Dominion Energy North Carolina Evaluation, Measurement, and Verification Report Docket No. E-22, Sub 545

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Table 3-4. Explanation of Adjustments

Appendix Section and Title in May 1, 2017 EM&V Report	Location of Correction	Reason for Correction
1. Adjustments to non-residentia savings equation. This affected	l lighting retrofit measure assumptions about building I the waste heat factor (energy and demand) for these	HVAC type in 2016 deemed e measures.
Appendix E. Section 9.1.1. Lighting Fixtures, Lamps and Delamping Appendix E. Section 11.1.3. LED Reflector Lamp & A-line LED Note: While this adjustment applies to the Non-residential Energy Audit program, there were no lighting measures installed in 2016 in either states. Therefore, no adjustments were necessary for this program Appendix E. Section 15. Non- residential Small Business Improvement Program, Lighting, Fixtures, Lamps, and Delamping measure	Table 89. Non-residential Lighting Parameters by Facility Type	Adjusted waste heat factors (WHF _e and WHF _d) applied to lighting fixtures installed in 2016. Assumed program participant build HVAC systems to be heat pump heating and cooling systems, rather than previously assumed AC cool and non-electric heat systems, in response to requests by the North Carolina Public Staff Utilities Commission Re: Docket No. E-22, Sub 545, on October 23, 2017.
2. Adjustments to non-residentia	I HVAC measure full load heating hours in 2016 deeme	ed savings equation.
Appendix E. Section 10.1.1. Unitary / Split HVAC and Heat Pumps	Table 33. Input Values for Non-residential HVAC Equipment, FLH _{heat} and FLH _{cool} Table 90. Full Load Cooling Hours for Non-residential Buildings Table 91. Heat Pump, VRF, and Mini Split Full Load Heating Hours for Non-residential Buildings	Adjusted full load heating hours (FLH _{heat}) in Table 90 and Table 91 to be consistent with those in the Mid- Atlantic TRM v.6. This is in response to requests by the North Carolina Public Staff Utilities Commission Re: Docket No. E-22, Sub 545, on October 23, 2017.
Appendix E. Section 10.1.2. Variable Refrigerant Flow Systems and Mini Split Systems	Table 37. Input Values for VRF Systems and Mini Split Systems, FLH _{heat} and FLH _{cool} Table 90. Full Load Cooling Hours for Non-residential Buildings Table 91. Heat Pump, VRF, and Mini Split Full Load Heating Hours for Non-residential Buildings	This affects multiple non-residential HVAC measures (e.g. heat pumps, variable refrigerant flow, mini split systems) that reference Table 90 and 91, in multiple non-residential programs.

Appendix Section and Title in May 1, 2017 EM&V Report	Location of Correction	Reason for Correction
Appendix E. Section 12. Non- residential Duct Testing and Sealing Program	Table 69. Input Values for Duct Sealing Savings Calculations, FLH _{heat} and FLH _{cool}	
	Table 90. Full Load Cooling Hours for Non-residential Buildings	
	Table 91. Heat Pump, VRF, and Mini Split Full Load Heating Hours for Non-residential Buildings	
Appendix E. Section 15.1.1 Unitary / Split Air Conditioning, Heat Pump, and Chiller Tune-Up	Table 80. Input Variables for AC/HP/Chiller Tune-Up Measure, FLH_{heat} and FLH_{cool}	
	Table 90. Full Load Cooling Hours for Non-residential Buildings	
	Table 91. Heat Pump, VRF, and Mini Split Full Load Heating Hours for Non-residential Buildings	
Appendix E. Section 12. Non- residential Duct Testing and Sealing Program	Table 90. Full Load Cooling Hours for Non-residential Buildings	Error correction in the calculation for North Carolina. The full load cooling hours for North Carolina in the code did not match the values in the STEP Manual.
3. Correction to Residential Hom flow showerhead measure ΔT	e Energy Check-Up and Residential Income and Age Qu value, in 2016 deemed savings equation.	alifying Home Improvement low-
Appendix E. Section 2.1.5 Low-Flow Showerhead	Table 8: Input Values for Low-Flow Shower Head Savings Calculations	Corrected "Low-Flow Showerhead" measures, "∆T" variable calculated value from 44.9°F (reported in STEP
Appendix E. Section 6.1.2 Low-Flow Showerhead		Manual 7.0.0) to 44.1°F (in Appendix F, STEP Manual 8.0.0, of this report.

