/kWh	Massachusetts TRM 2020, p. 37
DR_{winter}	Fixed	0.00044	kW/kWh	Massachusetts TRM 2020, p. 37

7.2.2.4 Default Savings

If the proper values are not supplied, a default savings may be calculated. The default per measure gross annual electric energy savings will be assigned according to the following calculation and by assuming that a heat pump is used for space conditioning.

$$\Delta kWh_{heat} = ESF_{heat} \times kWh_{heat}$$

$$= 0.030 \times 4{,}352$$

$$= 87.0\ kWh$$

$$\Delta kWh_{cool} = ESF_{cool} \times kWh_{cool}$$

$$= 0.035 \times 3{,}060$$

$$= 61.2\ kWh$$

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

$$= 87.0 + 61.2$$

$$= 148.2\ kWh$$

Default per measure, gross summer coincident peak reduction is calculated according to the following equation.

$$\Delta kW_{summer} = \Delta kWh_{cool} \times DR_{summer}$$

$$= 61.2 \times 0.0016$$

$$= 0.098\ kW$$

Per measure, gross summer coincident peak savings are calculated according to the following equation.

$$\Delta kW_{winter} = \Delta kWh_{heat} \times DR_{winter}$$

$$= 87.0 \times 0.00044$$

$$= 0.038\ kW$$

7.2.2.5 Effective Useful Life

The effective useful life of this measure is provided in Table 7-8.

Table 7-8. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Thermostat (Energy Efficiency) Program	1.00	year	Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures 2019 Plan-Year, May 2020, D.P.U. 20-50, p. 37

7.2.2.6 Source

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v10, pp. 103–106.

7.2.2.7 Update Summary

Updates to this section are described in Table 7-9.

Table 7-9. Summary of Update(s)

Updates in Version	Update Type	Description
2021		Initial release

7.2.3 Smart Thermostat Behavior- HVAC O&M Reports

Smart thermostat HVAC O&M reports are sent to customers participating in the system optimization and demand response thermostat programs. In contrast to traditional home energy reports, the HVAC O&M report emphasizes behavior and O&M actions that promote HVAC energy efficiency.

7.2.3.1 Impacts Estimation Approach

The energy savings for the HVAC O&M report are incorporated into the Smart Thermostat Behavior – System Optimization measure in Section 7.2.2.

7.2.3.2 Update Summary

Updates to this section are described in Table 7-10.

Table 7-10. Summary of Update(s)

Version with Updates	Update Type	Description
2021		Initial release

8 RESIDENTIAL THERMOSTAT SMART REWARDS DEMAND RESPONSE PROGRAM, DSM PHASE VIII

8.1 Heating Ventilation and Air Conditioning End Use

8.1.1.1 Measure Description

Residential customers living in an owner-occupied single-family home, townhouse, condominium, or manufactured home with central air conditioners or heat pumps who are not already participating in the Company's DSM Phase I Smart Cooling Rewards Program or on a time-of-use rate and who have a qualifying smart thermostat are eligible to enroll in the Thermostat Smart Rewards Demand Response Program. Enrolled customers also receive a "Connected Savings Energy Scorecard" based on their individual HVAC runtime data and temperature setpoint patterns. Demand response events are called by the Company during times of peak system demand throughout the year and thermostats of participating customers are gradually adjusted to achieve a specified amount of load reduction while maintaining reasonable customer comfort. Customers can opt-out of specific events if they choose to do so.

8.1.1.2 Impacts Estimation Approach

The regression equation that DNV used to estimate the ex post kW impacts per participant in 2021 is derived by fitting a linear regression model for each event hour ending 15–19 with the temperature humidity index (THI) as a predictor variable. The event hours included in the ex post analysis is determined by the start and end of each event.[131]

Ex ante event day demand reduction is calculated according to the following equations:

$$Predicted\ Ex\ Ante\ kW\ Impact_{16:00,day} = \hat{\beta}_{0,16:00} + \hat{\beta}_{1,16:00} * (THI_{16:00})$$

$$Predicted\ Ex\ Ante\ kW\ Impact_{17:00,day} = \hat{\beta}_{0,17:00} + \hat{\beta}_{1,17:00} * (THI_{17:00})$$

$$Predicted\ Ex\ Ante\ kW\ Impact_{18:00,day} = \hat{\beta}_{0,18:00} + \hat{\beta}_{1,18:00} * (THI_{18:00})$$

Where:

$\boldsymbol{\hat{\beta}_{0,hour}}$ = fixed estimate for the ex-ante kW impact
$\boldsymbol{\hat{\beta}_{1,hour}}$ = increase to the ex ante kW impact estimate when THI increases by one
$\boldsymbol{THI_{hour}}$ = THI value for a specific hour.

The Dominion peak condition for planning purposes is assumed to be 95°F, 43% relative humidity at hour ending 17:00. This corresponds with a THI of 83.4. Therefore, the ex ante peak demand savings are calculated according to the following equations:

[131] The impact analysis follows protocols outlined in Miriam L. Goldberg & G. Kennedy Agnew. Measurement and Verification for Demand Response, National Forum on the National Action Plan on Demand Response, https://www.ferc.gov/industries/electric/indus-act/demand-response/dr-potential/napdr-mv.pdf.

$$Predicted\ Ex\ Ante\ kW\ Impact_{17:00,day} = \hat{\beta}_{0,17:00} + \hat{\beta}_{1,17:00} * (83.4\ THI\ )$$

$$Predicted\ Ex\ Ante\ kW\ Impact_{17:00,day} = -0.57923 + 0.01972 * (83.4\ )$$

8.1.1.3 Input Variables

Table 8-1. Regression Parameters for the 2021 Thermostat DR Event Season

Component	Type	Value	Unit	Source
$\hat{\beta}_{0,16:00}$	Fixed	-3.33996	kW	Dominion, 2021 Thermostat DR Impact Analysis
$\hat{\beta}_{0,17:00}$	Fixed	-0.57923	kW	
$\hat{\beta}_{0,18:00}$	Fixed	2.09803	kW	
$\hat{\beta}_{1,16:00}$	Fixed	0.05626	kW	
$\hat{\beta}_{1,17:00}$	Fixed	0.01972	kW	
$\hat{\beta}_{1,18:00}$	Fixed	-0.01720	kW	
$THI_{16:00}$	Variable	–	THI	NOAA
$THI_{17:00}$	Variable	–	THI	
$THI_{18:00}$	Variable	–	THI	

8.1.1.4 Demand reduction

The kW impact per participant during Dominion's peak conditions for 2021 is 1.07 kW. Demand reduction is not deemed. All savings are taken from annual impact evaluations.

8.1.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 8-2.

Table 8-2. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Thermostat DR Program	1.00	years	Program design assumption

8.1.1.6 Source

Local weather data are gathered from NOAA, National Centers for Environmental Information.

8.1.1.7 Update Summary

Updates to this section are described in Table 8-3.

Table 8-3. Summary of Update(s)

Version with Updates	Update Type	Description
2021		Initial release

9 RESIDENTIAL CUSTOMER ENGAGEMENT PROGRAM, DSM PHASE VIII

The Residential Customer Engagement Program delivers paper and email home energy reports (HER) to participating customers selected by the Company. Customers can opt-out of participating in the program at any time.

9.1 Whole Building End Use

9.1.1 Home Energy Report

HERs contain account-specific information that allows customers to view their energy use over time. HERs compare energy use of recipient homes with clusters of similar homes and provide comparisons with other efficient and average homes. This "neighbor" comparison is believed to spur participants to modify their behavior and increase household energy efficiency. Reports also include a variety of seasonally appropriate energy-saving tips that are tailored for the home and are often used to promote other DSM program offerings.

9.1.1.1 Measure Description

Paper or email home energy reports.

9.1.1.2 Impacts Estimation Approach

Per measure, the gross annual electric energy savings are calculated according to the following equation. KW factors are under development.

$$\Delta kWh \quad = kWh_{whole\ house} \times ESF$$

There is no gross coincident demand reduction for this measure.

Where:

ΔkWh = gross annual electric energy savings

$kWh_{whole\ houset}$ = gross annual electric energy whole house consumption

ESF = energy savings factor
ΔkW_{summer} = gross coincident summer peak demand reduction
kW_{base} = baseline gross coincident electric demand
DSF = demand savings factor

9.1.1.3 Input Variables

Table 9-1. Input Variables for Measure Smart Thermostat-Behavioral

Component	Type	Value	Units	Source(s)
ESF	Variable	Email reports: 0.007 Paper reports: 0.012	–	Program design assumption

Component	Type	Value	Units	Source(s)
$kWh_{whole\ house}$	Variable	Customer-specific heating load	kWh	Customer billing data
		For default see Sub-Appendix F1-VIII: Residential Account Normalized Annual Consumption, Table 19-17		Average Virginia annual consumption from billing data
kW_{base}	Variable	Customer-specific demand	kW	

9.1.1.4 Default Savings

If the proper values are not supplied, a default savings may be calculated. The default per measure gross annual electric energy savings will be assigned according to the following calculation:

Default savings are calculated for email report.

$$\Delta kWh_{whole\ house} = ESF \times kWh_{whole\ house}$$

$$= 0.0007 \times 13{,}969.41$$

$$= 97.78 \text{ kWh}$$

There is no default per measure gross coincident demand reduction.

9.1.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 9-2.

Table 9-2. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	DSM Phase	Value	Units	Source(s)
VIII	Residential Customer Engagement Program	1.00	year	Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures, 2019 Plan-Year Report Version May 2020, p. 35.

9.1.1.6 Source

The primary source for this deemed savings approach is the Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures, 2019 Plan-Year Report Version May 2020, p. 35.

9.1.1.7 Update Summary

Updates to this section are described in Table 9-3.

Table 9-3. Summary of Update(s)

Updates in Version	Update Type	Description
2021		Initial release

10 RESIDENTIAL ENERGY EFFICIENCY KITS PROGRAM, DSM PHASE VIII

The Residential Energy Efficiency Kits Program provided to new residential accounts. New construction including modular and manufactured homes are eligible. Multifamily customers are ineligible. Each kit includes a Tier 1 advanced smart strip and educational materials. To receive additional measures, customers can complete a phone or web survey confirming their address and answer a few questions to identify which measures will be of value and produce electric energy savings.

The measures offered through the program and the sections that contain the savings algorithms for each measure are presented in Table 10-1.

Table 10-1. Residential Energy Efficiency Kits Program Measure List

End Use	Measure	Legacy Program	Manual Section
Building Envelope	Weatherization	–	Section 10.1.1
Domestic Hot Water	Domestic Hot Water Pipe Insulation	Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 2.1.1
	Faucet Aerator	Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 2.1.2
	Low-flow showerhead	Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 2.1.3
Lighting	LED Lamps	Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 2.3.1
Plug Load	Smart Strip	–	Section 10.4.1

10.1 Building Envelope End Use

10.1.1 Weatherization

10.1.1.1 Measure Description

This measure involves thermal shell air leak sealing through strategic use and location of air-tight materials such as door sweeps, gaskets on electrical outlets or switches, caulking, or weatherstripping on windows or doors. This measure is for situations where blower tests are not conducted.

This measure is offered through different programs listed in Table 10-2, and uses the impacts estimation approach described in this section.

Table 10-2. Programs that Offer Weatherization

Program Name	Section
Residential Energy Efficiency Kits Program, DSM Phase VIII	Section 10.1.1
Residential Manufactured Housing Program, DSM Phase VIII	Section 11.1.3

10.1.1.2 Impacts Estimation Approach

Per measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \Delta kWh_{heat,electric} + \Delta kWh_{heat,FAF\ fan} + \Delta kWh_{cool}$$

If electric resistance heating or a heat pump provided space heating, heating savings are calculated using the following equation:

$$\Delta kWh_{heat,electric} = \left(\frac{\Delta kWh_{heat,electric}}{HDD}\right) \times HDD \times ISR$$

If a forced air furnace (FAF) with gas heat and an electric fan provides heat, then $\Delta kWh_{heat,FAF\ fan}$, which is the kWh savings associated with the electric furnace air fan, follows the equations below, otherwise $\Delta kWh_{heating,FAF\ fan}$ is zero.

$$\Delta kWh_{heat,FAF\ fan} = \left(\frac{\Delta kWh_{heat,FAF\ fan}}{HDD}\right) \times HDD \times ISR$$

If space-cooling is provided, then ΔkWh_{cool} follows the equations below, otherwise ΔkWh_{cool} is zero.

$$\Delta kWh_{cool} = \left(\frac{\Delta kWh_{cool}}{CDD}\right) \times CDD \times cool_{adj} \times ISR$$

Per measure, the gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{\Delta kWh_{cool}}{EFLH_{cool}} \times CF_{summer}$$

Per measure, the gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \left(\frac{\Delta kWh_{heat,electric} + \Delta kWh_{heat,FAF\ fan}}{EFLH_{heat}}\right) \times CF_{winter}$$

Where:

ΔkWh	= gross annual electric energy savings
ΔkW_{summer}	= gross coincident summer peak demand reduction
ΔkW_{winter}	= gross coincident winter peak demand reduction
$\Delta kWh_{heat,eletcic}$	= gross annual electric savings due to electric heating system
$\Delta kWh_{heating,\ FAF\ fan}$	= gross annual electric savings to furnace air fan
ΔkWh_{cool}	= gross annual electric cooling due to electric cooling system
$\Delta kWh_{heat,electric}$ /HDD	= gross annual electric heating kWh savings per heating degree day

$\Delta kWh_{heating,\ FAF\ fan}/HDD$	= gross annual electric furnace air fan (FAF) kWh savings per heating degree day at buildings with gas furnaces with electric furnace fans
$\Delta kWh_{cooling}/CDD$	= gross annual electric cooling kWh savings per cooling degree day at buildings with electric cooling
HDD	= Heating Degree Days (base 60°F)
CDD	= Cooling Degree Days (base 65°F)
$Cool_{Adj}$	= Adjustment factor based on nearest weather station for converting heating savings to cooling savings
CF_{summer}	= summer peak coincidence factor
CF_{winter}	= winter peak coincidence factor
$EFLH_{cool}$	= Equivalent full load hours (cooling)
$EFLH_{heat}$	= Equivalent full load hours (heating)
ISR	= in-service rate

10.1.1.3 Input Variables

Table 10-3. Input Variables for Measure Name

Component	Type	Value	Units	Source(s)
HDD	Variable	See Table 19-4 in Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment	Heating Degree Days (HDD)	Table 19-4 is Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment
CDD	Variable	See Table 19-4 using base 65° F in Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment	Cooling Degree Days (CDD)	Table 19-4 is Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment
$Cool_{adj}$	Variable	See Table 10-5	–	See supplementary excel workbook called "2021 Measure Research_Version_1_06082020 – Weatherization 11-5-20.xlsx"
$EFLH_{cool}$	Variable	See Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment	hours	Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment
$EFLH_{heat}$	Variable	See Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment	hours	Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment
$\Delta kWh_{heat,electric}/HDD$	Variable	See Table 10-4.	kWh/HDD	2020 CT PSD pages 236-238, adjusted to Dominion HDD, and incorporating cooling savings by referencing air-sealing measure.
$\Delta kWh_{heating,\ FAF\ fan}/HDD$	Variable	See Table 10-4.	kWh/HDD	2020 CT PSD pages 236-238, adjusted to Dominion HDD, and incorporating cooling savings by referencing air-sealing measure.

Component	Type	Value	Units	Source(s)
$\Delta kWh_{cooling}$ /CDD	Variable	See Table 10-4.	kWh/HDD	2020 CT PSD pages 236-238, adjusted to Dominion HDD, and incorporating cooling savings by referencing air-sealing measure.
CF_{summer}	Fixed	0.69	–	Maryland/Mid-Atlantic TRM v10, p.93[132]
CF_{winter}	Fixed	0.69	–	Maryland/Mid-Atlantic TRM v10, p.93[132]
ISR	Variable	For direct install programs such as Residential Manufactured Housing Program, DSM Phase VIII = 1.0 For kit programs such as Residential Energy Efficiency Kits Program, DSM Phase VIII = 0.87	–	Illinois TRM v8.0 Volume 3, p. 292

Table 10-4. Cooling and Heating kWh/DD Values for Weatherization Types

Weatherization Type	Units	$\Delta kWh_{heat, electric}$/HDD		$\Delta kWh_{heat, FAF fan}$ /HDD	ΔkWh_{cool} /CDD
		Electric Resistance	Heat Pump		
Door sweep	per unit	0.0386	0.0193	0.0017	0.0060
Gasket	per unit	0.0020	0.0010	0.0001	0.0003
Caulk	oz.	0.0052	0.0026	0.0002	0.0008
Foam	in^2	0.0004	0.0002	0.0000	0.0001
Poly tape	linear foot	0.0022	0.0011	0.0001	0.0003
Weather strip	linear foot	0.0026	0.0013	0.0001	0.0004

Table 10-5. $Cool_{Adj}$ Values for each Location

State	Location	$Cool_{Adj}$
MD	Baltimore	0.555
VA	Richmond	0.926
VA	Norfolk	1.488
VA	Roanoke	0.555
VA	Sterling	0.465
VA	Arlington	0.858

132 The Maryland/Mid-Atlantic TRM v10 provides CF for room/wall AC and central AC systems in the ductless mini-split measure. In this section we use the generic value for central AC system. For other HVAC measures in the Maryland/Mid-Atlantic TRM v10, a utility-specific and equipment specific CF is provided. We use the more generic CF categories. There are no generic winter CF. Therefore, we apply summer CF.

State	Location	$Cool_{Adj}$
VA	Charlottesville	0.664
VA	Farmville	0.605
VA	Fredericksburg	0.635
NC	Elizabeth City	2.382
NC	Rocky Mount-Wilson	1.190

10.1.1.4 Default Savings

No default savings will be awarded for this measure if the proper values are not provided in the customer application.

10.1.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 10-6.

Table 10-6. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Energy Efficiency Kits; Residential Manufactured Housing	15.00	years	Iowa TRM 2018 Vol. 2, p. 260[133]

10.1.1.6 Source

The primary source for this deemed savings approach is the 2020 Connecticut Program Savings Documentation (PSD), pp. 236-238. The source for the measure life is the Iowa TRM 2018 Vol. 2, p. 260.

10.1.1.7 Update Summary

Updates to this section are described in Table 10-7.

Table 10-7. Summary of Update(s)

Updates in Version	Update Type	Description
2021		Initial release

[133] Iowa TRM 2018 Vol. 2 p. 260. According to Iowa TRM: “Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007.”

10.2 Domestic Hot Water End Use

10.2.1 Domestic Hot Water Pipe Insulation

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV. The savings are determined using the methodology described in Section 2.1.1.

10.2.2 Faucet Aerator

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV. The savings are determined using the methodology described in Section 2.1.2.

10.2.3 Low-flow Showerhead

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV. The savings are determined using the methodology described in Section 2.1.3.

10.3 Lighting

10.3.1 LED Lamps

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV. The savings are determined using the methodology described in Section 2.3.1.

10.4 Plug Load End Use

10.4.1 Smart Strip

10.4.1.1 Measure Description

This measure is a Tier 1 Advanced Power Strip with a master control socket arrangement to turn off the items plugged into the controlled power-saver sockets when they detect that the appliance plugged into the master control socket has been turned off. Conversely, the appliance plugged into the master control socket has to be turned on and left on for the devices plugged into the power-saver sockets to function.

The assumed baseline is a standard power strip that does not control any of the connected loads.

The efficient case is the use of Tier 1 Advanced Power Strip.

10.4.1.2 Impacts Estimation Approach

Per measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh \quad = kWh \times ESF$$

Per measure, the gross coincident summer peak demand reduction is calculated according to the following equation:

DNV

$$\Delta kW_{summer} = Load \times DSF_{summer}$$

Per measure, the gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = Load \times DSF_{winter}$$

Where:

ΔkWh	= gross annual electric energy savings
ΔkW_{summer}	= gross coincident summer peak demand reduction
ΔkW_{winter}	= gross coincident winter peak demand reduction
kWh	= annual electric energy consumption of devices plugged into power strip
ESF	= proportion of energy saved by power strip
Load	= power strip load, kW
DSF_{summer}	= percent of summer peak demand saved by smart strip
DSF_{winter}	= percent of winter peak demand saved by smart strip

10.4.1.3 Input Variables

Table 10-8. Input Variables for Measure Name

Component	Type	Value	Units	Source(s)
kWh	Variable	See Table 10-9	kWh	Maryland/Mid-Atlantic TRM v10, p. 200
		Default: 449		Unknow install location
ESF	Variable	See Table 10-9	–	Maryland/Mid-Atlantic TRM v10, p. 200[134]
		Default: 0.25		Unknow install location
DSF_{summer}	Variable	See Table 10-9	–	Maryland/Mid-Atlantic TRM v10, p. 200[134]
		Default: 0.19		Unknown install location
DSF_{winter}	Variable	See Table 10-9	–	Maryland/Mid-Atlantic TRM v10, p. 200[134, 135]
		Default: 0.19		Unknown install location
Load	Variable	See Table 10-9	kW	Maryland/Mid-Atlantic TRM v10, p. 200
		Default: 0.052		Unknow install location

The calculation inputs are based on the installation location. This measure is the only measure initially shipped to participants. All smart strips will be considered to have an Unknown/Other installation location. If the participant

[134] The ESF incorporates the in-service rate (ISR and realization rates (RR) from field studies.
[135] No winter peak DSF in the source TRM, so summer peak DSF is used

responds to a follow-up survey and provides an install location, savings will be applied appropriately. The values in the following table incorporate an install rate and realization rates based on impact evaluations according to the Maryland/Mid-Atlantic TRM v10.

Table 10-9. Input Values Based on Install Location

Install Location	kWh	ESF	DSF_{summer}	DSF_{winter}	Load, kW
Home entertainment system	471	0.27	0.20	0.20	0.058
Home office	399	0.21	0.18	0.18	0.038
Unknow/Other[136] (default)	449	0.25	0.19	0.19	0.052

10.4.1.4 Default Savings

The default gross annual electric energy savings per unit will be assigned according to the following calculation:

$$\Delta kWh = kWh \times ESF$$

$$= 449 \times 0.25$$

$$= 112.25\ kWh$$

The default gross summer peak demand reduction per unit will be assigned according to the following calculation:

$$\Delta kW_{summer} = Load \times DSF_{summer}$$

$$= 0.052 \times 0.19$$

$$= 0.0098\ kW$$

The default gross winter peak demand reduction per unit will be assigned according to the following calculation:

$$\Delta kW_{winter} = Load \times DSF_{winter}$$

$$= 0.052 \times 0.19$$

$$= 0.0098\ kW$$

[136] In some instances, a participant may report that the smart strip was not installed when/if they are surveyed at a later time. In these cases, the "Unknown/Other" installation location will be applied. This is because the savings values already incorporate an installation rate and it is still possible that the smart strip will be installed after the survey is completed.

10.4.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 10-10.

Table 10-10. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Energy Efficiency Kits	5.00	years	Maryland/Mid-Atlantic TRM v10, p. 200

10.4.1.6 Source

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v10, pp. 199-201.

10.4.1.7 Update Summary

Updates to this section are described in Table 10-11.

Table 10-11. Summary of Update(s)

Updates in Version	Update Type	Description
2021		Initial release

11 RESIDENTIAL MANUFACTURED HOUSING PROGRAM, DSM PHASE VIII

The Residential Manufactured Housing Program provides residential customers in manufactured housing with educational assistance and an incentive to install energy efficiency measures.

The measures offered through the program and the sections that contain the savings algorithms for each measure are presented in Table 11-1.

Table 11-1. Residential Manufactured Housing Program Measure List

End Use	Measure	Legacy Program	Manual Section
Leak Repair	Air Sealing	-	Section 11.1.1
	Building Insulation	Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 2.2.1
	Cool Roof	Residential Home Energy Assessment Program, DSM Phase VII	Section 5.1.1
	Weatherization	Residential Energy Efficiency Kits Program, DSM Phase VIII	Section 10.1.1
Domestic Hot Water	Domestic Hot Water Tank Wrap	–	Section 11.2.1
	Domestic Hot Water Pipe Insulation	Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 2.1.1
	Heat Pump Domestic Water Heater	Residential Home Energy Assessment Program, DSM Phase VII	Section 5.2.2
	Faucet Aerator	Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 2.1.2
	Low-Flow Showerhead	Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 2.1.3
	Water Heater Temperature Setback/Turndown	Residential Home Energy Assessment Program, DSM Phase VII	Section 5.2.5
HVAC	AC Cover for Wall/Window Unit	–	Section 11.3.1
	Digital Switch Plate Wall Thermometer	–	Section 11.3.2
	Duct Testing & Sealing	Residential Home Energy Assessment Program, DSM Phase VII	Section 5.3.5
	ECM Fan Motors	Residential Home Energy Assessment Program, DSM Phase VII	Section 5.3.3
	Filter Replacement	–	Section 11.3.5
	Heat Pump Tune-up	Residential Home Energy Assessment Program, DSM Phase VII	Section 5.3.2
	Heat Pump Upgrade	Residential Home Energy Assessment Program, DSM Phase VII	Section 5.3.1
Lighting	LED Lamps	Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 2.3.1

End Use	Measure	Legacy Program	Manual Section
Plug-Load/ Appliances	Refrigerator	Residential Efficient Products Marketplace Program, DSM Phase VII	Section 6.2.7

11.1 Building Envelope End Use

11.1.1 Air Sealing

11.1.1.1 Measure Description

This measure involves thermal shell air leak sealing through strategic use and location of air-tight materials. Leaks are detected and leakage rates measured with the assistance of a blower-door. Prescriptive savings are provided for use only where a blower door test is not possible (for example in large multifamily buildings).

The existing air leakage should be determined through approved and appropriate test methods using a blower door. The baseline condition of a building upon first inspection significantly impacts the opportunity for cost-effective energy savings through air-sealing. Air sealing materials and diagnostic testing should meet all eligibility program qualification criteria. The initial and final tested leakage rates should be performed in such a manner that the identified reductions can be properly discerned, particularly in situations wherein multiple building envelope measures may be implemented simultaneously.

This measure is offered through different programs listed in Table 6-13 and uses the impacts estimation approach described in this section.

Table 11-2. Programs that Offer Air Sealing

Program Name	Section
Residential Manufactured Housing Program, DSM Phase VIII	Section 11.1.1
Residential Home Retrofit Program, DSM Phase VIII	Section 12.1.1
Residential/Non-Residential Multifamily Program, DSM Phase VIII	Section 13.1.1
Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII	Section 16.1.1

11.1.1.2 Impacts Estimation Approach

Per measure, the gross annual electric energy savings are calculated according to the following equations:

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat,electric} + \Delta kWh_{heating,FAF}$$

If space cooling is provided, then ΔkWh_{cool} follows the equation below; otherwise ΔkWh_{cool} is zero.

$$\Delta kWh_{cool} = \frac{(cfm50_{base} - cfm50_{ee}) \times 60\frac{min}{hr} \times 24\frac{hr}{day} \times CDD \times DUA \times 0.018\frac{Btu}{ft^3 \cdot °F} \times LM}{N_{cool} \times SEER \times 1{,}000\frac{Btu}{kBtu}}$$

If electric heating is provided, then ΔkWh_{heat} follows the equation below, otherwise ΔkWh_{heat} is zero.

$$\Delta kWh_{heat} = \frac{(cfm50_{base} - cfm50_{ee}) \times 60\frac{min}{hr} \times 24\frac{hr}{day} \times HDD \times 0.018\frac{Btu}{ft^3 \cdot °F}}{N_{heat} \times COP \times DE \times 3{,}412\frac{kWh}{Btu}}$$

If a forced air furnace (FAF)[137] provides heat, then $\Delta kWh_{heating,FAF}$ follows the equation below, otherwise $\Delta kWh_{heating,FAF}$ is zero.

$$\Delta kWh_{heating,FAF} = \frac{(cfm50_{base} - cfm50_{ee}) \times 60\frac{min}{hr} \times 24\frac{hr}{day} \times HDD \times 0.018\frac{Btu}{ft^3 \cdot °F} \times ESF_{FAF}}{N_{heat} \times AFUE \times DE \times 3{,}412\frac{kWh}{Btu}}$$

Per measure, the gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{\Delta kWh_{cool}}{EFLH_{cool}} \times CF_{summer}$$

Per measure, the gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh_{heat} + \Delta kWh_{heating,FAF}}{EFLH_{heat}} \times CF_{winter}$$

Where:

ΔkWh	= gross annual electric energy savings
ΔkWh_{cool}	= per measure gross annual electric cooling energy savings
ΔkWh_{heat}	= per measure gross annual electric heating energy savings
$\Delta kWh_{heating,\ FAF\ fan}$	= gross annual electric savings to furnace air fan, if furnace air fan is present and affected by measure
ΔkW_{summer}	= summer gross coincident demand reduction
ΔkW_{winter}	= winter gross coincident demand reduction
$cfm50_{base}$	= existing infiltration at 50 Pascals as measured by blower door before air sealing
$cfm50_{ee}$	= new infiltration at 50 Pascals as measured by blower door before air sealing
CDD	= Cooling Degree Days (base 65°F)
HDD	= Heating Degree Days (base 60°F)
DUA	= Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it

[137] If the application cooling system type is cooling system type is Central AC or Packaged System AC and the heating fuel type is non-electric, the heating system is assumed to be a FAF.

DNV

LM	= Latent Multiplier to account for latent cooling demand
N_{cool}	= cooling conversion factor from leakage at 50 Pascal to leakage at natural conditions
N_{heat}	= heating conversion factor from leakage at 50 Pascal to leakage at natural conditions
SEER	= efficiency of cooling system, Seasonal Energy Efficiency Ratio (SEER)
COP	= efficiency of heating system, coefficient of performance (effective COP estimate = HSPF/3.413)
ESF_{FAF}	= furnace fan energy consumption as a percentage of annual fuel consumption
AFUE	= efficiency of gas furnace, Annual Fuel Utilization Efficiency
DE	= Distribution Efficiency (accounts for duct leakage in systems with ducts)
$EFLH_{cool}$	= Equivalent Full Load Hours (cooling)
CF_{summer}	= summer Coincidence Factor
CF_{winter}	= winter Coincidence Factor

11.1.1.3 Input Variables

Table 11-3. Input Variables for Measure Name

Component	Type	Value	Units	Source(s)
$cfm50_{base}$	Variable	See customer application	ft^3/min	Customer application
		For Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII default = 3,280		Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII participant data[138]
$cfm50_{ee}$	Variable	See customer application	ft^3/min	Customer application
		For Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII default = 2,495		Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII participant data[138]
CDD	Variable	See Table 19-4 in Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment	Cooling degree days (CDD)	Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment
HDD	Variable	See Table 19-4 in Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment	Heating Degree Days (HDD)	Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment
DUA	Fixed	0.75	–	IL TRM 2020 v8, Vol. 3. p. 286[139]

[138] DNV reviewed 2021 participant data to assess the default values. The default is the average $cfm50_{base}$ and $cfm50_{ee}$ for 117 participants, respectively.

[139] IL TRM 2020 v8, Vol. 3. p. 286. Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p. 31

Component	Type	Value	Units	Source(s)
LM	Variable	See Table 11-4	Btu/°F	See supplementary Excel workbook called “Latent Factor Calculation – 9-16-20.xlsx”
N_{cool}	Variable	See Table 11-5, for default use single story	–	See supplementary Excel workbook called “N_cool N_heat calcs 9-16-20.xlsx”, default based on conservative savings estimate
N_{heat}	Variable	See Table 11-6, for default use single story	–	See supplementary Excel workbook called “N_cool N_heat calcs 9-16-20.xlsx”, default based on conservative savings estimate
SEER[140]	Variable	For residential programs see Table 19-9. Residential Baseline and Efficient HVAC Equipment Efficiency Ratings and Table 19-10 Room Air Conditioner Federal Standard and ENERGY STAR® Minimum Efficiency For Non-Residential Programs see the Non-Residential Technical Reference Manual, Sub-Appendix F2-III: Non-Residential HVAC Equipment Efficiency Ratings.	kBtu/kWh	See baseline efficiencies in Sub-Appendix F1-V: Residential HVAC Equipment Efficiency Ratings Non-Residential Technical Reference Manual Sub-Appendix F2-III: Non-Residential HVAC Equipment Efficiency Ratings
COP	Variable	For residential programs see Table 19-9. Residential Baseline and Efficient HVAC Equipment Efficiency Ratings For Non-Residential Programs see the Non-Residential Technical Reference Manual Sub-Appendix F2-III: Non-Residential HVAC Equipment Efficiency Ratings.	–	See baseline efficiencies in Sub-Appendix F1-V: Residential HVAC Equipment Efficiency Ratings Non-Residential Technical Reference Manual Sub-Appendix F2-III: Non-Residential HVAC Equipment Efficiency Ratings
DE	Variable	Non-ducted systems (ductless mini-split or electric resistance heat): 1.0 Ducted systems (all other types): 0.85[141]	–	IL TRM 2020 v8, Vol. 3, p. 288
AFUE	Variable	See baseline efficiencies in Sub-Appendix F1-V: Residential HVAC Equipment Efficiency Ratings: Table 19-9	–	Sub-Appendix F1-V: Residential HVAC Equipment Efficiency Ratings

140 For Equipment types that don't have SEER values, other efficiency values are applied. For room air conditioners use CEER. For Nonresidential equipment types IEER may be applied.

141 IL TRM 2020 v8, Vol. 3. p. 288. Also, average duct system efficiency for heating season for CZ4-5 is 0.854 according to this BPI document, accessed 10/13/20: http://www.bpi.org/sites/default/files/Guidance%20on%20Estimating%20Distribution%20Efficiency.pdf

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Component	Type	Value	Units	Source(s)
ESF_{FAF}	Fixed	0.0314[142]	–	IL TRM 2020 v8, Vol. 3, p. 346
$EFLH_{cool}$	Variable	For residential programs see Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment For Non-Residential Programs see the Non-Residential TRM Sub-Appendix F2-II: Non-Residential HVAC Equivalent Full Load Hours	hours	Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment
CF_{summer}	Fixed	0.69	–	Maryland/Mid-Atlantic TRM v10, p.93[143]
CF_{winter}	Fixed	0.69	–	Maryland/Mid-Atlantic TRM v10, p. 93[143]

Table 11-4. Latent Multiplier (LM) Values

State	Location	LM
MD	Baltimore	1.75
VA	Richmond	1.81
VA	Norfolk	2.02
VA	Roanoke	1.74
VA	Sterling	1.79
VA	Arlington	1.82
VA	Charlottesville	1.81
VA	Farmville	1.71
VA	Fredericksburg	1.77
NC	Elizabeth City	2.12
NC	Rocky Mount	1.76

Table 11-5. N_{cool} Values

State	Location	N_{cool} (by # of stories)			
		1 (default)	1.5	2	3+
MD	Baltimore	45.0	38.6	29.7	19.6

142 IL TRM 2020 v8, Vol. 3. p. 346. According to IL TRM: "ESF_{FAF} is not one of the AHRI certified ratings provided for residential furnaces, but can be estimated from a calculation based on the certified values for fuel energy (E_f in MMBtu/yr.) and E_{ae} (kWh/yr.). An average of a 300-record sample (non-random) out of 1495 was 3.14%. This is, appropriately, ~50% greater than the ENERGY STAR version 3 criteria for 2% ESF_{FAF}"

143 The same CF as the other HVAC measures are used for consistency. This measure is expected to have a similar savings profile. The Maryland/Mid-Atlantic TRM v10 provides CF for central AC systems in the ductless mini-split measure. In other measures in the Maryland/Mid-Atlantic TRM v10 a utility-specific and equipment specific CF is provided. We use the more generic CF. There are no generic winter CF. Therefore, we apply summer CF.

State	Location	N_{cool} (by # of stories)			
		1 (default)	1.5	2	3+
VA	Richmond	40.0	34.3	26.4	17.4
VA	Norfolk	32.4	27.8	21.4	14.1
VA	Roanoke	47.2	40.5	31.1	20.6
VA	Sterling	49.3	42.3	32.5	21.5
VA	Arlington	37.8	32.4	25.0	16.5
VA	Charlottesville	57.8	49.6	38.1	25.2
VA	Farmville	66.7	57.2	44.0	29.1
VA	Fredericksburg	47.2	40.5	31.1	20.6
NC	Elizabeth City	35.8	30.7	23.6	15.6
NC	Rocky Mount	56.4	48.4	37.3	24.6

Table 11-6. N_{heat} Values

State	Location	N_{heat} (by # of stories)			
		1 (default)	1.5	2	3+
MD	Baltimore	25.7	22.1	17.0	11.2
VA	Richmond	26.0	22.3	17.2	11.3
VA	Norfolk	22.8	19.6	15.1	9.9
VA	Roanoke	27.2	23.3	18.0	11.9
VA	Sterling	27.5	23.6	18.1	12.0
VA	Arlington	23.8	20.4	15.7	10.4
VA	Charlottesville	33.1	28.4	21.8	14.4
VA	Farmville	35.9	30.8	23.7	15.7
VA	Fredericksburg	27.5	23.6	18.1	12.0
NC	Elizabeth City	26.6	22.8	17.6	11.6
NC	Rocky Mount	36.4	31.2	24.0	15.8

11.1.1.4 Default Savings

No default savings will be awarded for this measure if the proper values are not provided in the customer application.

11.1.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 11-7.

Table 11-7. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Manufactured Housing Program, DSM Phase VIII	15.00	years	Iowa TRM 2016 Vol. 2 p. 241[144]
	Residential Home Retrofit Program, DSM Phase VIII			
	Residential/Non-Residential Multifamily Program, DSM Phase VIII			
	Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII			

11.1.1.6 Source

The primary source for this savings approach is the IL TRM 2020 v8, Vol. 3. pp. 284-297. Weather dependent factors such as LM, N_{cool}, and N_{heat} were updated to be reflective of local conditions. Factors were update to the source for the measure life is the Iowa TRM 2016 Vol.2 pp. 241.

11.1.1.7 Update Summary

Updates to this section are described in Table 11-8.

Table 11-8. Summary of Update(s)

Updates in Version	Update Type	Description
2021		Initial release

11.1.2 Building Insulation

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program. The savings are determined using the methodology described in Section 2.2.1.

11.1.3 Cool Roof

This measure is also provided by the Residential Home Energy Assessment Program. For this program, this measure is only applicable for Mobile Homes and Modular Homes. The savings are determined using the methodology described in Section 5.1.1.

[144] Iowa TRM 2018 Vol. 2 p. 260. According to Iowa TRM: "Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007"

11.1.4 Weatherization

This measure is also provided by the Residential Energy Efficiency Kits Program, DSM Phase VIII. The savings are determined using the methodology described in Section 10.1.1.

11.2 Domestic Hot Water End Use

11.2.1 Domestic Hot Water Tank Wrap

11.2.1.1 Measure Description

This measure involves applying insulation wrap (insulation blanket) on the domestic hot water (DHW) tank. Insulating DHW tanks reduce the standby heat losses and thus reduces the heating cost. This measure applies only for homes that have an electric water heater that is not already well insulated.

The baseline condition is a standard electric domestic hot water tank without an additional tank wrap. The efficient condition is the same standard electric domestic hot water tank with an additional tank wrap.

11.2.1.2 Impacts Estimation Approach

Per measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \frac{(R_{base} - R_{ee}) \times Area \times \Delta T \times HOU}{3{,}412 \frac{Btu}{kWh} \times \eta_{DHW}}$$

The Area is calculated according to the following equation[145]:

$$Area = -0.0017 \times capacity^2 + 0.437 \times capacity + 7.831$$

Per measure, the gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \Delta kWh / HOU \times CF_{summer}$$

Per measure, the gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \Delta kWh / HOU \times CF_{winter}$$

Where:

ΔkWh	= gross annual electric energy savings
ΔkW	= gross coincident demand reduction
Capacity	= tank storage volume
Area	= surface area of storage tank prior to adding tank wrap

[145] Maryland/Mid-Atlantic TRM v10, p.141 provides areas for specific tank volume sizes. This equation is based on areas and tank volumes provided.

ΔT	= average temperature difference between tank water and outside air temperature (F)
HOU	= number of hours in a year (since savings are assumed to be constant over a year)
η_{DHW}	= recovery efficiency of electric hot water heater
R_{base}	= measure of resistance to heat flow prior to adding tank wrap
R_{ee}	= measure of resistance to heat flow after addition of tank wrap

11.2.1.3 Input Variables

Table 11-9: Input Variables for Domestic Hot Water Tank Wrap

Component	Type	Value	Units	Source(s)
Capacity	Variable	See customer application	gal	Customer application
		48.3		Dominion Residential Home Energy Use Survey 2019 - 2020 Appendix B, p. 37[146]
HOU	Fixed	8,760	hr	Maryland/Mid-Atlantic TRM v10, p.142
ΔT	Fixed	60	F	Maryland/Mid-Atlantic TRM v10, p.142
R_{base}	Fixed	8	hr·°F·ft2/Btu	Maryland/Mid-Atlantic TRM v10, p.142
R_{ee}	Fixed	18	hr·°F·ft2/Btu	Maryland/Mid-Atlantic TRM v10, p.142
η_{DHW}	Fixed	0.98	–	Maryland/Mid-Atlantic TRM v10, p.142
CF_{summer}	Fixed	1.0	–	Mid-Atlantic TRM v9, p. 187[147]
CF_{winter}	Fixed	1.0	–	Mid-Atlantic TRM v9, p. 187[147]

11.2.1.4 Default Savings

The default gross annual electric energy savings per unit will be assigned according to the following calculation. If tank specifics are unknown assume 48.3 gallons and the measure savings were resulted from adding R-10 to a poorly insulated R-8 tank.

$$Area = -0.0017 \times capacity^2 + 0.437 \times capacity + 7.831$$

$$= -0.0017 \times 48.3^2 + 0.437 \times 48.3 + 7.831$$

[146] The weighted average tank volumes is used

[147] Mid-Atlantic TRM v9 does not provide a CF, therefore a CF of 1.0 is implied.

$$= 24.97\ kWh$$

$$\Delta kWh = Area \times \left(\frac{1}{R_{base}} - \frac{1}{R_{ee}}\right) \times HOU \times \Delta T \ / \left((3{,}412 \frac{Btu}{kWh} \times \eta_{DHW} \right)$$

$$= 24.97 \times \left(\frac{1}{8.0} - \frac{1}{18.0}\right) \times 60 \times 8760/(3412 \times 0.98)$$

$$= 253\ kWh$$

The default gross summer peak demand reduction per unit will be assigned according to the following calculation:

$$\Delta kW_{summer} = (\Delta kWh/\ 8760) \times CF_{summer}$$

$$= 253/8760 \times 1.0$$

$$= 0.029\ kW$$

The default gross winter peak demand reduction per unit will be assigned according to the following calculation:

$$\Delta kW_{winter} = (\Delta kWh/\ 8760) \times CF_{winter}$$

$$= 253/8760 \times 1.0$$

$$= 0.029\ kW$$

11.2.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 11-10.

Table 11-10. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Manufactured Housing Program, DSM Phase VIII	5.00	years	Maryland/Mid-Atlantic TRM v10, p.144

11.2.1.6 Source

The primary source for this deemed savings approach is Maryland/Mid-Atlantic TRM v10, pp. 141-144.

DNV

11.2.1.7 Update Summary

Updates to this section are described in Table 11-11.

Table 11-11. Summary of Update(s)

Version	Update Type	Description
2021		Initial release

11.2.2 Domestic Hot Water Pipe Insulation

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV. The savings are determined using the methodology described in Section 2.1.1.

11.2.3 Heat Pump Domestic Water Heater

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings are determined using the methodology described in Section 5.2.2.

11.2.4 Faucet Aerator

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV. The savings are determined using the methodology described in Section 2.1.2.

11.2.5 Low-flow Showerhead

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV. The savings are determined using the methodology described in Section 2.1.3.

11.2.6 Water Heater Temperature Setback/Turndown

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings are determined using the methodology described in Section 5.2.5.

11.3 Heating, Ventilation, Air-Conditioning End Use

11.3.1 AC Cover for Wall/Window Unit

11.3.1.1 Measure Description

This measure covers the installation of a rigid, insulated cover installed on the inside of a room air conditioner (RAC) and a cover or sealing on the gap surrounding the unit. The cover is designed for RAC units, which are comprised of window air conditioners and through-the-wall air conditioners, left in place throughout the heating season and reduces heating load by limiting the infiltration of cold outside air. The building staff shall be instructed on proper annual removal and reinstallation to ensure persistence of savings.

DNV

11.3.1.2 Impacts Estimation Approach

Per measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \frac{1.08 \times cfm \times EFLH}{Eff_{heating} \times 3{,}412}$$

Per measure coincident summer peak demand reduction is zero because the energy saving happens in the heating season:

$$\Delta kW_{summer} = 0.0$$

Per measure summer coincident winter peak demand reduction is zero because the energy saving happens in the heating season:

$$\Delta kW_{winter} = 0.0$$

Where:

ΔkW_{winter} = per measure gross winter coincident demand reduction
cfm = cubic foot per minute on the gap surrounding the unit
$EFLH_{heat}$ = equivalent full-load hours for heating
$Eff_{heating}$ = efficiency of heating system

11.3.1.3 Input Variables

Table 11-12. Input Values for AC Cover Savings Calculations

Component	Type	Value	Units	Sources
cfm	Fixed	19	cubic foot per minute	New York TRM 2019, p. 49[148]
$EFLH_{heat}$	Variable	See Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment	hours	Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment
$Eff_{heating}$	Fixed	1	–	New York TRM v72019, p. 49[149]

11.3.1.4 Default Savings

If the proper values are not supplied, a default savings may be applied using conservative input values.