Table 3-5. Impact of adjustments

Program and State	Appendix Number in May 1, 2017, report and this report	Category	May 1, 2017, Reported 2016 Year- End Gross Value	Adjusted 2016 Gross Year-End Value (Should match 2016 Gross Year- End Value)	Difference	Difference in %, from May 1, 2017, Reported Value
Residential Home	2017 Report	Total Gross Deemed	6,803,477		24,556.1	
Energy Check-Up	Appendix: A.4	Savings (kWh/year	kWh/year		kWh/year	0.4%
Virginia		Demand Reduction		N/A Difference		1
vinginia.	This Report	(kW)	693 kW	included in	1.64 kW	0.2%
Residential Home	Section: 4.4	Total Gross Deemed	1,495	January 2017		
Energy Check-Up		Savings (kWh/year	kWh/year	value	-2.1 kWh/year	-0.1%
North Conalina		Total Gross				
North Carolina			0 17 kWh		-0 00044 KW	-0.3%
			0.17 KWH		0.00044 KW	0.570
Residential Income	2017 Report	Total Gross Deemed	3,575,492		-12,182.94	
and Age Qualifying	Appendix: A.5.	Savings (kWh/year	kWh/year		kWh/year	-0.3%
Home Improvement Program	and B.5 This Report	Total Gross Demand Reduction (kW)	398 KW		-1 10 kW	-0.3%
Residential Income		Total Gross Deemed	106,379		-306.89	0.370
and Age Qualifying		Savings (kWh/year	kWh/year		kWh/year	-0.3%
Home Improvement Program		Total Gross Demand Reduction (kW)				
North Carolina			11 kW		-0.03 kW	-0.3%
Non-residential Duct	2017 Report	Total Gross Deemed	57 202 610	26 352 640	-30 849 970	1
Testing and Sealing	Appendix: A.7.	Savings (kWh/year)	kWh/year	kWh/year	kWh/year	54%
Virginia	This Report Section: 5.1	Total Gross Demand Reduction (kW)	2,594 kW	2,594 kW	0 kW	0%
Non-residential Duct	2017 Report	Total Gross Deemed	633,600	550,135	-83,464	
Testing and Sealing	Appendix: B.6.	Savings (kWh/year)	kWh/year	kWh/year	kWh/year	13%
North Carolina	This Report Section: 5.1	Total Gross Demand Reduction (kW)	160 kW	160 kW	0 kW	0%

Program and State	Appendix Number in May 1, 2017, report and this report	Category	May 1, 2017, Reported 2016 Year- End Gross Value	Adjusted 2016 Gross Year-End Value (Should match 2016 Gross Year- End Value)	Difference	Difference in %, from May 1, 2017, Reported Value
*						
Non-residential Lighting Systems	2017 Report Appendix: A.9.	Total Gross Deemed Savings (kWh/year)	80,739,463 kWh/year	65,876,985 kWh/year	-14,862,478 kWh/year	-18%
and Controls	This Report	Total Gross Demand Reduction	15 212 1/14	1E 200 KW	169 141	10/
Virginia Non regidential	2017 Depart	(KVV)	2 014 664	10,000 KW	100 KW	1%
Lighting Systems	Appendix: B.8.	Savings (kWh/year)	kW/year	kWh/year	kWh/year	-13%
and Controls North Carolina	This Report Section: 5.3	Total Gross Demand Reduction (kW)	718 kW	743 kW	26 kW	4%
Non-residential Heating and Cooling	2017 Report Appendix: A.10.	Total Gross Deemed Savings (kWh/year)	13,801,883 kWh/year	13,647,306 kWh/year	-154,576 kWh/year	-1%
Efficiency	This Report	Total Gross Demand Reduction (kW)	2.084 kW	2.084 kW	0 kW	0%
Non-residential Heating and Cooling	2017 Report Appendix B.9.	Total Gross Deemed Savings (kWh/year)	312,404 kWh/year	289,500 kWh/year	-22,904 kWh/year	-7%
Efficiency North Carolina	This Report Section: 5.4	Total Gross Demand Reduction (kW)	93 kW	93 kW	0 kW	0%
Non-residential Small Business	2017 Report Appendix:	Total Gross Deemed Savings (kWh/year)	828,569 kWh/year	656,801 kWh/year	-171,768 kWh/year	-21%
Improvement	Appendix A.12.	Total Gross Demand Reduction				
Virginia	This Report Section: 5.6	(kW)	129 kWh/year	132 kW		2%