148 New York TRM v72019, page 49. Cubic foot per minute (CFM) is based on a negative pressure differential of 10 Pa
149 New York TRM v72019, page 49. For electric resistance heat, use a value of 1.0.

The default per measure gross annual electric energy savings will be assigned according to the following calculation: (e.g., for residential homes in Virginia, with Room AC and electric baseboard heating):

In Virginia:

$$\Delta kWh = \frac{1.08 \times CFM \times EFLH}{Eff_{heating} \times 3{,}412}$$

$$= \frac{1.08 \times 19 \times 519}{1 \times 3{,}412}$$

$$= 3.12\ kWh$$

11.3.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 11-13

Table 11-13. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Manufactured Housing	15.00	years	New York StateTRM_2019, p. 771

11.3.1.6 Source(s)

The primary source for this deemed savings approach is the New York TRM 2019, pp. 48-52 and p. 771. Other assumptions such as heating/cooling full load hours and temperature differences are based on NOAA TMY data estimations.

11.3.1.7 Update Summary

Updates to this section are described in Table 11-14. Summary of Update(s).

Table 11-14. Summary of Update(s)

Version	Update Type	Description
2021		Initial release

11.3.2 Digital Switch Plate Wall Thermometer

This measure does not have savings that have been validated by technical resource manuals or other secondary resources. While some savings may be realized at individual households, deemed savings are not attributed to this measure.

11.3.3 Duct Testing & Sealing

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings are determined using the methodology described in Section 5.3.5.

11.3.4 ECM Fan Motor

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings are determined using the methodology described in 5.3.3.

11.3.5 Filter Replacement

11.3.5.1 Measure Description

An air filter on a central forced air (heating) system is replaced prior to the end of its useful life with a new filter, resulting in a lower pressure drop across the filter. As filters age, the pressure drop increases as filtered medium accumulates. Replacing filters before they reach the point of becoming ineffective can save energy by reducing the pressure drop required by filtration, subsequently reducing the load on the blower motor.

If a HVAC tune up measure is performed, this measure will not receive energy savings. The tune up measure will incorporate savings for a filter replacement.

11.3.5.2 Impacts Estimation Approach

Per measure, gross annual electric energy savings are calculated according to the following equation:

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

$$\Delta kWh_{cool} = EFLH_{cool} \times kW_{motor} \times ESF \times ISR$$

$$\Delta kWh_{heat} = EFLH_{heat} \times kW_{motor} \times ESF \times ISR$$

Per measure coincident summer peak demand reduction is zero because the energy saving happens in the heating season:

$$\Delta kW_{summer} = \Delta kWh_{cool} \div EFLH_{cool} \times CF_{summer}$$

Per measure coincident summer peak demand reduction is zero because the energy saving happens in the heating season:

$$\Delta kW_{winter} = \Delta kWh_{heat} \div EFLH_{heat} \times CF_{winter}$$

Where:

ΔkW_{winter} = per measure gross winter coincident demand reduction

$EFLH_{cool}$	= equivalent full-load hours for cooling
$EFLH_{heat}$	= equivalent full-load hours for heating
kW_{motor}	= average motor full load electric demand
ESF	= energy savings factor
ISR	= in-service rate
CF_{summer}	= summer coincidence factor
CF_{winter}	= winter coincidence factor

11.3.5.3 Input Variables

Table 11-15. Input Values for AC Cover Savings Calculations

Component	Type	Value	Units	Sources
kW_{motor}	Fixed	0.377	kW	Pennsylvania TRM 2019, p. 45
$EFLH_{cool}$	Variable	See Table 19-5 in Sub-Appendix F1-I: Cooling and Heating Degree Days and Hours	hours, annual	Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment
$EFLH_{heat}$	Variable	See Table 19-5 in Sub-Appendix F1-I: Cooling and Heating Degree Days and Hours	hours, annual	Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment
ESF	Fixed	0.15	–	Pennsylvania TRM, 2019, p. 45
ISR	Fixed	0.15	–	Pennsylvania TRM 2019, p. 45
CF_{summer}	Fixed	0.31	–	Maryland/Mid-Atlantic TRM v10, p. 126
CF_{winter}	Fixed	0.31	–	Maryland/Mid-Atlantic TRM v10, p. 126[150]

11.3.5.4 Default Savings

If the proper values are not supplied, a default savings may be applied using conservative input values.

The default per measure gross annual electric energy savings will be assigned according to the following calculation: (e.g., for residential homes in Virginia, with central cooling and gas heating):

In Virginia:

$$\Delta kWh = EFLH_{cool} \times kW_{motor} \times EI \times ISR + EFLH_{heat} \times kW_{motor} \times EI \times ISR$$

$$= 765 \times 0.377 \times 0.15 \times 0.15 + 519 \times 0.377 \times 0.15 \times 0.15$$

[150] The source TRM does not include a winter CF. Therefore, we use the summer CF.

$$= 10.89\ kWh$$

$$\Delta kW_{summer} = \Delta kWh_{cool} \div EFLH_{cool} \times CF_{summer}$$

$$= 6.48 \div 765 \times 0.31$$

$$= 0.003\ kW$$

$$\Delta kW_{winter} = \Delta kWh_{heat} \div EFLH_{heat} \times CF_{winter}$$

$$= 4.40 \div 519 \times 0.31$$

$$= 0.003\ kW$$

11.3.5.5 Effective Useful Life

The effective useful life of this measure is provided in Table 11-16.

Table 11-16. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Manufactured Housing	5.00	years	Pennsylvania TRM 2019, p. 45

11.3.5.6 Source(s)

The primary source for this deemed savings approach is Pennsylvania TRM 2019, p. 45. Other assumptions such as heating/cooling full load hours and temperature differences are based on NOAA TMY data estimations.

11.3.5.7 Update Summary

Updates to this section are described in Table 11-17. Summary of Update(s).

Table 11-17. Summary of Update(s)

Updates in Version	Update Type	Description
2021		Initial release

11.3.6 HVAC Tune-Up

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings are determined using the methodology described in Section 5.3.2.

11.3.7 HVAC Upgrade

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings are determined using the methodology described in Section 5.3.1.

11.3.8 Smart Thermostat Installation

This measure is also provided by the Residential Thermostat (Energy Efficiency) Program. The savings are determined using the methodology described in Section 7.2.1.

11.4 Lighting

11.4.1 LED Lamps

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV. The savings are determined using the methodology described in Section 2.3.1.

11.5 Plug Load/Appliance End Use

11.5.1 ENERGY STAR Refrigerator

This measure is also provided by the Residential Efficient Products Marketplace Program, DSM Phase VII. The savings are determined using the methodology described in Section 6.2.7.

12 RESIDENTIAL HOME RETROFIT PROGRAM, DSM PHASE VIII

The Residential Home Retrofit Program would target high users of electricity within the Company's Virginia service territory with an incentive to conduct a comprehensive and deep whole house diagnostic home energy assessment by BPI certified whole house building technicians. The Program will provide rebate incentives for the installation of specific measures recommended as cost-effective by the Program's approved modeling software.

The measures offered through the program and the sections that contain the savings algorithms for each measure are presented in Table 12-1.

Table 12-1. Home Energy Assessment Program Measure List

End Use	Measure	Legacy Program	Manual Section
Building Envelope	Air Sealing	–	Section 11.1.1
	Building Insulation	Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 2.2.1
Domestic Hot Water	Domestic Hot Water Pipe Insulation	Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 2.1.1
	Faucet Aerator	Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 12.2.2
	Heat Pump Domestic Water Heater	Residential Home Assessment Program, DSM Phase VII	Section 5.2.2
	Low-Flow Showerhead	Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 2.1.3
	Water Heater Temperature Setback/Turndown	Residential Home Assessment Program, DSM Phase VII	Section 5.2.5
Plug-Load Appliances	Clothes Washer	Residential Efficient Products Marketplace Program, DSM Phase VII	Section 6.2.2
	Clothes Dryer	Residential Efficient Products Marketplace Program, DSM Phase VII	Section 6.2.3
	ENERGY STAR Refrigerator	Residential Efficient Products Marketplace Program, DSM Phase VII	Section 6.2.7
HVAC	HVAC Upgrade	Residential Home Energy Assessment Program, DSM Phase VII	Section 5.3.1
	HVAC Tune-Up	Residential Home Energy Assessment Program, DSM Phase VII	Section 5.3.2
	Duct Sealing	Residential Home Energy Assessment Program, DSM Phase VII	Section 5.3.5
	ECM Fan Motor	Residential Home Energy Assessment Program, DSM Phase VII	Section 5.3.3
	Duct Insulation	Residential Home Energy Assessment Program, DSM Phase VII	Section 5.3.4
	Smart Thermostat Installation	Residential Thermostat (Energy Efficiency) Program, DSM Phase VIII	Section 7.2.1
Whole Building	Central Home Energy Management System	–	Section 12.5.1

End Use	Measure	Legacy Program	Manual Section
Lighting	LED Lamps	Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 2.3.1

12.1 Building Envelope End Use

12.1.1 Air Sealing

This measure is also provided by the Residential Manufactured Housing Program, DSM Phase VIII. The savings are determined using the methodology described in Section 11.1.1.

12.1.2 Building Insulation

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV. The savings are determined using the methodology described in Section 2.2.1.

12.2 Domestic Hot Water End Use

12.2.1 Domestic Hot Water Pipe Insulation

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV. The savings are determined using the methodology described in Section 2.1.1.

12.2.2 Faucet Aerator

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV. The savings are determined using the methodology described in Section 2.1.2.

12.2.3 Heat Pump Domestic Water Heater

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings are determined using the methodology described in Section 5.2.2.

12.2.4 Low-flow Showerhead

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV. The savings are determined using the methodology described in Section 2.1.3.

12.2.5 Water Heater Temperature Setback/Turndown

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings are determined using the methodology described in Section 5.2.5.

12.3 Plug Load/Appliance End Use

12.3.1 Clothes Washer

This measure is also provided by the Residential Efficient Products Marketplace Program, DSM Phase VII. The savings are determined using the methodology described in Section 6.2.2.

12.3.2 Clothes Dryer

This measure is also provided by the Residential Efficient Products Marketplace Program, DSM Phase VII. The savings are determined using the methodology described in Section 6.2.3.

12.3.3 ENERGY STAR Refrigerator

This measure is also provided by the Residential Efficient Products Marketplace Program, DSM Phase VII. The savings are determined using the methodology described in Section 6.2.7.

12.4 Heating, Ventilation, Air-Conditioning End Use

12.4.1 HVAC Upgrade

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings are determined using the methodology described in Section 5.3.1.

12.4.2 HVAC Tune-Up

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings are determined using the methodology described in Section 5.3.2.

12.4.3 Duct Sealing

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings are determined using the methodology described in Section 5.3.5.

12.4.4 ECM Fan Motor

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings are determined using the methodology described in Section 5.3.3.

12.4.5 Duct Insulation

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings are determined using the methodology described in Section 5.3.4.

12.4.6 Smart Thermostat Installation

This measure is also provided by the Residential Thermostat (Energy Efficiency) Program, DSM Phase VIII. The savings are determined using the methodology described in Section 7.2.1.

12.5 Whole Building End Use

12.5.1 Central Home Energy Management System

12.5.1.1 Measure Description

This measure includes home energy monitor, smart plug, connected LED and motion sensor. The home energy monitor has reporting functionality that impacts customer behaviour to save energy. The device can see baseline “always on” energy use, notify customers of specific loads and give alarms. The smart plug is a connected plug that can be used for lighting or appliances. These devices allow for remote controlling and scheduling. Connected LED is a connected lamp with a hub that allows for remote controlling and scheduling. The smart hub with motion sensor controls connected appliances or lighting based on occupancy or remote control.

For all components included in this measure, the baseline in the absence of the control or monitoring device.

12.5.1.2 Impacts Estimation Approach

This measure is not a standard TRM measure. Therefore, we leverage several sources and make assumptions about related measures that are in TRMs. The energy monitor saves use a savings factor that was derived from DTE Insight: Energy Bridge Electrical Savings White Paper, which studied the impact of the technology. The smart plug assumes savings will be similar to a smart strip plug (also in Section 10.4.1). The motion sensor assume energy savings will be like a lighting occupancy sensor.

Per account, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \Delta kWh_{monitor} + \Delta kWh_{smart\ plug} + \Delta kWh_{LED} + \Delta kWh_{motion\ sensor}$$

The energy savings for each component are calculated as follows:

$$\Delta kWh_{monitor} = \left(kWh_{whole,house} - \Delta kWh_{all\ measures}\right) \times ESF_{monitor} \times PF_{monitor}$$

$$\Delta kWh_{smart\ plug} = \left(kWh_{office} \times office + kWh_{ent} \times ent\right) \times ISR_{smart\ plug}$$

$$\Delta kWh_{LED} = \frac{W_{base}}{1{,}000\ W/kW} \times HOU \times ESF_{LED} \times ISR_{LED} \times \left(WHF_{heat} + \left(WHF_{cool} - 1\right)\right) - kWh_{standby}$$

$$\Delta kWh_{motion\ sensor} = kW_{connected} \times HOU \times ESF_{motion\ sensor} \times ISR_{motion\ sensor} \times \left(WHF_{heat} + (WHF_{cool} - 1)\right)$$

The summer gross coincident demand reduction is assumed to be zero for the energy monitor. For the other components, the following equations are used to calculate the summer gross coincident demand reduction measure:

$$\Delta kW_{smart\ plug,\ summer} = \frac{\Delta kWh_{smart\ plug}}{HOU_{standby}} \times CF_{smart\ plug,summer}$$

$$\Delta kW_{LED,\ summer} = \frac{W_{base}}{1{,}000\ W/kW} \times DSF_{LED} \times ISR_{LED} \times WHF_{LED} \times CF_{LED,summer}$$

$$\Delta kW_{motion\ sensor,\ summer} = kW_{connected} \times DSF_{motion\ sensor} \times ISR_{motion\ sensor} \times WHF_{motion\ sensor,summer} \times CF_{motion\ sensor,summer}$$

The winter gross coincident demand reduction is assumed to be zero for the energy monitor, smart plug and connected LED. For motion sensor, the following equation is used to calculate the winter gross coincident demand reduction measure:

$$\Delta kW_{motion\ sensor,\ winter} = kW_{connected} \times DSF_{motion\ sensor} \times ISR_{motion\ sensor} \times WHF_{\ motion\ sensor,winter} \times CF_{motion\ sensor,winter}$$

Where:

ΔkWh	= gross annual electric energy savings
$\Delta kWh_{monitor}$	= gross annual electric energy savings from home energy monitor
$\Delta kWh_{smart\ plug}$	= gross annual electric energy savings from smart plug
ΔkWh_{LED}	= gross annual electric energy savings from connected LED lighting
$\Delta kWh_{motion\ sensor}$	= gross annual electric energy savings from motion sensor
$kWh_{whole\ house}$	= annual household energy consumption
ΔkWh_{other}	= gross annual electric energy savings for all other measures implemented at the premise through this program
$ESF_{monitor}$	= energy savings factor for home energy monitor
$PF_{monitor}$	= participation factor accounting for participant activity rate
kWh_{office}	= annual energy savings of smart plug on office equipment
office	= weighted percent of plugs installed on office equipment
kWh_{ent}	= annual energy savings of smart plug on an entertainment center
ent	= weighted percent of plugs installed on entertainment center
$ISR_{smart\ plug}$	= in-service rate of smart plug

W_{base}	= wattage of new connected LED lighting
HOU	= hours of use per year
ESF_{LED}	= annual baseline energy consumption for cooling
ISR_{LED}	= in-service rate of connected LED lighting
WHF_{heat}	= waste heat factor to account for electric heating increase due to reduced waste heat from connected LED lighting
WHF_{cool}	= waste heat factor to account for electric cooling decrease due to reduced waste heat from connected LED lighting
$kWh_{standby}$	= standby energy consumption of controlled LED lighting
$kW_{connected}$	= connected kW of LEDs controlled by motion sensor
$ESF_{motion\ sensor}$	= energy savings factor of motion sensor
$ISR_{motion\ sensor}$	= in service rate of motion sensor
$HOU_{standby}$	= hours smart plug is in standby
DSF_{LED}	= demand savings factor of connected LED
$WHF_{d,\ LED}$	= demand waste heat factor
$CF_{LED,\ summer}$	= connected LED summer peak coincident factor
$DSF_{motion\ sensor}$	= demand savings factor for motion sensor
WHF_{summer}	= summer demand waste heat factor for motion sensor
$CF_{motion\ sensor,\ summer}$	= motion sensor summer peak coincident factor
$WHF_{winter,\ motion}$	= winter demand waste heat factor for motion sensor
$CF_{motion\ sensor,\ winter}$	= motion sensor winter peak coincident factor

The calculation inputs are based on the default savings percentages from the Maryland/Mid-Atlantic TRM v10 and the heating and cooling kWh consumption derived from a billing analysis of monthly customer energy consumption prior to the purchase of the thermostat.

12.5.1.3 Input Variables

Table 12-2. Input Variables for Measure Smart Thermostat-Purchase

Component	Type	Value	Units	Source(s)
$kWh_{whole\ house}$	Variable	Customer-specific kWh	kWh	Customer billing data[151]
		Default see Sub-Appendix F1-VIII: Residential Account Normalized Annual Consumption, Table 19-17		Average of customer billing data
$\Delta kWh_{all\ measures}$	Variable	See customer application and savings for all measures implemented at household	kWh	Calculated from various sections of this manual
$ESF_{monitor}$	Fixed	0.0321	–	DTE Insight: Energy Bridge Electrical Savings White Paper[152], p.7

[152] https://www.michigan.gov/documents/mpsc/DTE_Insight_Electric_Energy_Bridge_522660_7.pdf, accessed on 05/07/2021.

Component	Type	Value	Units	Source(s)
$PF_{monitor}$	Fixed	0.21	–	DTE Insight Program 2018 Reconciliation report, p. 13[153]
kWh_{office}	Fixed	31	kWh	Mid-Atlantic TRM v9, p. 290
office	Fixed	0.41	–	Mid-Atlantic TRM v9, p. 290
kWh_{ent}	Fixed	75.1	kWh	Mid-Atlantic TRM v9, p. 290
ent	Fixed	0.59	–	Mid-Atlantic TRM v9, p. 290
$ISR_{smart\ plug}$	Fixed	0.178	–	Mid-Atlantic TRM v9, p. 290[154]
W_{base}	Fixed	9.5	W	Program design assumption
HOU	Fixed	679	hours, annual	Maryland/Mid-Atlantic TRM v10, p. 49
ESF_{LED}	Fixed	0.49	–	Maryland/Mid-Atlantic TRM v10, p. 49
ISR_{LED}	Fixed	0.98	–	Maryland/Mid-Atlantic TRM v10, p. 50
WHF_{heat}	Fixed	0.899	–	Maryland/Mid-Atlantic TRM v10, p. 50
WHF_{cool}	Fixed	1.087	–	Maryland/Mid-Atlantic TRM v10, p. 51
$kWh_{standby}$	Fixed	2.63	–	Maryland/Mid-Atlantic TRM v10, p. 51
$kW_{connected}$	Fixed	0.23	kW	Maryland/Mid-Atlantic TRM v10, p. 45[155]
$ESF_{motion\ sensor}$	Fixed	0.30	–	Maryland/Mid-Atlantic TRM v10, p. 45
$ISR_{motions\ sensor}$	Fixed	1.00	–	Maryland/Mid-Atlantic TRM v10, p. 45
$HOU_{standby}$	Fixed	6,351	–	Maryland/Mid-Atlantic TRM v10, p. 290
$CF_{smart\ plug,\ summer}$	Fixed	0.80	–	Maryland/Mid-Atlantic TRM v10, p. 291
DSF_{LED}	Fixed	0.49	–	Maryland/Mid-Atlantic TRM v10, p. 51

[153] https://mi-psc.force.com/sfc/servlet.shepherd/document/download/069t0000005YaxRAAS?operationContext=S1, Accessed on 07/07/2021, A total of 36,025 customers had 5 sessions or more within a year out of a total of 172,241 customers that downloaded the app. (36,025/172,241 = 21%)

[154] Smart strip can control multiple end-uses; Smart plugs, is this based on fencing. Therefore 0.89/5 = 0.178 is used.

[155] The connected number of lamps and average wattage is unknown, so the Mid-Atlantic TRM default value is used. This assumes 6.8 connect lamps with an average of 0.034 kW/lamp.

Component	Type	Value	Units	Source(s)
$WHF_{d,\,LED}$	Fixed	1.17	–	Maryland/Mid-Atlantic TRM v10, p. 52
$CF_{LED,\,summer}$	Fixed	0.059	–	Maryland/Mid-Atlantic TRM v10, p. 52
$DSF_{motion\ sensor}$	Fixed	0.30	–	Maryland/Mid-Atlantic TRM v10, p. 47
$WHF_{summer,\,motion\ sensor}$	Fixed	1.245	–	Maryland/Mid-Atlantic TRM v10, p. 47
$CF_{motion\ sensor,\,summer}$	Fixed	0.058	–	Maryland/Mid-Atlantic TRM v10, p. 47
$WHF_{winter,\,motion\ sensor}$	Fixed	0.751	–	Maryland/Mid-Atlantic TRM v10, p. 47
$CF_{motion\ sensor,\,winter}$	Fixed	0.124	–	Maryland/Mid-Atlantic TRM v10, p. 47

12.5.1.4 Default Savings

Default savings may be applied if the using conservative input values. In this section we calculate default savings for each component. However, we don't sum the components because the quantity of each may vary or in some instances not all components will be implemented.

The default per measure gross annual electric energy savings will be assigned according to the following calculations:

The per measure gross annual energy savings for $kWh_{smart\ plug}$ is calculated as follows:

$$\Delta kWh_{smart\ plug} = (kWh_{office} \times office + kWh_{ent} \times ent) \times ISR_{smart\ plug}$$

$$= (31 \times 0.41 + 75.1 \times 0.59) \times 0.178$$

$$= 10.2\ kWh$$

The per measure gross annual energy savings for kWh_{LED} is calculated as follows:

$$\Delta kWh_{LED} = \frac{W_{base}}{1{,}000\ W/kW} \times HOU \times ESF_{LED} \times ISR_{LED} \times \left(WHF_{heat} + (WHF_{cool} - 1)\right) - kWh_{standby}$$

$$= \frac{9.5}{1{,}000\ W/kW} \times 679 \times 0.49 \times 0.98 \times \left(0.899 + (1.087 - 1)\right) - 2.63$$

$$= 0.4\ kWh$$

The per measure gross annual energy savings for $kWh_{motion\ sensor}$ is calculated as follows:

$$\Delta kWh_{motion\ sensor} = kW_{connected} \times HOU \times ESF_{motion\ sensor} \times ISR_{motion\ sensor} \times \left(WHF_{heat} + (WHF_{cool} - 1)\right)$$

$$= 0.23 \times 679 \times 0.30 \times 1.00 \times \left(0.899 + (1.087 - 1)\right)$$

$$= 10.4\ kWh$$

The per measure gross annual energy savings for $kWh_{monitor}$ requires a default $kWh_{whole\ house}$. The participant premise type and region is used to assign this value. For the calculation show, below a central region is used and the premise type is unknown. It is assumed that no other measures are implementer in this program or across all programs. $kWh_{monitor}$ is calculated as follows:

$$\Delta kWh_{monitor} = (kWh_{whole\ house} - \Delta kWh_{all\ measures}) \times ESF_{monitor} \times PF_{monitor}$$

$$= (,351 - 0) \times 0.0321 \times 0.21$$

$$= 49.6\ kWh$$

The per measure gross annual energy savings is calculated as follows:

$$\Delta kWh = \Delta kWh_{monitor} + \Delta kWh_{smart\ plug} + \Delta kWh_{LED} + \Delta kWh_{motion\ sensor}$$

$$= 49.6 + 10.2 + 0.4 + 10.4$$

$$= 70.6\ kWh$$

The summer gross coincident demand reduction is assumed to be zero for the energy monitor. For the other components, the following equations are used to calculate the summer gross coincident demand reduction measure:

$$\Delta kW_{smart\ plug,\ summer} = \frac{\Delta kWh_{smart\ plug}}{HOU_{standby}} \times CF_{smart\ plug,summer}$$

$$= \frac{10.15}{6,351} \times 0.80$$

$$= 0.001\ kW$$

$$\Delta kW_{LED,\,summer} = \frac{W_{base}}{1{,}000\,W/kW} \times DSF_{LED} \times ISR_{LED} \times WHF_{LED} \times CF_{LED,summer}$$

$$= \frac{9.5}{1{,}000\,W/kW} \times 0.49 \times 0.98 \times 0.899 \times 0.059$$

$$= 0.000\,kW$$

$$\Delta kW_{motion\,sensor,\,summer} = kW_{connected} \times DSF_{motion\,sensor} \times ISR_{motion\,sensor} \times WHF_{motion\,sensor,summer} \times CF_{motion\,sensor,summer}$$

$$= 0.23 \times 0.30 \times 1.00 \times 1.245 \times 0.058$$

$$= 0.005\,kW$$

The winter gross coincident demand reduction is assumed to be zero for the energy monitor, smart plug and connected LED. For motion sensor, the default winter gross coincident demand reduction measure is calculated as follows:

$$\Delta kW_{motion\,sensor,\,winter} = kW_{connected} \times DSF_{motion\,sensor} \times ISR_{motion\,sensor} \times WHF_{motion\,sensor,winter} \times CF_{motion\,sensor,winter}$$

$$= 0.23 \times 0.30 \times 1.00 \times 0.751 \times 0.124$$

$$= 0.006\,kW$$

12.5.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 11-16.

Table 12-3. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Component	Value	Units	Source(s)
VIII	Residential Manufactured Housing	Home energy monitor	7.50	years	Maryland/Mid-Atlantic TRM v10, pp. 106[156]
		Smart plug	4.00		Mid-Atlantic TRM v9, p. 291
		Connected LED	15.00		Mid-Atlantic TRM v10, p. 53
		Motion sensor	10.00		Maryland/Mid-Atlantic TRM v10, p. 47

156 Assumed to be similar to Smart Thermostat

12.5.1.6 Source(s)

The primary source for this deemed savings approach is DTE Insight: Energy Bridge Electrical Savings White Paper, p.7, Maryland/Mid-Atlantic TRM v10, pp. 103–106, Mid-Atlantic TRM v10, pp. 48 - 53, Maryland/Mid-Atlantic TRM v10, pp. 42 - 47 and Mid-Atlantic TRM v9, pp. 289 - 291.

12.5.1.7 Update Summary

Updates to this section are described in Table 11-17. Summary of Update(s).

Table 12-4. Summary of Update(s)

Updates in Version	Update Type	Description
2021		Initial release

12.6 Lighting End Use

12.6.1 LED Lamps

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV. The savings are determined using the methodology described in Section 2.3.1.

13 RESIDENTIAL/NON-RESIDENTIAL MULTIFAMILY PROGRAM, DSM PHASE VIII

The Multifamily Program is designed to encourage investment in both residential and commercial service aspects of multifamily properties. The Program design is based on a whole building approach where the implementation vendor will identify as many cost-effective measure opportunities as possible in the entire building (both residential and commercial meter) and encourage property owners to address the measures as a bundle. This approach provides one stop-shop programming for multifamily property owners with solutions to include direct installing-unit measures and incentives for prescriptive efficiency improvements. The Program will identify, track and report residential (in-unit) and commercial (common space) savings separately according to the account type. The Program will be delivered through an expanded network of local trade allies that the implementation vendor will recruit and support while also establishing a robust relationship with property management companies since they are the gatekeeper for determining enrollment for their multifamily communities. Once a property management company has decided to enroll the residential property into the Program, the implementation vendor will send the tenants a letter that will provide information about Program benefits along with an opportunity to opt-out of participating within a defined time period. If a tenant does not take action to notify the program implementation vendor that they are opting out of participation, their unit will be included in the enrolled locations receiving the installed measures during the delivery phase.

The implementation vendor intends to complete site assessments at the time of the enlistment visit or within two weeks to identify all eligible measure savings. From the assessment, the property owner or manager will receive an assessment report identifying and quantifying savings opportunities with estimated project costs and available incentives. The program implementation vendor or trade ally auditor will perform a walkthrough audit covering the envelope and all energy systems in the buildings, paying particular attention to the condition of DHW and HVAC systems, level of insulation, and lighting. After assessing the entire structure and living units, the auditor will use the tool to perform appropriate calculations and generate a report showing projected energy and potential cost savings specific to each unit and/or common area. The auditor will review the findings and recommendations of the complete with the property owner and assist them in making measure installation and investment decisions. Participation will require that all services or installations qualifying for an incentive be completed by a participating contractor or properly credentialed building maintenance staff.

The measures offered through the program and the sections that contain the savings algorithms for each measure are presented in Table 13-1.

Table 13-1. Residential / Non-Residential Multifamily Program Measure List

End Use	Measure	Legacy Program	Residential Manual Section
Building Envelope	Air Sealing	Residential Manufactured Housing Program, DSM Phase VIII	Section 11.1.1
	Building Insulation	Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 2.2.1
Domestic Hot Water	Domestic Hot Water Pipe Insulation		Section 2.1.1
	Faucet Aerator		Section 2.1.2

End Use	Measure	Legacy Program	Residential Manual Section
	Low-Flow Showerhead	Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 2.1.3
	Water Heater Temperature Setback/Turndown	Residential Home Energy Assessment Program, DSM Phase VII	Section 5.2.5
HVAC	HVAC Upgrade	Residential Home Energy Assessment Program, DSM Phase VII	Section 5.3.1
	Heat Pump Tune-up		Section 5.3.2
	Duct Testing and Sealing		Section 5.3.5
	Smart Thermostat Installation	Residential Thermostat Purchase (Energy Efficiency) Program, DSM Phase VIII	Section 7.2.1
Lighting	LED Lamps	Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 2.3.1
Plug-Load Appliances	Energy Star Refrigerator	Residential Efficient Products Marketplace Program, DSM Phase VII	Section 6.2.7
	Refrigerator Coil Cleaning	–	Section 13.5.2
	Refrigerator Thermometers	–	Section 13.5.3
	ENERGY STAR Clothes Dryer	Residential Efficient Products Marketplace Program, DSM Phase VII	Section 6.2.3
	ENERGY STAR Clothes Washer		Section 6.2.2

13.1 Building Envelope End Use

13.1.1 Air Sealing

This measure is also provided by Residential Manufactured Housing Program, DSM Phase VIII. The savings are determined using the methodology described in Section 11.1.1.

13.1.2 Building Insulation

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV. The savings are determined using the methodology described in Section 2.2.1.

13.2 Domestic Hot Water End Use

13.2.1 Domestic Hot Water Pipe Insulation

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV. The savings are determined using the methodology described in Section 2.1.1.

13.2.2 Faucet Aerator

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV. The savings are determined using the methodology described in Section 2.1.2.

13.2.3 Low-flow Showerhead

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV. The savings are determined using the methodology described in Section 2.1.3.

13.2.4 Water Heater Temperature Setback/Turndown

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings are determined using the methodology described in Section 5.2.5.

13.3 Heating, Ventilation, Air-Conditioning End Use

13.3.1 HVAC Upgrade

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings are determined using the methodology described in Section 5.3.1.

13.3.2 HVAC Tune-Up

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings are determined using the methodology described in Section 5.3.2.

13.3.3 Duct Testing and Sealing

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings are determined using the methodology described in Section 5.3.5.

13.3.4 Smart Thermostat Installation

This measure is also provided by the Residential Thermostat (Energy Efficiency) Program. The savings are determined using the methodology described in Section 7.2.1.

13.4 Lighting

13.4.1 LED Lamps

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV. The savings are determined using the methodology described in Section 2.3.1.

13.5 Plug Load/Appliance End Use

13.5.1 ENERGY STAR Refrigerator

This measure is also provided by the Residential Efficient Products Marketplace Program, DSM Phase VII. The savings are determined using the methodology described in Section 6.2.7.

13.5.2 Refrigerator Coil Cleaning

This measure does not have savings that have been validated by technical resource manuals or other secondary resources. While some savings may be realized at individual households, deemed savings are not attributed to this measure.

13.5.3 Refrigerator Thermometers

This measure does not have savings that have been validated by technical resource manuals or other secondary resources. While some savings may be realized at individual households, deemed savings are not attributed to this measure.

13.5.4 Clothes Dryer

This measure is also provided by the Residential Efficient Products Marketplace Program, DSM Phase VII. The savings are determined using the methodology described in Section 6.2.3.

13.5.5 Clothes Washer

This measure is also provided by the Residential Efficient Products Marketplace Program, DSM Phase VII. The savings are determined using the methodology described in Section 6.2.2.

14 RESIDENTIAL ELECTRICAL VEHICLE (EE) PROGRAM, DSM PHASE VIII

The Residential Electrical Vehicle Program provides an incentive for the purchase of a qualifying level 2 EV charger.[157]

14.1 Plug Load/Appliance End Use

14.1.1 L2 Electric Vehicle Charger

14.1.1.1 Measure Description

A Level 2 EV charger is electric vehicle supply equipment (EVSE) and part of the infrastructure that is used to charge electric vehicle batteries. Battery electric vehicles (BEV) and plug in hybrid electric vehicles (PHEV) use EV chargers to charge electric batteries. The ENERGY STAR specification governs standby mode power consumption and connected Functionality (optional). EVSE that meet the connected functionality criteria are capable of supporting Demand Response (DR).

The baseline for PHEVs is a is a standard efficiency level 1 charger. The baseline for BEVs is a level 2 charger that is network connected. These baselines are determined by standard practices. For BEVs, there is a high adoption rate of level 2 chargers. For PHEVs, the standard practice is a level 1 charger.

14.1.1.2 Impacts Estimation Approach

Per measure, gross annual electric energy savings are calculated according to the following equation.

$$\Delta kWh = (BEV \times \Delta kWh_{BEV}) + (PHEV \times \Delta kWh_{PHEV})$$

Per measure, gross annual electric energy savings are calculated according to the following equation.

$$\Delta kWh_{BEV} = \Delta kWh_{standby,base} - \left(kWh_{no\ vehicle\ standby,ee} + kWh_{plug-in\ standby,ee}\right)$$

$$kWh_{standby,base} = \left(hours_{plug-in\ stand\ by} + hours_{no\ vehicle\ standby}\right) \times watts_{standby,base} \times \frac{1\ kW}{1{,}000\ W}$$

$$kWh_{plug-in\ standby,ee} = hours_{plug-in\ standby} \times watts_{plug-in\ standby,ee} \times \frac{1\ kW}{1{,}000\ W}$$

$$kWh_{no\ vehicle\ standby,ee} = hours_{no\ vehicle\ standby} \times watts_{no\ vehicle\ standby,ee} \times \frac{1\ kW}{1{,}000\ W}$$

[157] Electric Vehicle Supply Equipment (EVSE) Key Product Criteria

$$hours_{plug-in\ standby} = \left(\frac{kWh_{charge,BEV}}{kWh_{session}} \times hours_{session}\right) - hours_{charge}$$

$$kWh_{charge,BEV} = \left(\frac{mi_{BEVl}}{Charge_{eff,BEV}}\right)$$

$$hours_{charge} = \left(\frac{1}{Charge_{eff,BEV}}\right) \times \frac{(mi_{BEV})}{kW_{charger,BEV}}$$

$$hours_{no\ vehicle\ standby} = 8{,}760 - hours_{plug-in\ standby} - hours_{charge}$$

Per measure, gross annual electric energy savings are calculated according to the following equation.

$$\Delta kWh_{PHEV} = (kWh_{L1} - kWh_{L2}) - \left(kWh_{no\ vehicle\ standby,ee} + kWh_{plug-in\ standby,ee}\right)$$

$$kWh_{drive,PHEV} = \left(\frac{mi_{PHEV}}{Charge_{eff,PHEV}}\right)$$

$$kWh_{L1} = kWh_{drive,PHEV} - (1 - \eta_{L1})$$

$$kWh_{L2} = kWh_{drive,PHEV} - (1 - \eta_{L2})$$

There is no gross coincident demand reduction for this measure.

Where:

ΔkWh	= gross annual electric energy savings
ΔkWh_{BEV}	= gross annual electric energy savings for BEVs
ΔkWh_{PHEV}	= gross annual electric energy savings for PHEVs
$kWh_{standby,\ base}$	= baseline annual electric energy consumption during standby mode including both when no vehicle is present and when a vehicle is plugged in but not charging
$kWh_{no\ vehicle\ standby,\ ee}$	= energy-efficient annual electric energy consumption during standby mode when no vehicle is present
$kWh_{plug-in\ standby,\ ee}$	= energy-efficient annual electric energy consumption during standby mode when a vehicle is present but not charging
$hours_{plug-in\ standby}$	= annual hours in standby mode when a vehicle is present but not charging
$hours_{no\ vehicle\ standby}$	= annual hours in standby mode when no vehicle is present
$watts_{standby,\ base}$	= baseline charger standby wattage including both when no vehicle is present and when a vehicle is plugged in but not charging
$watts_{plug-in\ standby,\ ee}$	= energy-efficient charger standby wattage when a vehicle is plugged in but not charging
$watts_{no\ vehicle\ standby,\ ee}$	= energy-efficient charger standby wattage when no vehicle is present
$kWh_{charge,BEV}$	= annual driving energy consumption

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$kWh_{session}$	= average energy consumption per charging session
$hours_{charge}$	= annual hours charger in charging mode
$hours_{session}$	= hours per charge session
$charge_{eff,BEV}$	= average charge efficiency of BEV
$charge_{eff,PHEV}$	= average charge efficiency of PHEV
BEV	= Percent weight of EV vehicles that are BEV
mi_{BEV}	= annual miles driven by BEV
EVR_{BEV}	= ratio of miles driven in EV mode to total miles driven by BEV
PHEV	= percent weight of EV vehicles that are PHEV
mi_{PHEV}	= annual miles driven by PHEV in EV mode
EVR_{PHEV}	= ratio of miles driven in EV mode to total miles driven by PHEV
kWh_{L1}	= kWh charging for the baseline L1 charger
kWh_{L2}	= kWh charging for the efficient case L2 charger
$kWh_{drive,PHEV}$	= Annual kWh consumed while driving
η_{L1}	= Baseline L1 charger efficiency
η_{L2}	= Baseline L2 charger efficiency
$kW_{charge,BEV}$	= steady state charger power output for BEV
$kW_{charge,PHEV}$	= steady state charger power output for PHEV

14.1.1.3 Input Variables

Table 14-1. Input Variables for Level 2 EV Charger

Component	Type	Value	Units	Source(s)
$Watts_{standby, base}$	Fixed	9.9	watts	Regional Technical Forum, Level 2 Electric Vehicle Chargers, ResElectric Vehicle Chargerv1.1.xlsx[158]
$Watts_{plug\text{-}in\ standby,\ ee}$	Variable	See Table 14-2	watts	ENERGY STAR Qualified Product List model specifications
$Watts_{no\ vehicle\ standby,\ ee}$	Variable	See Table 14-2	watts	ENERGY STAR Qualified Product List model specifications
$kWh_{session}$	Fixed	7.4	kWh	Regional Technical Forum, Level 2 Electric Vehicle Chargers, ResElectric Vehicle Chargerv1.1.xlsx[159]
$hours_{session}$	Variable	12.87	hours	Regional Technical Forum, Level 2 Electric Vehicle Chargers, ResElectric Vehicle Chargerv1.1.xlsx[160]
$charge_{eff,\ BEV}$	Fixed	3.3	mile/ kWh	Regional Technical Forum, Level 2 Electric Vehicle Chargers, ResElectric Vehicle Chargerv1.1.xlsx[161]

[158] INL charger testing https://avt.inl.gov/evse-type/ac-level-2 and ENERGY STAR Market and Industry Scoping Report Electric Vehicle Supply Equipment (EVSE) September 2013 (source data is from INL). Average Prior and Post Steady State Charging Wattages for networked Level 2 units.

[159] Avista (2018)

[160] Data provided by Avista. Total hours EV is plugged into charging station including both charge and standby time, BEV = 14.7 and PHEV = 11.7, applied the weighted average of BEV and PHEV

[161] Analysis of Avista Docket No. UE-160082 – Avista Utilities Semi-Annual Report on Electric Vehicle Supply Equipment Pilot Program (November 2018). Average for all vehicles and trips.

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Component	Type	Value	Units	Source(s)
$charge_{eff, PHEV}$	Fixed	2.7	mile/ kWh	Regional Technical Forum, Level 2 Electric Vehicle Chargers, ResElectric Vehicle Chargerv1.1.xlsx[162]
BEV	Fixed	0.391	-	Dominion Energy Residential Home Energy Use Survey 2019 - 2020, July 15. 2020, p. 24 Question 65
mi_{BEV}	Fixed	8,993	miles	Federal Highway Administration, 2017 National Household Travel Survey (NHTS)[163]
EVR_{BEV}	Fixed	1.00	-	Regional Technical Forum, Level 2 Electric Vehicle Chargers, ResElectric Vehicle Chargerv1.1.xlsx[164]
PHEV	Fixed	0.609	-	Dominion Energy Residential Home Energy Use Survey 2019 - 2020, July 15. 2020, p. 24 Question 65
mi_{PHEV}	Fixed	8,993	miles	Federal Highway Administration, 2017 National Household Travel Survey (NHTS)[163]
η_{L1}	Fixed	0.838	-	A Comparison of Electric Vehicle Level 1 and Level 2 Charging Efficiency, Vermont Energy Investment Corporation, 2014 IEEE Conference
η_{L2}	Fixed	0.894	-	A Comparison of Electric Vehicle Level 1 and Level 2 Charging Efficiency, Vermont Energy Investment Corporation, 2014 IEEE Conference
$kW_{charge\ BEV}$	Fixed	8.2	kW	Regional Technical Forum, Level 2 Electric Vehicle Chargers, ResElectric Vehicle Chargerv1.1.xlsx
$kW_{charge, PHEV}$	Fixed	4.2	kW	Regional Technical Forum, Level 2 Electric Vehicle Chargers, ResElectric Vehicle Chargerv1.1.xlsx

Table 14-2 provides a summary of charger rated wattages from the ENERGY STAR qualified product lists.

Table 14-2. ENERGY STAR Standby Power Ratings

Model	No Vehicle Mode Input Power (W)	Partial On Mode Input Power (W)	Idle Mode Input Power (W)	Plug-in Standby Power[165] (W)
CPH50-NEMA14-50-L23 **CPH50-NEMA6-50-L23**	0.80	1.36	3.53	2.45

162 Analysis of Avista Docket No. UE-160082 – Avista Utilities Semi-Annual Report on Electric Vehicle Supply Equipment Pilot Program (November 2018). Average for all vehicles and trips.

163 South Atlantic Region Database Queries: http://nhts.ornl.gov

164 2014 EV Project percentage of the time vehicle operates purely as an EV https://avt.inl.gov/sites/default/files/pdf/EVProj/eVMTMay2014.pdf

165 Calculated as the average of partial on mode input power and idle mode input power

Model	No Vehicle Mode Input Power (W)	Partial On Mode Input Power (W)	Idle Mode Input Power (W)	Plug-in Standby Power[165] (W)
JuiceBox 40 JuiceBox 32	2.97	2.03	4.39	3.21
CPH12-P	1.90	1.90	2.00	1.95
CPH25-P	1.80	1.90	2.00	1.95
2JBO401RNA-PJWX-200	1.57	1.19	1.71	1.45

14.1.1.4 Default Savings

There are no default savings for this measure. The savings are calculated depending on the model charger installed.

14.1.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 14-3.

Table 14-3. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Electrical Vehicle (EE) Program, DSM PHASE VIII	10	Years	ResEVChargers_v1_1.xlsx from Eric Shum, PE. Regional Technical Forum, 2019, Residential Level 2 AC Electric Vehicle (EV) Chargers.

14.1.1.6 Source

The primary source for this deemed savings approach is Eric Shum, PE. Regional Technical Forum, 2019, Residential Level 2 AC Electric Vehicle (EV) Chargers.

14.1.1.7 Update Summary

Updates to this section are described in Table 14-4.

Table 14-4. Summary of Update(s)

Updates in Version	Update Type	Description
2021		Initial release

15 RESIDENTIAL ELECTRICAL VEHICLE (DR) PROGRAM, DSM PHASE VIII

Customers who participate in the Residential Electrical Vehicle (EE) Program are eligible to enroll in the Residential Electrical Vehicle (DR) Program. When Dominion calls an event, the EV charging power is reduced for a defined interval. Events will be called by the Company during times of peak system demand throughout the year to reduce system load. Customers can opt-out of specific events if they choose to do so.