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3.3 Research Activities through 2017

The EM&V approach incorporates deemed annualized energy savings and demand reduction calculations outlined in the STEP Manual (Appendix F), customer surveys, billing analyses using customer data, and onsite evaluations at customer homes and businesses. Each year, as scheduled in the EM&V plans, DNV GL undertakes various research activities across the Company's DSM programs to evaluate each program through impact evaluations. The following research activities are used to evaluate the DSM programs:

- Data Quality Review: DNV GL reviews the program tracking data to ensure they have all the
 necessary information to compute savings and to feed into potential future evaluation research data
 requirements. DNV GL performs data quality review on a monthly basis throughout the year for all
 programs and performs an in-depth data quality check at least twice a year for all programs. Section
 3.2 provides more details about the data quality reviews that DNV GL conducts.
- **Deemed Savings Calculations:** DNV GL estimates energy savings and peak demand reductions across programs with standardized calculations and assumptions outlined in the STEP Manual. DNV GL tracks deemed estimates for all programs on a monthly basis throughout the year and reports draft deemed estimates to Dominion Energy each month.
- Satisfaction Surveys: Satisfaction survey questions help the Company determine how satisfied its customers are with the programs it offers. These questions generally cover satisfaction with the program as a whole, the rebate application and payments, and, if applicable, the contractors used. This survey is often combined with a NTG estimation or verification survey (sometimes both) to reduce the number of interactions with the participant.
- **Billing Analysis:** This approach applies Company-specific customer usage data to actual participating households or facilities to quantify annualized energy savings and peak demand reductions for a program. DNV GL analyzes monthly billing data from households or facilities for a 12-month period before and after the audit/install date of a program measure. The savings calculated from this method allow DNV GL to create an adjustment factor to the engineering algorithms known as a realization rate. This realization rate is then applied to future deemed calculations for savings.
- **NTG Estimation Surveys:** Depending on the program design and the evaluation methodology used, survey research methods can be used to estimate the NTG factor, which is the percentage of savings that are attributable to the program because participants would not have performed the program measures in the absence of the program. This survey is often combined with the satisfaction and verification surveys, and conducted during a single interaction with the participant and/or contractor.
- Verification Surveys: Survey verification questions help verify the customer did participate in the program and install any or all measures as recorded in the tracking data. The survey results are used to calculate a verification rate that is applied to the deemed savings. This survey is often combined with the satisfaction survey and NTG-estimation survey and conducted during a single interaction with the participant.
- **On-site Verification:** This occurs when a member of the evaluation team visits a random selection of sites and verifies that the measures are actually installed. This may be used in conjunction with or in place of verification surveys to help the Company verify program participation and measure installation.

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- **On-site Measurement:** This is physical verification of an installed measure's power load and energy usage through the use of metering equipment. The measurement results help make deemed savings calculations more accurate and precise.
- **Building Simulation Modeling:** When on-site measurement is not available at the measure-level, or where interactive effects of multiple installed measures cannot be determined, modeling is used to more accurately determine measured power load and energy usage of multiple measures installed at a single site. Like on-site measurement, the results of modeling help the Company to adjust its deemed savings calculations.
- Load-Shape Analysis: The Company conducts a load-shape analysis using data from a combination of data inputs (e.g., on-site verification, on-site measurement, and modeling) to determine each program's annual power load profile for the Company-specific system peak and for PJM-defined performance periods.¹⁸

Table 3-6 on the next page provides an overview of the research activities conducted for each program through the end of 2017. The years listed in the table represent the year that the EM&V study report was published. All programs undergo data quality review and evaluation using deemed calculations.