15.1 Plug Load/Appliance End Use

15.1.1 L2 Electric Vehicle Charger-DR

15.1.1.1 Measure Description

A Level 2 EV charger is electric vehicle supply equipment (EVSE) and part of the infrastructure that is used to charge electric vehicle batteries. The Energy Star specification governs standby mode power consumption and connected Functionality (optional). EVSE that meet the optional connected functionality criteria defined by Energy Star is capable of supporting Demand Response (DR).[166]

15.1.1.2 Impacts Estimation Approach

For participants with AMI meters, a linear regression approach is used to calculate impacts from demand response events. If AMI data is not available, high interval charger data supplied by the charger control vendor is used. This program did not call any demand response events in 2021. Therefore, there are no regression results or impacts to report.

15.1.1.3 Demand reduction

Demand reduction is not deemed. All savings are taken from impact evaluations.

15.1.1.4 Effective Useful Life

The effective useful life of this measure is provided in Table 15-1.

Table 15-1. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential Electric Vehicle Charger (DR)	1.00	Year	Annual participation

15.1.1.5 Source

Local weather data are gathered from NOAA, National Centers for Environmental Information.

[166] ENERGY STAR Electric Vehicle Supply Equipment (EVSE) Key Criteria v1.0 (Revised April 2017)

15.1.1.6 Update Summary

Updates to this section are described in Table 15-2.

Table 15-2. Summary of Update

Updates in Version	Update Type	Description
2021		Initial release

16 RESIDENTIAL HB 2789 PROGRAM (HEATING AND COOLING/HEALTH AND SAFETY), DSM PHASE VIII

This program offers incentives for the installation of measures that reduce residential heating and cooling costs. It also offers measures that enhance the health and safety of residents including repairs and improvements to home heating and cooling systems and installation of energy-saving measures in the house, such as insulation and air sealing.

This program is for income qualifying, elderly and disabled individuals. The Program conforms to the Virginia Department of Housing and Community Development qualification guidelines, which is currently set at 60% State Median Income. It is also available to customers who are 60 years or older with a household income of 120% of the State Median Income. The Program is available to customer residing in single-family homes, multifamily homes, and mobile homes.

Table 16-1: Residential HB / Non-Residential Multifamily Program Measure List

End Use	Measure	Legacy Program	Manual Section
Building Envelope	Air Sealing	Residential Manufactured Housing Program	Section 11.1.1
	Building Insulation	Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 2.2.1
Health & Safety	Various Health & Safety Measures	-	Section 16.2
HVAC	Heat Pump Upgrade	Residential Home Energy Assessment Program, DSM Phase VII	Section 5.3.1
	Duct Testing and Sealing	Residential Home Energy Assessment Program, DSM Phase VII	Section 5.3.5
	HVAC Tune-up	Residential Home Energy Assessment Program, DSM Phase VII	Section 5.3.2
	Programable Thermostat	New Measure	Section 7.2.1
	Home Ventilation Improvement	New Measure	Section 16.3.6

16.1 Building Envelope

16.1.1 Air Sealing

This measure is also provided by the Residential Manufactured Housing Program, DSM Phase VIII. The savings are determined using the methodology described in Section 11.1.1.

16.1.2 Building Insulation

This measure is also provided by the Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV. The savings are determined using the methodology described in Section 2.2.1

16.2 Health & Safety

Health & Safety measures are offered through this program. These measures do not have energy savings. Measures include: dehumidifier, ventilation improvement, air quality control, assess indoor air quality, carbon monoxide detector and source, combustion appliance safety check and enhance, fire and fall safety check and enhance, mold and mildew removal, re-wiring and roof repair.

16.3 Heating, Ventilation, Air-Conditioning End Use

16.3.1 Heat Pump Upgrade

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings are determined using the methodology described in Section 5.3.1.

16.3.2 Duct Testing & Sealing

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings are determined using the methodology described in Section 5.3.5.

16.3.3 Duct Insulation

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings are determined using the methodology described in Section 5.3.4.

16.3.4 Heat Pump Tune-up

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings are determined using the methodology described in Section 5.3.2.

16.3.5 Programable Thermostat

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings are determined using the methodology described in Section 7.2.1.

16.3.6 Home Ventilation Improvement

16.3.6.1 Measure Description

This measure realizes energy savings by replacing a standard performance ventilation fan with a high-performance ventilation fan. The high-performance ventilation fan provides the same amount of airflow with lower power (cfm/watts).

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16.3.6.2 Impacts Estimation Approach

Per measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = cfm \times \left(\frac{1}{fan_{efficacy,base}} - \frac{1}{fan_{efficacy,ee}}\right) \times \frac{1\ kW}{1{,}000\ W} \times HOU$$

Per measure, gross summer peak coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{Summer} = cfm \times \left(\frac{1}{fan_{efficacy,base}} - \frac{1}{fan_{efficacy,ee}}\right) \times \frac{1\ kW}{1{,}000\ W} \times CF_{summer}$$

Per measure, gross winter peak coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{Winter} = cfm \times \left(\frac{1}{fan_{efficacy,base}} - \frac{1}{fan_{efficacy,ee}}\right) \times \frac{1\ kW}{1{,}000\ W} \times CF_{winter}$$

Where:

ΔkWh	= per measure gross annual electric energy savings per faucet
ΔkW_{Summer}	= gross summer peak coincident demand reductions
ΔkW_{Winter}	= gross winter peak coincident demand reductions
cfm	= fan rated airflow rate
$fan_{efficacy,base}$	= fan efficacy of baseline equipment
$fan_{efficacy,ee}$	= fan efficacy of efficient equipment
HOU	= hours of use per year
CF_{summer}	= summer peak coincident factor
CF_{winter}	= winter peak coincident factor

16.3.6.3 Input Variables

Table 16-2. Input Values for Home Ventilation Improvement Savings Calculations

Component	Type	Value	Unit	Source(s)
cfm	Fixed	See customer application	cfm	Customer application
		For default see Table 16-3		Illinois TRM 2019, p. 129
$Fan_{efficacy,base}$	Variable	See Table 16-3	cfm/watt	Illinois TRM 2019, p. 129
$Fan_{efficacy,ee}$	Variable	See customer application	cfm/watt	Customer application
		See Table 16-3		Illinois TRM 2019, p. 129
HOU	Variable	standard usage: 1,089 continuous: 8,760	hours	Illinois TRM 2019, p. 129
		For default use standard usage = 1,089		Conservative value used as default

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Component	Type	Value	Unit	Source(s)
CF_{Summer}	Fixed	standard usage: 0.135 continuous: 1.0	–	Illinois TRM 2019, p. 129
		For default use standard usage = 0.135		
CF_{Winter}	Fixed	standard usage: 0.135 continuous: 1.0	–	Illinois TRM 2020, p. 129[167]
		For default use standard usage = 0.135		

Table 16-3: Ventilation Default cfm and Fan Efficacy based on Application

Application	Min cfm	Max cfm	Default cfm	$Fan_{efficacy,base}$, cfm/watt	Default $Fan_{efficacy,ee}$, cfm/watt
Standard usage	10	89	70.6	1.7	4.9
	90	200	116.1	2.6	5.6
	Unknown (default)		92.4	2.2	5.3
Continuous usage	N/A		50.0	1.7	5.1

16.3.6.4 Default Savings

If the proper values are not supplied, a default savings may be applied using conservative input values. The default per measure gross annual savings will be assigned according to the following calculations.

$$\Delta kWh = CFM \times \left(\frac{1}{fan_{efficacy,base}} - \frac{1}{fan_{efficacy,ee}}\right) \times \frac{1\ kW}{1{,}000\ W} \times HOU$$

$$= 92.4 \times \left(\frac{1}{2.2} - \frac{1}{5.3}\right) \times \frac{1\ kW}{1{,}000\ W} \times 1{,}089$$

$$= 26.75\ kWh$$

$$\Delta kW_{Summer} = CFM \times \left(\frac{1}{fan_{efficacy,base}} - \frac{1}{fan_{efficacy,ee}}\right) \times \frac{1\ kW}{1{,}000\ W} \times CF_{summer}$$

[167] Source TRM does not provide winter CF. For continuous usage (8,760 hours), the CF will be 1.0 regardless of the peak period definition. For the standard usage we apply the summer CF for winter CF as there is no better information available

$$= 92.4 \times \left(\frac{1}{2.2} - \frac{1}{5.3}\right) \times \frac{1\ kW}{1{,}000\ W} \times 0.135$$

$$= 0.003\ kW$$

$$\Delta kW_{winter} = CFM \times \left(\frac{1}{fan_{efficacy,base}} - \frac{1}{fan_{efficacy,ee}}\right) \times \frac{1\ kW}{1{,}000\ W} \times CF_{winter}$$

$$= 92.4 \times \left(\frac{1}{2.2} - \frac{1}{5.3}\right) \times \frac{1\ kW}{1{,}000\ W} \times 0.135$$

$$= 0.003\ kW$$

16.3.6.5 Effective Useful Life

The effective useful life of this measure is provided in Table 16-4.

Table 16-4. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential HB 2789 Program (Heating and Cooling/Health and Safety), DSM Phase VIII	19.00	years	Illinois TRM 2020, p. 128

16.3.6.6 Source(s)

The primary source for this deemed savings approach is the Illinois TRM 2020, pp.128-130.

16.3.6.7 Update Summary

Updates to this section are described in Table 16-5.

Table 16-5. Summary of Update(s)

Version with Updates	Update Type	Description
2021		Initial release

17 RESIDENTIAL NEW CONSTRUCTION PROGRAM, DSM VIII

The Residential New Construction Program will provide incentives to home builders for the construction of new homes that are ENERGY STAR certified by directly recruiting existing networks of homebuilders and Home Energy Rating System Raters (HERS Raters) to build and inspect ENERGY STAR Certified New Homes. ENERGY STAR certification requires that homes be efficient at the system level and involves a whole-house set of standards that ensure homes are at least 10% more efficient than a home built to state-level minimum building codes. Key components include shell improvements, HVAC performance, proper ventilation requirements and durability (proper weather sealing, flashing details, site and foundation details). Participating homes must submit an energy model developed using Ekotrope or REM/Rate energy modeling software, along with a copy of the home's ENERGY STAR certificate (both provided by the rater) in order to qualify for an incentive.

The projected program participation is 24,000 customers over 5 years, expected to start with lower participation, increasing as large volume production builders participate in the program.

17.1 Whole Building End Use

17.1.1 ENERGY STAR New Home

17.1.1.1 Impacts Estimation Approach

Site level energy savings are determined using Ekotrope or REM/Rate energy modeling, both of which are RESNET accredited HERS software tools[168] and appear on DOE's list of approved software for calculating the energy efficient home credit.[169].

To perform data validation, DNV will conduct an in-depth review of a sample of five building models to check simulation output, thermostat schedules and setpoints, equipment sizing, appropriate baseline assumptions consistent with relevant code, etc. Subsequently, the monthly savings claims will be screened by energy savings per square foot of conditioned space correlated to HERS index.

Per project, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{DHW} + \Delta kWh_{LA} + \Delta kWh_{heating}$$

Per project, gross summer peak coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \Delta kW_{summer,cooling} + \Delta kW_{summer,DHW} + \Delta kW_{summer,LA} + \Delta kW_{summer,heating}$$

The gross summer peak coincident demand reduction is calculated for each end-use as follows:

$$\Delta kW_{summer,cooling} = \frac{\Delta kWh_{cooling}}{hours_{summer,cooling}}$$

[168] https://www.resnet.us/providers/accredited-providers/hers-software-tools/
[169] https://www.energy.gov/eere/buildings/list-approved-software-calculating-energy-efficient-home-credit

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$$\Delta kW_{summer,DHW} = \frac{\Delta kWh_{DHW}}{hours_{summer,DHW}}$$

$$\Delta kW_{summer,LA} = \frac{\Delta kWh_{LA}}{hours_{summer,LA}}$$

$$\Delta kW_{summer,heating} = \frac{\Delta kWh_{LA}}{hours_{summer,heating}}$$

Per project, gross winter peak coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \Delta kW_{winter,cooling} + \Delta kW_{winter,DHW} + \Delta kW_{winter,LA} + \Delta kW_{winter,heating}$$

The gross winter peak coincident demand reduction is calculated for each end-use as follows:

$$\Delta kW_{winter,cooling} = \frac{\Delta kWh_{cooling}}{hours_{winter,cooling}}$$

$$\Delta kW_{winter,DHW} = \frac{\Delta kWh_{DHW}}{hours_{summer,DHW}}$$

$$\Delta kW_{winter,LA} = \frac{\Delta kWh_{LA}}{hours_{summer,LA}}$$

$$\Delta kW_{winter,heating} = \frac{\Delta kWh_{heating}}{hours_{winter,heating}}$$

Where:

ΔkWh	= gross annual electric energy savings
$\Delta kWh_{cooling}$	= space cooling end-use gross annual electric energy savings
ΔkWh_{DHW}	= space domestic hot water end-use gross annual electric energy savings
ΔkWh_{LA}	= space lighting and appliance end-use gross annual electric energy savings
$\Delta kWh_{heating}$	= space heating end-use gross annual electric energy savings
ΔkW_{summer}	= gross summer peak coincident demand reduction
ΔkW_{winter}	= gross winter peak coincident demand reduction
$\Delta kW_{summer, cooling}$	= space cooling end-use gross summer peak coincident demand reduction
$\Delta kW_{summer, DHW}$	= domestic hot water end-use gross summer peak coincident demand reduction
$\Delta kW_{summer, LA}$	= lighting and appliance end-use gross summer peak coincident demand reduction
$\Delta kW_{summer, heating}$	= space heating end-use gross summer peak coincident demand reduction
$hours_{summer, cooling}$	= space cooling end-use summer peak coincident hours of use to adjust from annual kWh to peak period kW
$hours_{summer, DHW}$	= domestic hot water end-use summer peak coincident hours of use to adjust from annual kWh to peak period kW

$hours_{summer, LA}$	= lighting and appliance end-use summer peak coincident hours of use to adjust from annual kWh to peak period kW
$hours_{summer, heating}$	= space heating end-use summer peak coincident hours of use to adjust from annual kWh to peak period kW
$\Delta kW_{winter, cooling}$	= space cooling end-use gross winter peak coincident demand reduction
$\Delta kW_{winter, DHW}$	= domestic hot water end-use gross winter peak coincident demand reduction
$\Delta kW_{winter, LA}$	= lighting and appliance end-use gross winter peak coincident demand reduction
$\Delta kW_{winter, heating}$	= space heating end-use gross winter peak coincident demand reduction
$hours_{winter, cooling}$	= space cooling end-use winter peak coincident hours of use to adjust from annual kWh to peak period kW
$hours_{winter, DHW}$	= domestic hot water end-use winter peak coincident hours of use to adjust from annual kWh to peak period kW
$hours_{winter, LA}$	= lighting and appliance end-use winter peak coincident hours of use to adjust from annual kWh to peak period kW
$hours_{winter, heating}$	= space heating end-use winter peak coincident hours of use to adjust from annual kWh to peak period kW

17.1.1.1 Input Variables

Table 17-1. Input Variables for ENERGY STAR New Homes

Component	Type	Value	Units	Source(s)
$\Delta kWh_{cooling}$	Variable	See customer application	kWh	Customer application
ΔkWh_{DHW}				
ΔkWh_{LA}				
$\Delta kWh_{heating}$				
$hours_{summer, cooling}$	Fixed	887	hours	Analysis of end-use load shapes[170]
$hours_{summer, DHW}$	Fixed	11,341		
$hours_{summer, LA}$	Fixed	9,100		
$hours_{summer, heating}$	Fixed	10,382		
$hours_{winter, cooling}$	Fixed	99,999		
$hours_{winter, DHW}$	Fixed	11,829		
$hours_{winter, LA}$	Fixed	9,070		
$hours_{winter, heating}$	Fixed	1,966		

Default Savings

There are no default savings as whole-building model savings are required for each project.

[170] DNV used ratio-based load shape format independent of calendar and usage level. These values are scaled up to usage and analysed for peak periods. The hours use ratios are calculated as the sum of annual usage (kWh for all 8,760 hours) divided by the peak hour (or average of peak hours).

17.1.1.2 Effective Useful Life

The effective useful life of this measure is provided in Table 17-2.

Table 17-2. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Residential New Construction	25	years	Ohio TRM_2010, p. 142

17.1.1.3 Source

The primary source for this deemed savings is the Ekotrope or REM/Rate energy modelling.

17.1.1.4 Update Summary

Updates to this section are described in Table 17-3.

Table 17-3. Summary of Update(s)

Updates in Version	Update Type	Description
2021		Initial release

18 REFERENCES

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19 SUB-APPENDICES

19.1 Sub-Appendix F1-I: Definition of Terms

baseline condition	Typically the less efficient system that is being replaced (pre-retrofit); for HVAC equipment upgrades, the baseline energy efficiency values used to calculate savings equal the minimum requirements set forth by the state building code or federal standards, as relevant.
CDD	Annual cooling degree days
CEE	Consortium for Energy Efficiency
COP	The Coefficient of Performance (COP) of a heat pump is the ratio of the change in heat at the system output to the energy input of the heat pump
DBT	A Dry-Bulb Temperature (DBT) is the temperature of air measured using a thermometer freely exposed to the air but shielded from radiation and moisture. This is the most commonly reported measure of air temperature.
EER	The Energy Efficiency Ratio (EER), an energy efficiency rating for unitary air conditioning and heat pump equipment, is the ratio of cooling output to electric input at a prescribed set of interior and exterior conditions that reflect peak operation
energy-efficient condition	The efficient replacement system (post-retrofit)
ENERGY STAR®	A program, operated by the Environmental Protection Agency, to benchmark efficiency standards for energy-consuming equipment or buildings
HDD	Annual heating degree days
HOU	Annual hours of use for energy-consuming equipment
HSPF	The Heating Seasonal Performance Factor (HSPF) is an estimate of seasonal heating energy efficiency that represents the total heating output of a heat pump, including supplementary electric heat, during the normal heating season (in Btu) as compared to the total electricity consumed (in watt-hours) during the same period
IEER	The Integrated Energy Efficiency Ratio (IEER) is an energy efficiency rating for unitary air conditioning and heat pump equipment larger than 65 kBtu/h, comprised of cooling part-load EER on the basis of weighted operation at various load capacities
ISR	In-service rate represents the proportion of rebated equipment that remains installed and operational
kW/ton	Water-cooled chiller system efficiency, in kW/ton
ODP	Open, drip-proof (ODP) motor enclosure type
participant	Multiple strategies to count participants are in use (see Table 8-7)
Pascal	A Pascal is a derived SI unit of pressure equal to 1 $kg/(m \cdot s^2)$ or 1 N/m^2
ppb	Parts per billion
R	R-value quantifies the degree of insulation provided by a material or building assembly[171]

[171] New York Residential TRM. Prepared for New York Department of Public Service by New York Evaluation Advisory Contractor Team, p. 27.

rpm	Rotational speed of motor, in revolutions per minute (rpm)
SEER	The Seasonal Energy Efficiency Ratio (SEER), an energy efficiency rating for unitary air conditioning and heat pump equipment ≤65 kBtu/h, is the total cooling output divided by the total electric input across a typical cooling season
SVGe	Percentage of annual lighting energy saved by lighting control
SVGd	Percentage of lighting demand saved by lighting control
∆T	Average difference in temperature between cold intake water and shower water
TEFC	Totally enclosed fan-cooled (TEFC) motor enclosure type
TRM	Technical Reference Manual
time of sale[172]	Time at which new equipment purchase takes place to replace an older, pre-existing piece of equipment that has reached the end of its useful life. Also referred to as "replace on burn-out."
VRF	This is a special type of air conditioner or heat pump that allows for Variable Refrigerant Flow (VRF) whereby refrigerant may be used as a cooling and heating medium simultaneously.
∆Water	Customer annual water savings per residential unit, in gallons
WBT	The Wet-Bulb Temperature (WBT) is the air temperature measured with a wet cloth surrounding the thermometer bulb while moving the bulb to simulate a breeze.
WHF	Waste-heat factor to account for electric cooling savings and/or negative electric heating savings from replacing baseline equipment with efficient equipment (e.g., clothes dryers and lighting)[173]

19.1.1 Update Summary

Updates to this section are described in Table 19-1.

Table 19-1. Summary of Update(s)

Updates in Version	Update Type	Description
2021	Definition	Embellished R-value definition
2020	New table	Added table of participant definitions

19.2 Sub-Appendix F1-II: General Equations

Equation 1: Cooling Capacities – Btu/h to tons

$$Size_{ton} = \frac{Size_{Btu/h}}{12{,}000\ Btu/h \cdot ton}$$

[172] Mid-Atlantic TRM 2016, p. 97.
[173] Mid-Atlantic TRM, p. 22.

Equation 2: Cooling Capacities – tons to Btu/h

$$Size_{Btu/h} = Size_{ton} \times 12{,}000\, Btu/h \cdot ton$$

Equation 3: Energy Efficiencies - SEER to EER,[174] for systems < 65,000 Btu/h

If SEER ⩽ 26.0, then use the following quadratic equation,

$$EER \cong -0.02 \times SEER^2 \mp 1.12 \times SEER$$

Otherwise use,

$$EER \cong 15.6$$

If EER ≤ 15.68, then use the following quadratic equation,

$$SEER \cong \frac{1.12 - \sqrt{(-1.12)^2 - (4 \times 0.02 \times EER)}}{2 \times 0.02}$$

Otherwise use,

$$SEER \cong \frac{EER}{0.9}$$

Equation 4: Energy Efficiencies - EER to IEER

$$IEER \cong \frac{EER}{0.9}$$

Equation 5: Energy Efficiencies - HSPF to COP[175]

If HSPF ≤ 11.7, then

$$COP \cong -0.0255 \times HSPF^2 + 0.6239 \times HSPF$$

Otherwise, use

$$COP \cong \frac{HSPF}{3.412}$$

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[174] A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Master's Thesis, University of Colorado at Boulder, Wassmer, M. (2003). Note this is appropriate for single-speed units only.

[175] Ibid.

Equation 6: Energy Efficiencies - COP to HSPF

If COP ≤ 3.81, then use:

$$HSPF \cong \frac{0.6239 + \sqrt{[(-0.6239)^2 - (4 \times 0.0255 \times COP)]}}{2 \times 0.0255}$$

Otherwise, use:

$$HSPF \cong 3.412 \times COP$$

Equation 7: Energy Efficiencies - COP to EER

$$EER \cong 3.412 \times COP$$

Equation 8: Energy Efficiencies – $\frac{\mathbf{kW}}{\mathbf{ton_{full-load}}}$ to $\frac{\mathbf{kW}}{\mathbf{ton_{IPLV}}}$

$$\frac{kW}{ton_{IPLV}} \cong C \times \frac{kW}{ton_{full-load}}$$

where C = 0.80 for water-cooled chillers < 200 tons

= 0.95 for water-cooled chillers ≥ 200 tons

Equation 9: Energy Efficiencies – $\mathbf{EER_{full-load}}$ to $\mathbf{EER_{IPLV}}$

$$EER_{IPLV} \cong C \times EER_{full-load}$$

where C = 0.76 for air-cooled chillers

Equation 10: Heat to Electric Energy – Btu/h to kW

$$kW = 3{,}412\ Btu/h$$

19.2.1 Update Summary

Updates to this section are described in Table 19-2.

Table 19-2. Summary of Update(s)

Updates in Version	Update Type	Description
2021	Added equation condition	Added condition to allow for SEER values higher than 26.
	Revised equation range	Removed lower bound of system size for which Equation 3 can be used
2020	Added equation	Heat-to-electric energy unit conversion added as Equation 10

19.3 Sub-Appendix F1-III: Cooling and Heating Degree Days and Hours

This section provides the reference cooling degree days (CDD) and heating degree days (HDD) using TMY3 data found in the National Solar Radiation Data Base, 1991 – 2005 Update: Typical Meteorological Year 3 (TMY3) produced by the Renewable Resource Data Center (RRDC) of the National Renewable Energy Laboratory (NREL). Data for the following weather stations are used:

- Baltimore BLT-Washington International AP (Weather station number 724060)
- Richmond International AP (Weather station number 724010)
- Norfolk International Airport (Weather station number 723080)
- Roanoke Regional Airport (Weather station number 724110)
- Washington, DC Dulles International Airport (Sterling) (Weather station number 724030)
- Washington, DC Reagan Airport (Arlington) (Weather station number 724050)
- Charlottesville (Weather station number 724016)
- Farmville (Weather station number 724017)
- Shannon Airport (Fredericksburg) (Weather station number 724033)
- Elizabeth City Coast Guard AP (Weather station number 746943)
- Rocky Mount-Wilson AP. (Weather station number 723068)

Weather station identification codes can be found at:
https://www.google.com/fusiontables/DataSource?docid=1EsB07O-9SiqyJDlzl69GO8jTHsomsNIpkA1SLL8#rows:id=1.

TMY3 data can be found at http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3.

TMY3 data spans a base time period between 1976 to 2005 wherever they are available (out of 1,020 locations) and from 1991 to 2005 for the remaining locations. The TMY3 data set provides a reasonably-sized annual dataset that holds hourly meteorological values that typify conditions at a specific location over a longer period of time. It represents a typical climatic condition for a location and excludes extremes. For the purposes of this document, DNV determined that it is more appropriate to use weather data that represents typical climatic conditions. Also, DNV uses actual temperatures from USAF stations in modeling consumption in post-installation evaluations. The corresponding temperatures from TMY3 are then used to predict weather-adjusted—or normalized—consumption. The goal is that models and predictions based on temperature data are using data from the same stations.

The TMY3 hourly data are available for 1,020 USAF stations. For each station, DNV calculates the average hourly temperature for each day. The CDD and HDD are calculated using a range of cooling and heating base temperature. If the average daily temperature is greater than the cooling base temperature, CDD is the deviation in degrees Fahrenheit from the average daily temperature with respect to a cooling base temperature and zero otherwise. If the average daily temperature is less than the heating base temperature, HDD is the deviation in degrees Fahrenheit from the average daily temperature with respect to a heating base temperature and zero otherwise. Daily CDD and HDD are summed for each station to come up with an annual estimate of CDD and HDD, shown in Table 19-4. The same processes are repeated using average hourly temperatures to yield the Cooling Degree Hours (CDH) and Heating Degree Hours (HDH), provided in Table 19-5.

The Maryland/Mid-Atlantic TRM v10 uses different base temperatures for the HDD and CDD calculations, depending upon the measure type. Table 19-3 shows the base temperatures used to determine the CDD, HDD, CDH, and HDH values by the Maryland/Mid-Atlantic TRM for each sector and end use.

Table 19-3. Base Temperatures by Sector and End Use

Sector	End Use	Cooling Base Temperature, °F	Heating Base Temperature, °F	Source
Residential	Plug Load (appliance recycling, only)	65	65	Maryland/Mid-Atlantic TRM v10, p. 67
Residential	HVAC	75	60	Maryland/Mid-Atlantic TRM v10, p.116
Residential	DHW	75	60	–
Residential	Building Envelope	75	60	Mid-Atlantic TRM v9, p. 253, p. 255[176]
Non-Residential	HVAC (except infrared heaters)	65	65	–

Based on the base temperatures used by the Maryland/Mid-Atlantic TRM Version 10, both tables that follow—Table 19-4 and Table 19-5—provide the CDD, HDD, CDH, and HDH values using:

- Base temperatures of 65°F and 75°F for cooling metrics
- Base temperatures of 60°F and 65°F for heating metrics

Prior to the DSM Phase VII programs, savings for all residential measures are calculated using 65°F as the base temperature for CDD, HDD, CDH, and HDH. For DSM Phase VII and beyond, savings for all residential measures—besides refrigerator and freezer recycling—are calculated using 75°F as the base temperature for CDD and CDH and 60°F for HDD and HDH. For refrigerator and freezer recycling, savings are still calculated using 65°F as the base temperature for CDD, HDD, CDH, and HDH.

The location is assigned by the project's utility office code. For projects without an office code, a default location is assigned. The defaults are assigned based on the projects state. Projects in Virginia use a default location of Richmond, VA. Projects in North Carolina, use a default location of Elizabeth City, NC.

[176] Maryland/Mid-Atlantic TRM Version 10 does not include building envelope measures, so values from the Mid-Atlantic TRM v9 are used.

Table 19-4. Reference Cooling and Heating Degree Days

State	Weather Station	Location	Cooling Degree Days		Heating Degree Days		
			CDD – 65 °F[177]	CDD – 75 °F	HDD - 50 °F	HDD - 60 °F	HDD – 65 °F[178]
MD	724060	Baltimore	1,222	231	1,788	3,499	4,611
VA	724010	Richmond (default for VA)	1,436	319	1,367	2,891	3,863
VA	723080	Norfolk	1,610	378	1,069	2,442	3,398
VA	724110	Roanoke	1,100	132	1,536	3,146	4,232
VA	724030	Sterling	1,086	147	1,922	3,697	4,806
VA	724050	Arlington	1,505	440	1,519	3,186	4,268
VA	724016	Charlottesville	1,079	146	1,219	2,668	3,695
VA	724017	Farmville	1,272	205	1,481	3,070	4,081
VA	724033	Fredericksburg	1,355	327	1,808	3,486	4,573
NC	746943	Elizabeth City (default for NC)	1,748	363	642	1,831	2,712
	723068	Rocky Mount	1,355	188	818	2,048	2,951

[177] National Solar Radiation Data Base. 1991-2005 Update: Typical Meteorological Year 3. Accessed June 2017. http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3

[178] Ibid.

Table 19-5. Reference Cooling and Heating Degree Hours

State	Weather Station	Location	Cooling Degree Hours		Heating Degree Hours	
			CDH - 65 °F[179]	CDH - 75 °F	HDH – 60 °F[180]	HDH – 65 °F
MD	724060	Baltimore	32,841	9,616	87,360	113,644
VA	724010	Richmond (default for VA)	39,416	12,954	73,168	97,043
	723080	Norfolk	42,140	12,282	62,307	85,031
	724110	Roanoke	30,730	7,894	80,292	105,902
	724030	Sterling	31,126	8,931	93,950	120,405
	724050	Arlington	38,554	13,178	79,256	104,873
	724016	Charlottesville	31,278	8,202	69,452	94,063
	724017	Farmville	35,914	11,873	78,497	103,328
	724033	Fredericksburg	38,081	13,634	89,662	115,322
NC	746943	Elizabeth City (Default for NC)	45,491	12,936	47,855	68,632
	723068	Rocky Mount-Wilson	38,294	10,759	54,648	76,594

19.3.1 Update Summary

Updates to this section are described in Table 19-6.

Table 19-6. Summary of Update(s)

Updates in Version	Update Type	Description
2021	Modified Weather Station	Updated Virginia weather stations, 7 additional weather stations for Virginia are added. Removed average North Carolina weather stations and apply Elizabeth City and Rocky Mount-Wilson weather stations independently

[179] For consistency across all measures, DNV calculated cooling degree hours at the base 65°F temperature to be used in the attic insulation measure. These values are also used to derive the HVAC full load hours in Sub-Appendix II: Residential HVAC Equipment Full Load Hours.

[180] Ibid.

Updates in Version	Update Type	Description
2020	Modified Weather Station	Updated North Carolina weather station from Charlotte to an average of Elizabeth City and Rocky Mount-Wilson
	Base Temperature	Modified base temperature used for some measures

19.4 Sub-Appendix F1-IV: Residential Equivalent Full-Load Hours for HVAC Equipment

Table 19-7 provides the equivalent full-load hours (EFLH) that are used as defaults to calculate gross annual electric energy savings for Dominion residential programs. The Dominion full-load cooling and heating hours are determined by using ratios of the Cooling Degree Hours (CDH) and Heating Degree Hours (HDH) provided in Sub-Appendix I: Cooling and Heating Degree Days and Hours to adapt the EFLH provided in the Maryland/Mid-Atlantic TRM v10 for Baltimore, MD to represent a location in Dominion's service territory.

$$City\_State\_EFLH_{cool} = \frac{City\_State\_CDH}{Baltimore\_MD\_CDH} \times Baltimore\_MD\_EFLH_{cool}$$

The same method is used to determine the equivalent full-load hours for residential heating systems as follows:

$$City\_State\_EFLH_{heat} = \frac{City\_State\_HDH}{Baltimore\_MD\_HDH} \times Baltimore\_MD\_EFLH_{heat}$$

The location is assigned by the project's utility office code. For projects without an office code, a default location is assigned. The defaults are assigned based on the projects state. Projects in Virginia use a default location of Richmond, VA. Projects in North Carolina, use a default location of Elizabeth City, NC.

Table 19-7. Cooling and Heating Equivalent Full Load Hours (EFLH) for Residential Buildings

System Type	State	Location	$EFLH_{cool}$	$EFLH_{heat}$
Air-source Heat Pump[181]	MD	Baltimore, MD: reference city from Maryland/Mid-Atlantic TRM v10	778[182]	852[183]
	VA	Richmond, VA (default for VA)	1,048	714
	VA	Norfolk, VA	994	608
	VA	Roanoke, VA	639	783
	VA	Sterling, VA	723	916
	VA	Arlington, VA	1,066	773
	VA	Charlottesville, VA	664	677
	VA	Farmville, VA	961	766
	VA	Fredericksburg, VA	1,103	874
	NC	Elizabeth City (default for NC)	1,047	467
	NC	Rocky Mount-Wilson	870	533

[181] Air-source Heat Pump is used for PTHPs. The source TRM does not provide specific EFLH values for PTHPs at residential applications.

[182] Maryland/Mid-Atlantic TRM Version 10, p. 82. Maryland Utility-Specific EFLH Values. Based on EmPOWER Maryland Final Evaluation Report, Evaluation Year 4, Residential HVAC Program, dated April 4, 2014.

[183] Maryland/Mid-Atlantic TRM v10, p. 116. Based on billing analysis of furnace program Evaluation of the High efficiency heating and cooling program, technical report, June 1995.

System Type	State	Location	$EFLH_{cool}$	$EFLH_{heat}$
Ground-source Heat Pump	MD	Baltimore, MD: reference city from Maryland/Mid-Atlantic TRM v10	542[184]	620[185]
	VA	Richmond, VA (default for VA)	730	519
	VA	Norfolk, VA	692	442
	VA	Roanoke, VA	445	570
	VA	Sterling, VA	503	667
	VA	Arlington, VA	743	562
	VA	Charlottesville, VA	462	493
	VA	Farmville, VA	669	557
	VA	Fredericksburg, VA	768	636
	NC	Elizabeth City (default for NC)	729	340
	NC	Rocky Mount-Wilson	606	388
Central AC[186]	MD	Baltimore, MD: reference city from Maryland/Mid-Atlantic TRM v10	568[187]	–
	VA	Richmond, VA (default for VA)	765	–
	VA	Norfolk, VA	725	–
	VA	Roanoke, VA	466	–
	VA	Sterling, VA	528	–
	VA	Arlington, VA	778	–
	VA	Charlottesville, VA	484	–
	VA	Farmville, VA	701	–
	VA	Fredericksburg, VA	805	–
	NC	Elizabeth City (default for NC)	764	–
	NC	Rocky Mount-Wilson	636	–

[184] Maryland/Mid-Atlantic TRM v10, p. 116. Maryland Utility-Specific EFLH Values. Based on EmPOWER Maryland Final Evaluation Report, Evaluation Year 4, Residential HVAC Program, dated April 4, 2014.

[185] Maryland/Mid-Atlantic TRM v10, p. 116. Based on billing analysis of furnace program Evaluation of the High efficiency heating and cooling program, technical report, June 1995.

[186] Central AC is also used for PTAC units. The source TRM does not contain a specific PTAC EFLHs for residential applications

[187] Maryland/Mid-Atlantic TRM v10, p. 75. Based on Maryland-specific values that the evaluation team calculated in EY3 based on EY1 and EY3 metering data.

System Type	State	Location	$EFLH_{cool}$	$EFLH_{heat}$
Forced-air Furnace and Baseboard Electric Resistance Heating[188]	MD	Baltimore, MD: reference city from Maryland/Mid-Atlantic TRM	–	620[189]
	VA	Richmond, VA (default for VA)	–	519
	VA	Norfolk, VA	–	442
	VA	Roanoke, VA	–	570
	VA	Sterling, VA	–	667
	VA	Arlington, VA	–	562
	VA	Charlottesville, VA	–	493
	VA	Farmville, VA	–	557
	VA	Fredericksburg, VA	–	636
	NC	Elizabeth City (default for NC)	–	340
	NC	Rocky Mount-Wilson	–	388
Window/Room AC	MD	Baltimore, MD: reference city from Maryland/Mid-Atlantic TRM	326[190]	–
	VA	Richmond, VA (default for VA)	439	–
	VA	Norfolk, VA	416	–
	VA	Roanoke, VA	268	–
	VA	Sterling, VA	303	–
	VA	Arlington, VA	447	–
	VA	Charlottesville, VA	278	–
	VA	Farmville, VA	403	–
	VA	Fredericksburg, VA	462	–
	NC	Elizabeth City (default for NC)	439	–
	NC	Rocky Mount-Wilson	365	–

188 Forced-air furnace and baseboard electric resistance heating don't have $EFLH_{heat}$ in the source TRM. Therefore, the ground-source heat pump $EFLH_{heat}$ is applied. This is a reasonable approximation as the heating capacity is not likely to vary with weather conditions.

189 Maryland/Mid-Atlantic TRM Version 10, p. 98, Based on assumption from BG&E billing analysis of furnace program in the '90s, from conversation with Mary Straub; "Evaluation of the High efficiency heating and cooling program, technical report", June 1995. For other utilities offering this measure, a Heating Degree Day adjustment may be appropriate to this FLH heat assumption.

190 Mid-Atlantic TRM Version 8, p. 78. "VEIC calculated the average ratio of EFLH for Room AC (provided in RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008) to EFLH for Central Cooling (provided by AHRI: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) at 31%. Applying this to the EFLH for Central Cooling provided for Baltimore (1050) we get 325 EFLH for Room AC." DNV replicated the equation and calculated 325.5 $EFLH_{cool}$ and rounded to 326 $EFLH_{cool}$

19.4.1 Update Summary

Updates to this section are described in Table 19-8.

Table 19-8. Summary of Update(s)

Updates in Version	Update Type	Description
2021	Modified Weather Station	Updated Virginia weather stations, added seven weather stations for Virginia
	Expanded System Types	Added EFLH for ground source heat pump
2020	Modified Weather Station	Updated North Carolina weather station from Charlotte to an average of Elizabeth City and Rocky Mount-Wilson

DNV

19.5 Sub-Appendix F1-V: Residential HVAC Equipment Efficiency Ratings[191]

The efficiency ratings for residential baseline HVAC equipment, <65 kBtu/h, are based upon building code requirements in Virginia and North Carolina, as shown in Table 19-9.

Table 19-9. Residential Baseline and Efficient HVAC Equipment Efficiency Ratings

Standard	System Type[192]	SEER (Btu/Wh)	EER (Btu/Wh)	HSPF (Btu/Wh)	COP[193] (dimension-less)	AFUE (dimension-less)
Federal Standard[194] (baseline case)	Air conditioning system, split-system	13.0	<45 kBtu/h: 12.2 ≥45 kBtu/h (default): 11.7	-	<45 kBtu/h: 3.57 ≥45 kBtu/h (default): 3.42	–
	Air conditioning system, package	14.0	11.0	-	3.22	–
	Air-source heat pump, split-system, ductless mini split heat pump (default for air-source heat pump)	14.0	11.8[195]	8.2	3.40	–
	Air-source heat pump, package	14.0	11.8	8.0	3.35	–
	Resistance heat	–	–	3.4	1.00	–
	Indoor gas furnace	–	–	–	–	0.80
	Outdoor gas furnace	–	–	–	–	0.81
ENERGY STAR[196] (efficient case)	Air conditioning, split system	15.0	12.5	–	–	–
	Air conditioning, package system	15.0	12.0	–	–	–
	Air-source heat pump, split-system	15.0	12.5	8.5	3.46	–
	Air-source heat pump, package system	15.0	12.0	8.2	3.40	–
	Ductless Mini-split heat pump[197]	15.0	12.5	8.5	3.46	–

191 Mid-Atlantic TRM v9 2019, p. 87. Baseline system efficiencies are based on the applicable minimum Federal Appliance & Equipment Standards, Southern Region, consistent with 2015 IECC Table C403.2.3(2)–Minimum Efficiency Requirements: Electrically Operated Unitary and Applied Heat Pump. Further, the table provides minimum efficiency values for units less than 65,000 Btu/h.

192 The gas furnace location is assumed to be indoors if the cooling system type is a split system and outdoor for package systems.

193 For all values except resistance heat, this is calculated using Equation 7 in Sub-Appendix F1-II: General Equations.

194 10 CFR Ch. II (1-1-12 Edition) §430.32 at https://www.govinfo.gov/content/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf, effective 2015-01-01.

195 Since this value was not provided by 10 CFR Ch. II (1-1-12 Edition) §430.32, it was estimated using Equation 3 in Sub-Appendix III: Residential HVAC Equipment Efficiency Ratings.

196 ENERGY STAR Air-Source Heat Pumps and Central Air Conditioners Key Product Criteria at https://www.energystar.gov/products/heating_cooling/heat_pumps_air_source/key_product_criteria (accessed 2019-12-04).

197 Mid-Atlantic TRM v9, p. 120. Ductless mini-split heat pump measure, efficient condition follows Energy Star standards.

DNV

Standard	System Type[192]	SEER (Btu/Wh)	EER (Btu/Wh)	HSPF (Btu/Wh)	COP[193] (dimension-less)	AFUE (dimension-less)
AHRI Qualified Equipment	Ground-source heat pump[198]	21.2[199]	19.1	8.5	3.1	–

Table 19-10 Room Air Conditioner Federal Standard and ENERGY STAR® Minimum Efficiency[200]

Product Type and Class (Btu/h)		Federal Standard with louvered sides (CEER), default[201]	Federal Standard without louvered sides (CEER)	ENERGY STAR with louvered sides (CEER)	ENERGY STAR without louvered sides (CEER)
Without Reverse Cycle	<8,000 (default)[201]	11.0	10.0	12.1	11.0
	8,000 – 10,999	10.9	9.6	12.0	10.6
	11,000 – 13,999	10.9	9.5	12.0	10.5
	14,000 – 19,999	10.7	9.3	11.8	10.2
	20,000 – 24,999	9.4	9.4	10.3	10.3
	25,000 – 27,999	9.0	9.4	10.3	10.3
	≥ 28,000	9.0	9.4	9.9	10.3
With Reverse Cycle	< 14,000	N/A	9.3	N/A	10.2
	14,000 - 19,999	9.8	8.7	10.8	9.6
	≥ 20,000	9.3	N/A	10.2	N/A
Casement Only	Any		9.5		10.5
Casement-Slider	Any		10.4		11.4

19.5.1 Update Summary

Updates to this section are described in Table 19-11.

Table 19-11. Summary of Update(s)

Version with Updates	Update Type	Description
2021	New table	Added new table for Room /Wall AC unit efficiency values
	New equipment	Added ground source heat pump efficiencies to table

198 Ground-source heat pumps aren't included in federal standards or ENERGY STAR qualified equipment. Therefore, to establish an efficiency level that can be used for this equipment type in retrocommsinioning measures, we assign the minimum efficiency levels in AHRI database for residential geoexchange heat pumps, found here: https://www.ahridirectory.org/Search/SearchHome (accessed on 11/01/2021)

199 SEER is not provided in the AHRI database for this equipment type, therefore the EER is converted using the general equation/

200 From Maryland/Mid-Atlantic TRM v10, p.70

201 Default value was selected which yields the most conservative savings estimate

Version with Updates	Update Type	Description
	Combined equipment category	Combined the ductless mini-split heat pump category with the air source heat pump split system as this is a single category in the federal standard baseline.
2020	Added equipment categories	• Added efficiency requirements for ductless mini-split heat pumps • Distinguished between split-system and packaged air-conditioning systems
	Added efficiency category	Added column for COP

19.6 Sub-Appendix F1-VI: Residential Refrigeration Factors

Table 19-12 provides the federal standard refrigerator maximum annual energy consumption if configuration and volume are known.