¹⁸ PJM is the Company's regional transmission organization (www.pjm.com).

able 3-6. EM&V Research	h Activities	Conducted	Through 2	017 by F	rogram						
Program	Data Quality Review	Deemed Savings Calcu- lations	Billing Analysis	Satis- faction Survey	Verifi- cation Survey	NTG Studies	On-Site Verifi- cation	On-Site Meas- ureme nt	Building Simula- tion Modeling	Load- Shape Analysis	Other
				Residentia	al Program	15					
Residential Appliance Recycling	2016- present	2016- present								2016- present	
Residential Duct Sealing	2012- present	2012- present		2015	2015					2015- present	
Residential Heat Pump Tune-Up	2012- present	2012- present		2015	2015					2015- present	
Residential Heat Pump Upgrade	2012- present	2012- present		2015, 2016	2015, 2016	2015, 2016	2015, 2016	2015, 2016		2015- present	
Residential Home Energy Check-up	2012- present	2012- present	2015- 2016	2015, 2016	2015, 2016	2016				2015- present	
Residential Income and Age Qualifying Home Improvement	2016- present	2016- present								2016- present	
Residential Retail LED Lighting	2017	2017								2017	
			No	n-residen	tial Progr	ams					
Non-residential Duct Testing and Sealing	2012- present	2012- present		2015	2015	2015	2015			2015- present	
Non-residential Energy Audit	2012- present	2012- present		2015	2015	2015	2015	2015		2015- present	
Non-residential Heating & Cooling	2015- present	2015- present								2015- present	
Non-residential Lighting Systems & Controls	2015- present	2015- present							сэ.	2015- present	
Non-residential Prescriptive	2017	2017								2017	
Non-residential Small Business Improvement	2016 - present	2016 - present								2016 - present	
Non-residential Window Film	2015- present	2015- present								2015- present	
			P	eak Shavi	ng Progra	ms					
Residential AC Cycling	2010- present	2010- present	2012- 2017		-		10/2011			2015- present	
Non-residential Distributed Generation	2013- present	2013- present	2013- 2017							2015- present	
				Closed	Programs						
Commercial HVAC (Closed)	2010-2013, 2015	2010-2013, 2015				4/2012	4/2012	4/2012			

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Program	Data Quality Review	Deemed Savings Calcu- Iations	Billing Analysis	Satis- faction Survey	Verifi- cation Survey	NTG Studies	On-Site Verifi- cation	On-Site Meas- ureme nt	Building Simula- tion Modeling	Load- Shape Analysis	Other
Commercial Lighting (Closed)	2010-2013, 2015	2010-2013, 2015				4/2012	4/2012	4/2012			
Residential Lighting (Closed)	2010-2012	2010-2012									Retail sales survey (4/2011)
Residential Low Income (Closed)	2010-2016	2010-2016	4/2012- 2014	4/2011		4/2011					

3.4 Planned Research Activities in 2018

In 2018, DNV GL will begin a new cycle of EM&V activities for all of Dominion Energy's active programs. Those activities will be the same as the activities conducted for 2017, as shown above in Table 3-6. An indepth description of the planned activities for each program is provided in Appendices G through O of this report.

In October 2017, in Case No. PUR-2017-00129, the Company filed for an extension of the DSM Phase IV Residential Income and Age Qualifying Home Improvement Program. Similar to the DSM Phase II programs, should any residual tracking data from the end of 2017 remain to be processed by DNV GL in 2018, there may be minimal EM&V activities for this program in 2018.