Table 19-12. Default kWh_{base} Based on Category[202]

Category	Formula for kWh_{base}
1. Refrigerator-freezers and refrigerators other than all-refrigerators with manual defrost	$7.99 \times Volume_{adj.} + 225.0$
1A. All-refrigerators—manual defrost	$6.79 \times Volume_{adj.} + 193.6$
2. Refrigerator-Freezer—partial automatic defrost	$7.99 \times Volume_{adj.} + 225.0$
3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without an automatic icemaker	$8.07 \times Volume_{adj.} + 233.7$
3-BI. Built-in refrigerator-freezer—automatic defrost with top-mounted freezer without an automatic icemaker.	$9.15 \times Volume_{adj.} + 264.9$
3I. Refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker without through-the-door ice service.	$8.07 \times Volume_{adj.} + 317.7$
3I-BI. Built-in refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker without through-the-door ice service.	$9.15 \times Volume_{adj.} + 348.9$
3A. All-refrigerators—automatic defrost.	$7.07 \times Volume_{adj.} + 201.6$
3A-BI. Built-in All-refrigerators—automatic defrost.	$8.02 \times Volume_{adj.} + 228.5$
4. Refrigerator-Freezers--automatic defrost with side-mounted freezer without an automatic icemaker	$8.51 \times Volume_{adj.} + 297.8$
4-BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker.	$10.22 \times Volume_{adj.} + 357.4$
4I. Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service.	$8.51 \times Volume_{adj.} + 381.8$
4I-BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service.	$10.22 \times Volume_{adj.} + 441.4$
5. Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without an automatic icemaker	$8.85 \times Volume_{adj.} + 317.0$
5-BI. Built-In Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker.	$9.40 \times Volume_{adj.} + 336.9$

202 Pennsylvania TRM 2019, pp. 95-102.

Category	Formula for kWh_{base}
5I. Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service.	$8.85 \times Volume_{adj.} + 401.0$
5I-BI. Built-In Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service.	$9.40 \times Volume_{adj.} + 420.9$
5A. Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service.	$9.25 \times Volume_{adj.} + 475.4$
5A-BI. Built-in refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service.	$9.83 \times Volume_{adj.} + 499.9$
6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service	$8.40 \times Volume_{adj.} + 385.4$
7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service	$8.54 \times Volume_{adj.} + 432.8$
7-BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service.	$10.25 \times Volume_{adj.} + 502.6$
11. Compact Refrigerator and Refrigerator-Freezer other than All-Refrigerator - manual defrost	$9.03 \times Volume_{adj.} + 252.3$
11A. Compact All-Refrigerator - manual defrost	$7.84 \times Volume_{adj.} + 219.1$
12. Compact Refrigerator-Freezer - partial automatic defrost	$5.91 \times Volume_{adj.} + 335.8$
13. Compact refrigerator-freezers - automatic defrost with top-mounted freezer	$11.80 \times Volume_{adj.} + 339.2$
13I. Compact refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker.	$11.80 \times Volume_{adj.} + 423.2$
13A. Compact All-Refrigerators - automatic defrost	$9.17 \times Volume_{adj.} + 259.3$
14. Compact Refrigerator-Freezer - automatic defrost with side-mounted freezer	$6.82 \times Volume_{adj.} + 456.9$
14I. Compact Refrigerator-Freezer - automatic defrost with side-mounted freezer with an automatic icemaker	$6.82 \times Volume_{adj.} + 540.9$
15. Compact Refrigerator-Freezer - automatic defrost with Bottom-Mounted freezer	$11.80 \times Volume_{adj.} + 339.2$
15I. Compact Refrigerator-Freezer - automatic defrost bottom-mount- with an automatic icemaker	$11.80 \times Volume_{adj.} + 423.2$

19.6.1 Update Summary

Updates to this section are described in Table 19-13.

Table 19-13. Summary of Update(s)

Updates in Version	Update Type	Description
2021	Initial release	Moved table from refrigerator measure to Sub-Appendix

19.7 Sub-Appendix F1-VII: Residential Lighting Factors

Table 19-14 provides the following associated values for residential LED Lighting measures:

- Annual hours of use (HOU)
- Annual electric waste heat factors for heating season ($WHFe_{heat}$)
- Annual electric waste heat factors for cooling season ($WHFe_{cool}$)
- Demand reduction waste heat factors (WHFd) and
- Sumer coincident factor (CF_{winter})
- Winter coincident factor (CF_{winter})

Table 19-14. Input Values by Room Type for LED Lighting Savings

Fixture Location	Annual HOU[203] (hours)	EUL[204] (years)	For DSM Phase VII and earlier, and unknown heating in DSM Phase VIII[205]			For DSM Phase VIII						CF_{winter}	CF_{winter}
			$WHFe_{heat}$	$WHFe_{cool}$	WHFd	$WHFe_{heat}$		$WHFe_{cool}$		WHFd			
						with electric heating	w/o electric heating	with cooling	w/o cooling	with cooling	w/o cooling		
24-hour indoor	8,760	1.71	0.899	1.077	1.17	0.730	1.000	1.087	1.000	1.190	1.000	1.000	1.000
24-hour outdoor	8,760	1.71	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Dining Room	770	19.48	0.899	1.077	1.170	0.730	1.000	1.087	1.000	1.190	1.000	0.058	0.124
Bedroom	661	20.00	0.899	1.077	1.170	0.730	1.000	1.087	1.000	1.190	1.000	0.058	0.124
Bathroom	788	19.04	0.899	1.077	1.170	0.730	1.000	1.087	1.000	1.190	1.000	0.058	0.124

[203] Hours of use for Dining Room, Bedroom, Bathroom, Hallway, Living Room, Kitchen and Garage are from Navigant, EM&V Report for the 2012 Energy Efficient Lighting Program, Duke Energy Progress, July 2013, p. 23. Hours of use for Indoor ("Residential Interior and in-unit Multi-Family"), and Exterior are from the 2019 Mid-Atlantic TRM, p. 34.

[204] The EUL is based on the methodology used in Maryland/Mid-Atlantic TRM v10, p 34. The EUL is the rated lifetime hours divided by HOU, Rated Lifetime hours is the ENERGY STAR Specifications v2.1 for Integrated Screw Based solid state lighting required to maintain 70% of initial light output for 15,000 hours. The lifetime is capped at 20 years.

[205] The $WHFe_{heat}$, $WHFe_{cool}$, and WHFd factors were drawn from the 2019 Mid-Atlantic TRM v9, pp. 29 – 41.

Fixture Location	Annual HOU[203] (hours)	EUL[204] (years)	For DSM Phase VII and earlier, and unknown heating in DSM Phase VIII[205]			For DSM Phase VIII						CF winter	CF winter
			WHFe heat	WHFe cool	WHFd	WHFe heat		WHFe cool		WHFd			
						with electric heating	w/o electric heating	with cooling	w/o cooling	with cooling	w/o cooling		
Hallway	920	16.30	0.899	1.077	1.170	0.730	1.000	1.087	1.000	1.190	1.000	0.058	0.124
Living Room	916	16.38	0.899	1.077	1.170	0.730	1.000	1.087	1.000	1.190	1.000	0.058	0.124
Kitchen	2,902	5.17	0.899	1.077	1.170	0.730	1.000	1.087	1.000	1.190	1.000	0.058	0.124
Indoors (residential interior)	679	20.00	0.899	1.077	1.170	0.730	1.000	1.087	1.000	1.190	1.000	0.058	0.124
Exterior	1,643	9.13	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.018	0.124
Garage	391	20.00	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.018	0.124
Unknown[206]	760	19.74	0.899	1.077	1.170	0.730	1.000	1.087	1.000	1.190	1.000	0.058	0.124

206 For fixtures in unknown locations, the HOU is a weighted average of those for indoor-, outdoor-, and garage-located fixtures using the weights reported in Final EM&V Report for the 2013 Energy Efficient Lighting Program for Duke Energy Progress by Navigant, p. 23, of 89%, 9%, and 2%, respectively.

Table 19-15. provides the Dominion customer proportion (DCP) to account for likely leakage rate due to purchased lighting products that are installed outside of the Dominion service territory.

Table 19-15. DCP Values for In-Store Lighting Purchases[207]

Store Location	DCP Value
100 Old Fair Grounds Way, Kilmarnock, VA 22482	0.6670
1000 19th Street, Virginia Beach, VA 23451	1.0000
10001 Southpoint Pkwy, Fredericksburg, VA 22407	0.8740
10083 Brook Rd Ste 76, Glen Allen, VA 23059	0.9010
101 Washington Square Plz, Fredericksburg, VA 22405	0.8380
10100 Brook Rd, Glen Allen, VA 23059	0.9059
10101 Southpoint Pkwy, Fredericksburg, VA 22407	0.8930
1020 Battlefield Blvd N, Chesapeake, VA 23320	1.0000
10233 Lakeridge Pkwy, Ashland, VA 23005	0.9339
1027 Centerbrooke Ln, Suffolk, VA 23434	1.0000
10301 New Guinea Rd, Fairfax, VA 22032	0.9764
10310B Main St, Fairfax, VA 22030	0.8226
10461 Midlothian Tpk, Richmond, VA 23235	1.0000
1055 Independence Blvd, Virginia Beach, VA 23455	1.0000
10586 Tinsbloom Mill Ln, King George, VA 22485	0.6670
10689 Sudley Manor Dr, Manassas, VA 20109	0.6750
10731 Jefferson Ave, Newport News, VA 23601	1.0000
10776 Sudley Manor Dr, Manassas, VA 20109	0.6670
109 Lucy Ln, Waynesboro, VA 22980	0.6670
10905 Hull Street Rd, Midlothian, VA 23112	1.0000
1095 International Pkwy, Fredericksburg, VA 22406	0.7230
1098 Frederick Blvd, Portsmouth, VA 23707	1.0000
1100 Stafford Market Pl, Stafford, VA 22556	0.6670
11008 Warwick Blvd Ste 400, Newport News, VA 23601	1.0000
1105 S Military Hwy, Chesapeake, VA 23320	1.0000
1112 London Blvd, Portsmouth, VA 23704	1.0000
11181 Lee Hwy, Fairfax, VA 22030	0.8529
11213 Lee Hwy, Fairfax, VA 22030	0.8950

[207] Provided by program implementation vendor, CleaRESULT.

DNV

Store Location	DCP Value
11214 Jefferson Ave, Newport News, VA 23601	1.0000
11260 W Broad St, Glen Allen, VA 23060	0.9606
11290 W Broad St, Glen Allen, VA 23060	0.9579
11301 Midlothian Tpk, Richmond, VA 23235	1.0000
11400 W Broad St, Glen Allen, VA 23060	0.9586
1149 Nimmo Pkwy, Virginia Beach, VA 23456	1.0000
1157 Nimmo Pkwy Ste 102, Virginia Beach, VA 23456	1.0000
117 Market Place Dr, Hampton, VA 23666	1.0000
1170 N Military Hwy, Norfolk, VA 23502	1.0000
11740 W Broad St Ste 101, Richmond, VA 23233	0.9570
1180 Carl D Silver Pkwy, Fredericksburg, VA 22401	0.9422
1200 N Main St, Suffolk, VA 23434	1.0000
12000 Iron Bridge Rd, Chester, VA 23831	0.9863
12000 Ridgefield Pkwy, Richmond, VA 23233	0.9900
1201 Gateway Blvd, Fredericksburg, VA 22401	0.8777
1201 Mall Dr, Richmond, VA 23235	1.0000
1204 S Military Hwy, Chesapeake, VA 23320	1.0000
12101 Jefferson Davis Hwy, Chester, VA 23831	0.9780
1211 N Lee Hwy, Lexington, VA 24450	0.6650
12121 Jefferson Ave, Newport News, VA 23602	1.0000
12130 Jefferson Ave, Newport News, VA 23602	1.0000
1216 N Main St, Suffolk, VA 23434	0.9999
12197 Sunset Hills Rd, Reston, VA 20190	0.9919
12200 Chattanooga Plz, Midlothian, VA 23112	1.0000
1221 Harris St, Charlottesville, VA 22903	0.7880
12275 Price Club Plz, Fairfax, VA 22030	0.8378
12300 Chattanooga Plz, Midlothian, VA 23112	0.9997
12300 Jefferson Davis Hwy, Chester, VA 23831	0.9464
1236 Concord Ave, Richmond, VA 23228	0.9760
12372 Dillingham Sq., Woodbridge, VA 22192	0.6670
12401 Jefferson Ave, Newport News, VA 23602	1.0000
12407 Jefferson Ave, Newport News, VA 23602	1.0000
1245 N Military Hwy, Norfolk, VA 23502	1.0000

Store Location	DCP Value
12490 Warwick Blvd, Newport News, VA 23606	1.0000
125 Washington Square Plz, Fredericksburg, VA 22405	0.8400
1250 E Atlantic St, LaCrosse, VA 23950	0.6660
1261 N Military Hwy, Norfolk, VA 23502	1.0000
12651 Apollo Dr, Woodbridge, VA 22192	0.6670
12725 Jefferson Ave, Newport News, VA 23602	1.0000
1280 Smithfield Plz, Smithfield, VA 23430	0.6670
13047 Fair Lakes Shopping Ctr, Fairfax, VA 22033	0.8476
1305 Carmia Way, Richmond, VA 23235	1.0000
13059 Fair Lakes Parkway, Fairfax, VA 22033	0.8521
1308 Battlefield Blvd N, Chesapeake, VA 23320	1.0000
1316 Greenbrier Pkwy, Chesapeake, VA 23320	1.0000
1317 W Broad St, Waynesboro, VA 22980	0.6670
1320 N Laburnum Ave, Richmond, VA 23223	1.0000
13345 Worth Ave, Woodbridge, VA 22192	0.6700
13580 Minnieville Rd, Woodbridge, VA 22192	0.6840
1361 Carl D Silver Pkwy, Fredericksburg, VA 22401	0.9051
13653 Lee Jackson Memorial Hwy # B, Chantilly, VA 20151	0.8860
1367 Kempsville Rd, Chesapeake, VA 23320	1.0000
1385 Fordham Dr Ste 113, Virginia Beach, VA 23464	1.0000
13856 Metrotech Dr, Chantilly, VA 20151	0.8582
1386 Carmia Way, Richmond, VA 23235	1.0000
14 Lee Jackson Hwy, Staunton, VA 24401	0.6670
1400 Tintern St, Chesapeake, VA 23320	1.0000
1401 Emmet St N, Charlottesville, VA 22903	0.7660
1401 Mall Dr, North Chesterfield, VA 23235	0.9999
1405B S Main St, Farmville, VA 23901	0.6670
1410 Airport Road, Suffolk, VA 23434	0.9990
14120 Lee Hwy # B, Centreville, VA 20120	0.7720
1413 N Armistead Ave, Hampton, VA 23666	1.0000
14390 Chantilly Crossing Ln, Chantilly, VA 20151	0.8262
14391 Chantilly Crossing Ln, Chantilly, VA 20151	0.8605
14501 Hancock Village St, Chesterfield, VA 23832	0.9899

DNV

Store Location	DCP Value
1457 Mt Pleasant Rd Ste 101A, Chesapeake, VA 23322	1.0000
14610 Lee Hwy, Gainesville, VA 20155	0.6670
15 Town Center Way, Hampton, VA 23666	1.0000
1500 Cornerside Blvd Ste B, Vienna, VA 22182	1.0000
1500 Wilson Blvd, Rosslyn, VA 22209	0.8396
1501 Sams Cir, Chesapeake, VA 23320	1.0000
1502 Boulevard, Colonial Heights, VA 23834	0.6960
1504 N Parham Rd, Richmond, VA 23229	1.0000
1505 Lynnhaven Pkwy Ste 1355, Virginia Beach, VA 23453	1.0000
1509 Sams Cir, Chesapeake, VA 23320	1.0000
1510 W Broad St, Richmond, VA 23220	1.0000
1512 Koger Center Blvd, Richmond, VA 23235	1.0000
1521 Sams Cir, Chesapeake, VA 23320	1.0000
1540 International Blvd, Norfolk, VA 23513	1.0000
157 Hillcrest Pkwy, Chesapeake, VA 23322	1.0000
1629 Tappahannock Blvd, Tappahannock, VA 22560	0.6670
1651 Reston Pkwy, Reston, VA 20194	0.9616
171 W Lee Hwy, Warrenton, VA 20186	0.6670
1720 E Little Creek Rd, Norfolk, VA 23518	1.0000
17342 General Puller Hwy, Deltaville, VA 23043	1.0000
1800 Carl D Silver Pkwy, Fredericksburg, VA 22401	0.9558
1800 Liberty St Ste 106, Chesapeake, VA 23324	1.0000
18109 Triangle Shopping Plz, Dumfries, VA 22026	0.6670
1832 Kempsville Rd, Virginia Beach, VA 23464	1.0000
1832 Peery Dr, Farmville, VA 23901	0.6670
1900 Cunningham Dr, Hampton, VA 23666	1.0000
1909 Landstown Centre Way, Virginia Beach, VA 23456	1.0000
1918 William St, Fredericksburg, VA 22401	0.8430
1937 E Pembroke Ave, Hampton, VA 23663	1.0000
1948 Diamond Springs Rd, Virginia Beach, VA 23455	1.0000
1949 Lynnhaven Pkwy Ste 1552, Virginia Beach, VA 23453	1.0000
1950 Anderson Hwy, Powhatan, VA 23139	0.9166
1952 Laskin Rd Ste 512, Virginia Beach, VA 23454	1.0000

Store Location	DCP Value
1973 S Military Hwy, Chesapeake, VA 23320	1.0000
1991 Daniel Stuart Sq., Woodbridge, VA 22191	0.6690
200 Marquis Pkwy, Williamsburg, VA 23185	1.0000
2002 Power Plant Pkwy, Hampton, VA 23666	1.0000
201 Hillcrest Pkwy, Chesapeake, VA 23322	1.0000
201 Perimeter Dr, Midlothian, VA 23113	0.9954
202 E Williamsburg Rd, Sandston, VA 23150	1.0000
2020 Lynnhaven Pkwy, Virginia Beach, VA 23456	1.0000
2020 Rio Hill Ctr, Charlottesville, VA 22901	0.6950
2021 Lynnhaven Pkwy, Virginia Beach, VA 23456	1.0000
2044 Victory Blvd, Portsmouth, VA 23702	1.0000
2060 S Independence Blvd, Virginia Beach, VA 23453	1.0000
2098 Nickerson Blvd Ste A, Hampton, VA 23663	1.0000
2098 Nickerson Blvd, Hampton, VA 23663	1.0000
210 Monticello Ave, Williamsburg, VA 23185	1.0000
21398 Price Cascades Plz, Sterling, VA 20164	0.8133
215 Maple Ave W, Vienna, VA 22180	0.9710
21800 Towncenter Plz Ste 237, Sterling, VA 20164	0.8430
2210 Portsmouth Blvd, Portsmouth, VA 23704	1.0000
222 W 21st St, Norfolk, VA 23517	1.0000
2233 Upton Dr, Virginia Beach, VA 23454	1.0000
22330 S Sterling Blvd Ste A123, Sterling, VA 20164	0.7970
2324 Elson Green Ave, Virginia Beach, VA 23456	1.0000
233 Carmichael Way, Chesapeake, VA 23322	1.0000
237 Battlefield Blvd S Ste 13, Chesapeake, VA 23322	1.0000
2371 Carl D Silver Parkway, Fredericksburg, VA 22401	0.9558
2371 Carl D. Silver Pkwy, Fredericksburg, VA 22401	0.9558
2375 Pocahontas Trl, Quinton, VA 23141	1.0000
2384 Hayes Rd, Hayes, VA 23072	1.0000
2403 Virginia Beach Blvd, Virginia Beach, VA 23454	1.0000
2410 Sheila Ln, Richmond, VA 23225	1.0000
2420 E Little Creek Rd, Norfolk, VA 23518	1.0000
2421 Old Taylor Rd, Chesapeake, VA 23321	1.0000

Store Location	DCP Value
2430 Sheila Ln, Richmond, VA 23225	1.0000
2444 Chesapeake Square Ring Rd, Chesapeake, VA 23321	1.0000
2448 Chesapeake Square Ring Rd, Chesapeake, VA 23321	1.0000
25 S Gateway Dr, Fredericksburg, VA 22406	0.8448
2501 Sheila Ln, Richmond, VA 23225	1.0000
2530 Weir Rd, Chester, VA 23831	0.9511
2601 George Washington Mem Hwy, Yorktown, VA 23693	1.0000
2601 Weir Pl, Chester, VA 23831	0.9293
264 Cedar Ln SE Ste Ab-C, Vienna, VA 22180	0.9880
2715 W Main St, Waynesboro, VA 22980	0.6670
2720 N Mall Dr Ste 208, Virginia Beach, VA 23452	1.0000
2815 Merrilee Dr, Fairfax, VA 22031	0.9868
2905 District Ave, Fairfax, VA 22031	0.9963
299 Banks Ford Pkwy, Fredericksburg, VA 22406	0.8269
300 Chatham Dr, Newport News, VA 23602	1.0000
301 E Atlantic St, South Hill, VA 23970	0.6670
3061 Plank Rd, Fredericksburg, VA 22401	0.9440
308 Cavalier Sq., Hopewell, VA 23860	0.7070
3101 Jefferson Davis Hwy, Alexandria, VA 22305	0.9828
3102 Plank Rd Ste 600, Fredericksburg, VA 22407	0.8309
3105 S Crater Rd, Petersburg, VA 23805	0.6670
314 King St, Keysville, VA 23947	0.6660
3146 Western Branch Blvd, Chesapeake, VA 23321	1.0000
315 Cowardin Ave, Richmond, VA 23224	1.0000
3157 Magic Hollow Blvd, Virginia Beach, VA 23453	1.0000
3171 District Ave, Charlottesville, VA 22901	0.7669
3201 Holland Rd, Virginia Beach, VA 23453	1.0000
3201 Old Lee Hwy, Fairfax, VA 22030	0.9444
32032 N Main St, Boykins, VA 23827	0.6670
321 Thacker Ave, Covington, VA 24426	0.6670
3230 Tidewater Dr, Norfolk, VA 23509	1.0000
325 Chatham Dr, Newport News, VA 23602	1.0000
3330 S Crater Rd, Petersburg, VA 23805	0.6670

Store Location	DCP Value
3332 Princess Anne Rd, Virginia Beach, VA 23456	1.0000
3345 Virginia Beach Blvd, Virginia Beach, VA 23452	1.0000
335 Merchant Walk Sq. Bldg. 800, Charlottesville, VA 22902	0.8630
3350 E Princess Anne Rd, Norfolk, VA 23502	1.0000
3352 Virginia Beach Blvd, Virginia Beach, VA 23452	1.0000
337 Perimeter Dr, Midlothian, VA 23113	0.9970
3376 S Military Hwy, Chesapeake, VA 23323	1.0000
3412 W Mercury Blvd, Hampton, VA 23666	0.9980
3565 Holland Rd, Virginia Beach, VA 23452	1.0000
3569 Bridge Rd # 201, Suffolk, VA 23435	0.9900
3601 Old Halifax Rd Ste 200, South Boston, VA 24592	0.6670
3690 King St, Alexandria, VA 22302	0.9020
3750 Virginia Beach Blvd Ste B, Virginia Beach, VA 23452	1.0000
3818 Kecoughtan Rd, Hampton, VA 23669	1.0000
3857 Kecoughtan Rd, Hampton, VA 23669	1.0000
3877 Holland Rd, Virginia Beach, VA 23452	1.0000
3915 Centreville Rd, Chantilly, VA 20151	0.8520
3978 Meadowdale Blvd, Richmond, VA 23234	1.0000
40 Main Street -, Mathews, VA 23109	1.0000
400 S Pickett St, Alexandria, VA 22304	1.0000
400 W 21st St, Norfolk, VA 23517	1.0000
4000 Glenside Dr, Richmond, VA 23228	1.0000
4036 Victory Blvd, Portsmouth, VA 23701	1.0000
4040 Victory Blvd, Portsmouth, VA 23701	1.0000
4080 Jermantown Rd, Fairfax, VA 22030	0.8922
411 Wythe Creek Rd, Poquoson, VA 23662	1.0000
416 13th Street, West Point, VA 23181	0.6700
420 Pantops Ctr, Charlottesville, VA 22911	0.7140
4200 Portsmouth Blvd Ste 600, Chesapeake, VA 23321	1.0000
4300 Portsmouth Blvd Ste 170, Chesapeake, VA 23321	1.0000
4311 Walney Rd, Chantilly, VA 20151	0.8914
43150 Broadlands Center Plz Ste 110, Ashburn, VA 20148	0.6670
4318B George Washington Mem Hwy, Yorktown, VA 23692	1.0000