The SCC issued its order regarding new rules governing the EM&V of the effects of utility-sponsored DSM programs (Case No. PUR-2017-00047) on November 9, 2017. The new rules apply prospectively to new or renewing DSM programs starting from the order date. As of this EM&V report, there have been no new or renewing DSM programs. Should the above mentioned DSM Phase IV Residential Income and Age Qualifying Home Improvement Program be renewed by the SCC, it will be the first program to adhere to these new rules in 2018.

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4 ENERGY EFFICIENCY PROGRAMS – RESIDENTIAL

This section reports on residential EE program progress in 2017 for a total of seven residential EE programs. Of those, five programs were available in both Virginia and North Carolina, one was available in Virginia only, and another was available in North Carolina only. The programs available in both states are as follows:

- 1. Residential Heat Pump Upgrade (DSM Phase II)
- 2. Residential Heat Pump Tune-up (DSM Phase II)
- 3. Residential Duct Sealing (DSM Phase II)
- 4. Residential Home Energy Check-up (DSM Phase II)
- 5. Residential Income and Age Qualifying Home Improvement (DSM Phase IV)

The Residential Appliance Recycling program (DSM Phase IV) was only available in Virginia and has closed, as intended, in 2017. The Residential LED Lighting program (DSM Phase V) was only available in North Carolina in 2017 and will continue to be only available in North Carolina in 2018.

This is the last EM&V report that will show new participants for the DSM Phase II programs listed above, because those programs have closed as intended. Those programs operated in Virginia for five years, and for three years in North Carolina. The DSM Phase II program data in this report are from services that were completed by participating contractors by December 24, 2016, with rebate applications received by Dominion Energy by February 7, 2017.

Cumulatively, from program inception through the end of 2017, there have been 188,766 participants across all six residential programs (excluding the Residential Retail LED Lighting program, because participation in that program is measured in lamps rather than households). Residential programs account for 94% of all residential and non-residential DSM program participants. The cumulative net annualized energy savings from these programs (including the Residential Retail LED Lighting program) were 83,315,420 kWh/year, or 22% of all DSM program energy savings.

Figure 4-1 and Figure 4-2 show the cumulative count of residential EE program participation and gross annualized energy savings in the two states, at the county level with the exception of the Residential Retail LED Lighting program.¹⁹ The more intense the color, the greater the participation and gross annualized energy savings.

The top three jurisdictions in Virginia with the highest participation are Chesterfield, Henrico, and Virginia Beach City, in decreasing order. In North Carolina, the top three jurisdictions (in decreasing order) with the highest participation are Dare, Currituck, and Halifax.

In terms of energy savings, the top three jurisdictions in Virginia with the highest gross annualized energy savings (in decreasing order) are Chesterfield, Fairfax, and Henrico. And in North Carolina the top three jurisdictions (in decreasing order) with the highest energy savings are Dare, Currituck, and Pasquotank.

¹⁹ Program data not available in the format required to be included in maps.

Figure 4-1. VA and NC Residential Energy Efficiency Program Participation Map, by County, Inception to December 31, 2017



Figure 4-2. VA and NC Residential Energy Efficiency Program Gross Annualized Energy Savings Map, by County, Inception to December 31, 2017



4.1 Residential Heat Pump Upgrade – Virginia and North Carolina

The now-closed DSM Phase II Residential Heat Pump Upgrade Program provided incentives to Virginia and North Carolina residential customers who installed a new, greater efficiency (ENERGY STAR®-rated) air or geothermal heat pump unit. To be eligible for the program, customers were required to live in singlefamily residences, townhomes, or multi-family housing



(apartments and condos) with electric heating and cooling with an air source heat pump, and either own the home or be able to obtain permission from the owner to perform the repairs or improvements. Qualifying equipment was required to have better seasonal EE ratio (SEER) and heating seasonal-performance factor (HSPF) ratings than the nationally mandated efficiency standards. Existing homes qualified for the program if the heat pump SEER rating was 14.5 or greater and the HSPF rating was 8.2 or greater. New homes qualified if the heat pump SEER rating was 15 or greater and the HSPF rating was 8.2 or greater. Customers were eligible for one upgrade per unit during the six-year program time period.