Store Location	DCP Value
4336 Virginia Beach Blvd, Virginia Beach, VA 23452	1.0000
4340 S Laburnum Ave, Richmond, VA 23231	1.0000
4368 Chantilly Shopping Center Dr, Chantilly, VA 20151	0.8568
4401 Pouncey Tract Rd, Glen Allen, VA 23060	0.9515
44110 Ashburn Shopping Plz, Ashburn, VA 20147	0.6670
4511 John Tyler Hwy Ste L, Williamsburg, VA 23185	1.0000
4521 S Laburnum Ave, Richmond, VA 23231	1.0000
45425 Dulles Crossing Plz, Sterling, VA 20166	0.7757
455 Oriana Rd, Newport News, VA 23608	1.0000
4551 S Laburnum Ave, Henrico, VA 23231	1.0000
4554 Virginia Beach Blvd, Virginia Beach, VA 23462	1.0000
4601 Commonwealth Centre Pkwy, Midlothian, VA 23112	0.9996
462 Wythe Creek Rd, Poquoson, VA 23662	1.0000
4630 Monticello Ave, Williamsburg, VA 23188	1.0000
4640 Monticello Ave, Williamsburg, VA 23188	1.0000
4655 Monticello Ave, Williamsburg, VA 23188	1.0000
4670 Casey Blvd, Williamsburg, VA 23188	1.0000
4708 Portsmouth Blvd, Chesapeake, VA 23321	1.0000
4725 W Ox Rd, Fairfax, VA 22030	0.9032
475 Kempsville Rd, Chesapeake, VA 23320	1.0000
4805 Shore Dr Ste B, Virginia Beach, VA 23455	1.0000
4814 Penlan Rd, New Canton, VA 23123	0.6670
4821 Virginia Beach Blvd, Virginia Beach, VA 23462	1.0000
4925 W Broad St Ste 404, Richmond, VA 23230	1.0000
500 S. Washington St, Falls Church, VA 22046	1.0000
5001 Holt Ave, Hampton, VA 23666	1.0000
5001 Nine Mile Rd, Henrico, VA 23223	1.0000
5007 Victory Blvd, Yorktown, VA 23693	1.0000
504 Bud Dr, Chesapeake, VA 23322	1.0000
5061 Westfields Blvd, Centreville, VA 20120	0.8050
5073 Jefferson Davis Hwy, Fredericksburg, VA 22408	0.9120
508 Fort Evans Rd, Leesburg, VA 20176	0.6670
5115 Leesburg Pike, Falls Church, VA 22041	1.0000

Store Location	DCP Value
514 N Main St, Emporia, VA 23847	0.6670
5210 Wilkinson Rd, Henrico, VA 23227	0.9990
5215 Plank Rd, Fredericksburg, VA 22407	0.9630
5221 Brook Rd, Richmond, VA 23227	0.9863
5222 Oaklawn Blvd Ste B2, Hopewell, VA 23860	0.6910
525 First Colonial Rd, Virginia Beach, VA 23451	1.0000
5270A Chamberlayne Rd, Richmond, VA 23227	0.9850
5275 Waterway Dr, Dumfries, VA 22025	0.6670
5277 Princess Anne Rd, Virginia Beach, VA 23462	1.0000
5401 W Broad St, Richmond, VA 23230	1.0000
546 First Colonial Rd, Virginia Beach, VA 23451	1.0000
5630 Princess Anne Rd Ste B, Virginia Beach, VA 23462	1.0000
57 W Windsor Blvd, Windsor, VA 23487	0.8120
5700 Hopkins Rd, North Chesterfield, VA 23234	1.0000
5771 Plank Rd, Fredericksburg, VA 22407	0.9497
5885 Kingstowne Blvd, Alexandria, VA 22315	1.0000
5900 E Virginia Beach Blvd Ste 206, Norfolk, VA 23502	1.0000
6000 Burke Commons Rd, Burke, VA 22015	0.9863
605 Newmarket Dr N Ste 1, Newport News, VA 23605	0.9990
6100 Arlington Blvd, Falls Church, VA 22044	1.0000
6101 N Military Hwy Ste 100, Norfolk, VA 23518	1.0000
6111 Jefferson Ave, Newport News, VA 23605	0.9979
614 S Hicks St, Lawrenceville, VA 23868	0.6670
6140 Rose Hill Dr, Alexandria, VA 22310	1.0000
6198 Little River Tpk, Alexandria, VA 22312	1.0000
6210 Seven Corners Ctr, Falls Church, VA 22044	1.0000
6215 Portsmouth Blvd, Portsmouth, VA 23701	1.0000
622 S Main St, Emporia, VA 23847	0.6670
6255 College Dr, Suffolk, VA 23435	0.9980
6259 College Dr, Suffolk, VA 23435	1.0000
6303 Richmond Hwy, Alexandria, VA 22306	0.9715
632 Grassfield Pkwy, Chesapeake, VA 23322	1.0000
6425 Mechanicsville Tpk, Mechanicsville, VA 23111	0.9984

Store Location	DCP Value
6449 Centralia Rd, Chesterfield, VA 23832	0.9780
6493 Mechanicsville Tpk, Mechanicsville, VA 23111	0.9820
6501 W Broad St, Richmond, VA 23230	1.0000
6555 Little River Tpk, Alexandria, VA 22312	1.0000
6569 Market Dr, Gloucester, VA 23061	1.0000
657 Phoenix Dr, Virginia Beach, VA 23452	1.0000
6600 Richmond Hwy, Alexandria, VA 22306	0.9983
6600 Springfield Mall, Springfield, VA 22150	1.0000
6610 Mooretown Rd, Williamsburg, VA 23188	1.0000
663 Turnberry Blvd, Newport News, VA 23602	1.0000
6659 George Washington Memorial Hwy, Gloucester, VA 23061	1.0000
6691 Frontier Dr, Springfield, VA 22150	1.0000
6700 Mooretown Rd, Williamsburg, VA 23188	1.0000
6715 Backlick Rd, Springfield, VA 22150	1.0000
672 Elden St, Herndon, VA 20170	0.9590
673 Cedar Rd, Chesapeake, VA 23322	1.0000
6730 Jefferson Davis Hwy, Richmond, VA 23237	1.0000
6750 Richmond Hwy, Alexandria, VA 22306	0.9848
6757 Lake Harbour Dr, Midlothian, VA 23112	0.9960
6819 Waltons Ln, Gloucester, VA 23061	1.0000
6825 Phenix Main St, Phenix, VA 23959	0.6670
6920 Braddock Rd, Annandale, VA 22003	1.0000
6920 Forest Ave, Richmond, VA 23230	1.0000
6921 Waltons Ln, Gloucester, VA 23061	1.0000
7 Town Center Way, Hampton, VA 23666	1.0000
7001 Winterpock Rd, Chesterfield, VA 23832	0.9910
701 Battlefield Blvd N Ste D, Chesapeake, VA 23320	1.0000
7041 Brookfield Plz, Springfield, VA 22150	1.0000
7107 Forest Hill Ave, Richmond, VA 23225	1.0000
7126 Hayes Shopping Ct, Hayes, VA 23072	1.0000
72 Coliseum Xing, Hampton, VA 23666	1.0000
7235 Bell Creek Rd, Mechanicsville, VA 23111	1.0000
7251 Bell Creek Rd, Mechanicsville, VA 23111	0.9947

Store Location	DCP Value
7300 Midlothian Tpk Ste A, Richmond, VA 23225	1.0000
731 E Rochambeau Dr, Williamsburg, VA 23188	1.0000
7373 Boston Blvd, Springfield, VA 22153	0.9811
7390 Bell Creek Rd Ste 308A, Mechanicsville, VA 23111	0.9960
7430 Bell Creek Rd, Mechanicsville, VA 23111	0.9924
7448 Little River Tpk Ste B, Annandale, VA 22003	1.0000
7525 Tidewater Dr, Norfolk, VA 23505	1.0000
7528 Mechanicsville Tpk, Mechanicsville, VA 23111	1.0000
7530 Tidewater Dr, Norfolk, VA 23505	1.0000
7552 W Broad St, Richmond, VA 23294	1.0000
7635 Granby St, Norfolk, VA 23505	1.0000
7700 Gunston Plz # A, Lorton, VA 22079	0.9020
7710 Richmond Hwy, Alexandria, VA 22306	1.0000
7734 Hampton Blvd Ste A, Norfolk, VA 23505	1.0000
7812 Richmond Hwy, Alexandria, VA 22306	1.0000
7901 Brook Rd, Richmond, VA 23227	0.9718
7910 Richmond Hwy, Alexandria, VA 22306	1.0000
7940 Richmond Hwy, Alexandria, VA 22306	0.9878
8001 Brook Rd, Richmond, VA 23227	0.9765
801 E Rochambeau Dr, Williamsburg, VA 23188	1.0000
801 Merrimac Trl, Williamsburg, VA 23185	1.0000
830 Southpark Blvd, Colonial Heights, VA 23834	0.6670
8315 Sudley Rd, Manassas, VA 20109	0.6670
8401 Hampton Blvd Ste 2, Norfolk, VA 23505	1.0000
8484 Kings Hwy, King George, VA 22485	0.6670
8490 Centreville Rd # A, Manassas Park, VA 20111	0.6670
850 Glenrock Rd, Norfolk, VA 23502	1.0000
8601 Airport Rd, Quinton, VA 23141	1.0000
869 S Pickett St, Alexandria, VA 22304	1.0000
8784 Guinea Road, Hayes, VA 23072	1.0000
8794 Sacramento Dr, Alexandria, VA 22309	1.0000
8920 Patterson Ave, Richmond, VA 23229	1.0000
900 Tidewater Dr, Norfolk, VA 23504	1.0000
900 Walmart Way, Midlothian, VA 23113	1.0000
9001 Staples Mill Rd, Henrico, VA 23228	0.9824
901 Walmart Way, Midlothian, VA 23113	0.9984
9140 Amelia St, Amelia Court House, VA 23002	0.6670
9159 Atlee Rd, Mechanicsville, VA 23116	0.9861

DNV

Store Location	DCP Value
922 N Main St Ste A, Suffolk, VA 23434	1.0000
9232 Old Keene Mill Rd Ste B, Burke, VA 22015	1.0000
928 Diamond Springs Rd Ste 102, Virginia Beach, VA 23455	1.0000
9422 W Broad St, Richmond, VA 23294	0.9660
9440 W Broad St, Richmond, VA 23294	0.9685
9490 W Broad St, Richmond, VA 23294	0.9718
9534 Main St, Fairfax, VA 22031	0.9520
9536 Woodman Rd # 9540, Richmond, VA 23228	0.9730
955 Providence Sq. Shopping Ctr, Virginia Beach, VA 23464	1.0000
9573 Shore Dr, Norfolk, VA 23518	1.0000
9620 Granby St, Norfolk, VA 23503	1.0000
9650 W Broad St, Glen Allen, VA 23060	0.9649
9692 Liberia Ave, Manassas, VA 20110	0.6670
970 Hilton Heights Rd, Charlottesville, VA 22901	0.7528
9714 Sliding Hill Rd, Ashland, VA 23005	0.9008
9785 Jefferson Davis Hwy, Fredericksburg, VA 22407	0.8403
9870 W Broad St, Glen Allen, VA 23060	0.9820
99 Hill Carter Pkwy, Ashland, VA 23005	0.6670
9901 County Dr, Disputanta, VA 23842	0.6670

19.7.1 Update Summary

Updates to this section are described in Table 19-16.

Table 19-16. Summary of Update(s)

Updates in Version	Update Type	Description
2021		No Updates
2020		Initial release

19.8 Sub-Appendix F1-VIII: Residential Account Normalized Annual Consumption

Forecasted ex ante savings or deemed savings for the smart thermostat, home energy reports, and central home energy management measures are calculated by multiplying a savings factor by either participant specific normalized energy usage or the average energy usage of Dominion's residential customers by premise type and region. This section describes how customer usage values are applied to the deemed savings calculations for applicable measures. The normalized customer specific annual kWh values are determined using the methodology discussed in Sub-Appendix F1-IX: Billing Analysis. The annual kWh default values shown in Table 19-17 will be updated annually.

If a customer specific annual kWh value is unavailable, or outside an acceptable range, a default value is assigned. Examples of circumstances where the default may be required includes:

- The customer/premise combination is not found in the Dominion Energy provided billing usage data set. This will apply in the case of new construction.
- The predicted annual consumption from the individual customer regression prior to normalization is not within 25% of actual consumption

Defaults values in Table 19-17 are assigned by region and premise type (when available).

Table 19-17. Default Residential Normalized Consumption by Region and Premise Type

Region	Premise Type	Default Whole House Annual Consumption, kWh	Default Base Load Annual Consumption, kWh	Default Cool Load Consumption, kWh	Default Heating Load Consumption, kWh
Central	Condo	9,775	5,574	1,698	2,503
	Garden APT	8,487	5,172	1,541	1,774
	MID/HI Rise	7,548	4,963	1,121	1,464
	Mobile Home	15,207	7,550	2,177	5,480
	Single Family Home	15,701	8,590	2,790	4,321
	Townhouse	9,615	5,920	1,896	1,798
	Average	**7,351**	**3,930**	**1,311**	**2,110**
Eastern	Condo	11,062	6,501	1,689	2,872
	Garden APT	8,905	5,553	1,406	1,947
	MID/HI Rise	7,995	5,218	1,167	1,611
	Mobile Home	15,135	7,597	1,876	5,662
	Single Family Home	14,845	8,561	3,067	3,217
	Townhouse	10,938	6,627	2,028	2,283
	Average	**8,723**	**5,078**	**1,464**	**2,182**

Region	Premise Type	Default Whole House Annual Consumption, kWh	Default Base Load Annual Consumption, kWh	Default Cool Load Consumption, kWh	Default Heating Load Consumption, kWh
	Condo	11,482	6,257	1,521	3,704
	Garden APT	7,657	4,786	1,345	1,526
	MID/HI Rise	6,661	4,507	1,155	999
Northern	Mobile Home	15,572	7,510	2,101	5,962
	Single Family Home	15,605	9,621	2,832	3,152
	Townhouse	11,044	7,012	2,087	1,945
	Average	**9,264**	**5,323**	**1,472**	**2,469**
	Condo	7,911	3,675	2,694	1,542
	Garden APT	10,290	5,396	1,867	3,027
	MID/HI Rise	9,698	5,231	1,886	2,580
Southern	Mobile Home	16,029	8,360	2,378	5,291
	Single Family Home	15,823	8,296	3,405	4,122
	Townhouse	9,644	5,004	2,075	2,565
	Average	**10,330**	**5,525**	**1,838**	**2,967**
	Condo	10,425	5,794	1,282	3,349
	Garden APT	8,565	5,010	1,036	2,519
	MID/HI Rise	8,620	5,339	949	2,332
Western	Mobile Home	15,574	7,935	1,356	6,283
	Single Family Home	15,006	8,526	1,855	4,626
	Townhouse	11,002	6,218	1,446	3,338
	Average	**8,037**	**4,489**	**1,002**	**2,546**
Average		**9,387**	**5,463**	**1,554**	**2,370**

19.8.1 Update Summary

Updates to this section are described in Table 19-18.

Table 19-18. Summary of Update(s)

Updates in Version	Update Type	Description
2021		Initial release

19.9 Sub-Appendix F1-IX: Billing Analysis

19.9.1 Billing Analysis Summary

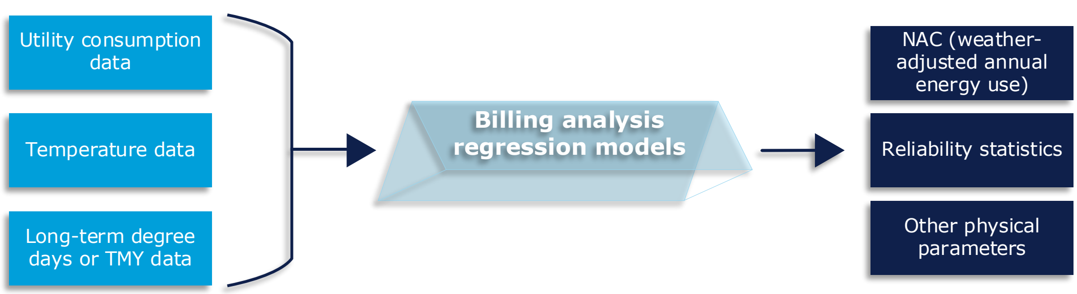
Billing analysis (a form of consumption data analysis) is an industry-standard EM&V method for determining the energy consumption effects of DSM programs. Billing analysis allows a comparison of the energy consumption of buildings or households. This appendix provides an overview of billing analysis methods. The application of billing analysis to specific measure level or program savings estimates can be found in the respective measure sections.

19.9.2 Determining Whole-facility Normalized Annual Consumption

Heating and cooling consumption are estimated using a widely applied method based on the decades-old PriSM approach (PRInceton Scorekeeping Method) at the customer account/site level. This approach involves estimating a set of regression models based on billing data (energy consumption) as a function of weather. The estimated weather parameters combined with typical weather data provide heating and cooling estimates for residential homes to produce estimates of normalized annual consumption (NAC).[208]

This physical model of residential energy consumption is well determined due to the linear relationship between the outdoor temperature and energy consumption for heating and cooling, coupled with the consistent patterns of household behavior.[209] Conditions such as changes in occupancy, retrofits or renovations that impact heating or cooling loads or equipment efficiency, or life events that produce changes in behavior influence the strength of model results, but are detectable and can be adjusted for in an analysis.

Figure 19-1. Regression-based Billing Analysis Method for Single/Group Household Account(s)



19.9.3 Regression Model

The regression model is given by:

$$Eim = \beta 0 + \beta hHim(\tau h) + \beta cCim(\tau c) + \varepsilon im$$

Where:

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[208] Further discussion of these methods can be found in Li, M.; Haeri, H.; Reynolds, A. (2017). The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures, “Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol,” CO; National Renewable Energy Laboratory. NREL/SR-7A40-70472; CALTRACK Models, Technical Appendix; Fels, M. F. 1986. "PRISM: An introduction," Energy & Buildings 9: pp. 5-18.

[209] The linear relationship between heat pump operations and outdoor temperature is less well determined than traditional gas and electric HVAC equipment and billing analysis methods for heat pumps are adjusted accordingly.

Eim	= average electric consumption per day for participant i during period m
$Him(\tau h)$	= heating degree-days (HDD) at the heating base reference temperature, τh
$Cim(\tau c)$	= cooling degree-days (CDD) at the cooling base reference temperature, τc
$\beta 0, \beta h, \beta c$	= site-level regression coefficients measuring intercept (base load), heating load, and cooling load, on a single year's energy consumption, respectively
τh	= heating base temperatures, determined by choice of the optimal regression
τc	= cooling base temperatures, determined by choice of the optimal regression
εim	= regression residual

Multiple models are estimated over a range of heating and cooling degree days. The models are screened to remove estimates that have implausible (negative) cooling and heating coefficients and insufficient data. Statistical tests identify the optimal model and the associated site-specific reference temperature base. The optimal site-level models produce parameters that indicate the level of energy consumption correlated with HDD or CDD as well as levels of energy consumption not correlated with either HDD or CDD (baseload).

Model parameter estimates for each site allow the prediction of site-level heating, cooling, and baseload consumption, under any weather condition. For ex post savings calculations, heating and cooling consumption will be put on a typical weather basis, using TMY values or 10–12 years of actual daily or hourly temperature data, converted to degree days based on the site-specific optimal degree-day bases (determined by the reference temperature). Total heating and cooling consumption or normalized annual consumption (NAC) will be estimated on an annual basis for electricity consumption for each residential household in Dominion's service territory. Average customer values, or default estimates will also be calculated for household that do not have site-specific heating and cooling estimates.

19.9.4 Second Stage Billing Analysis or Measure-Level Savings

Assuming that non-program-related change has been addressed (through billing analysis methods described above and a comparison group), the overall billing analysis result provides the average overall savings given the mix of the measures installed. With the second stage, regression is used to apportion the pre-post change in consumption to specific measures. A number of factors need to line up to get reasonable estimates of measure-level savings for all measures: savings that do not have too much variation, a large population, and a varied mix of measures. This can be an issue for programs with multiple measures or when there cross-participation between energy efficiency programs.

There are practical limits to a regression's ability to produce a well-founded measure-level estimate of savings under some common scenarios. For example, if two measures are always installed together, it will never be possible to get individual measure, regression-based estimates of savings. Furthermore, highly variable savings for a measure across different measure combinations can produce a measure-level estimate of savings that is not consistent with actual savings for any particular measure mix. As a result, pre-post savings are rarely apportioned rationally to all end use measures.

There are multiple solutions for producing measure-level estimates when the measure-level regression results are insufficient. They include using engineering models as well as secondary source information. Most important however for determining program level savings, is that the estimates aggregate to the overall savings produced by the billing analysis. This kind of consistency is essential and relatively easy to confirm.

19.9.5 Annual Electric Heating and Cooling Consumption

The billing analysis methods described above are used to disaggregate seasonal household electric heating and cooling consumption from total consumption for measures where savings are calculated as a percentage of seasonal consumption.[210]

Average heating and cooling consumption values are developed from account level consumption data for the population of residential customers according to premise type and location.

Premise type

1. Single family home, mobile home, and premises with usage data but no premise type is classified as single family.
2. Condo, garden apartment, mid/high rise, and townhouse are considered multifamily dwelling type.
3. Customers with no premise type are classified as single family because their consumption is comparable to single family and probabilistically, they are more likely to be single family than multifamily.

Location

The geographical variables correspond to regions in Dominion's service territory and associated weather stations for the Northern, Eastern, Central, Southern and Western service areas according to the participants address.

19.9.6 Update Summary

The updates to this section are described in Table 19-16.

Table 19-19. Summary of Update(s)

Updates in Version	Type of Change	Description of Change
2021		Initial release

[210] As of 2021 this includes smart thermostats, smart thermostat optimization, home energy management systems, and home energy reports in the Customer Engagement Program.