This program was implemented through a contractor network, so customers were required to contact a participating contractor to be eligible for the rebate. Customers were not considered participants until a completed application form was processed and a rebate issued. This process could take several months since the customers had 45 days to submit their rebate application, and the Company had 90 days to process it.

In 2016, Dominion Energy announced the program closed to new participants in both states, and that to be eligible for a rebate, the service must have been completed by a participating contractor by December 24, 2016, and rebate applications received by February 7, 2017. The rebate form submission and processing

time all together can add up to 135 days before a participant shows up in the tracking and reporting system. This report section shows those final enrollments of 2017 that were serviced in the last months of 2016.

Dominion Energy filed an application with the SCC to continue this program, but it was not approved,²⁰ as previously mentioned in Section 1.

4.1.1 Methods for the Current Reporting Period

For the current period, the approach included reviewing the tracking data and then estimating gross energy savings and peak demand reduction using STEP Manual calculations with the realization rate estimated from the 2015-2016 load shape study.

Table 4-1 outlines Dominion Energy's initial program planning assumptions that were used to design the program.

Table 4-1.	Residential	Heat Pump	Upgrade	Program	Planning	Assum	otions S	vstem-wide
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Item	Description
Target Market	Residential customers with eligible HVAC systems
NTG Factor	85%
Measure Life	15 years
Average Energy Savings (kWh) per Participant per Year	856 kWh per participant per year
Average Peak Demand Reductions (kW) per Participant	0.29 kW per participant per year
Average Rebate (US \$) per Participant	\$205 per participant

4.1.2 Assessment of Program Progress Towards Plan

The next section describes the program's progress towards planned participants, energy savings, and peak demand reductions.

4.1.2.1 Key Virginia and North Carolina Program Data

Table 4-2, Figure 4-3, and Figure 4-4 on the next pages summarize key indicators of progress in Virginia from August 2012 through December 2017. Table 4-3, Figure 4-5, and Figure 4-6, also on the following pages, summarize key indicators of progress in North Carolina from January 2014 through December 2017.

Detailed monthly program indicators for Virginia appear in Appendix A.1 and for North Carolina in Appendix B.1.

²⁰ Case PUE-2016-00111. June 1, 2017.

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		Virginia								
Category	Item	2012	2013	2014	2015	2016	2017	Program Total (2012- 2017)		
Operations	Direct Rebate									
and Management	Direct Implementation									
Costs (\$)	Direct EM&V									
	Indirect Other (Administrative)	\$126,049	\$202,451	\$101,388	\$76,038	\$78,750	\$29,454	\$614,131		
Total Costs	Total									
(\$)	Dlapped									
	Varianco									
	Cumulative % of Planned	52%	50%	36%	43%	41%	142%	45%		
								1		
Participants	Total (Gross)	86	3,295	3,649	4,210	5,395	1,149	17,784		
	Planned (Gross)	4,396	11,992	18,221	18,221	3,748	0	56,578		
	Variance	-4,310	-8,697	-14,572	-14,011	1,647	1,149	-38,794		
	Cumulative % of planned (Gross)	2%	27%	20%	23%	144%	N/A	31%		
Installed Energy	Total Gross Deemed Savings	199,447	6,665,695	5,667,002	2,405,953	3,072,240	553,935	18,564,272		
Savings (kWh/year)	Realization Rate Adjustment (78%) ²¹	13,363	446,602	379,689	-538,933	-688,182	-124,081	-511,543		
	Adjusted Gross Savings	212,810	7,112,296	6,046,691	1,867,020	2,384,058	429,854	18,052,729		
	Net-to-Gross Adjustment (45%) ²²	-31,922	-1,066,844	-907,004	-1,024,994	-1,308,848	-235,990	-4,575,601		
	Net Adjusted Savings	180,889	6,045,452	5,139,687	842,026	1,075,210	193,864	13,477,128		
	Planned Savings (Net)	3,207,000	8,724,528	15,761,165	15,761,165	742,316	0	44,196,174		

Table 4-2	VA	Posidontial	Host Dum	n Ilnarado	Drogram	Dorformanco	Indicators	(2012 - 2017)
Iddle 4-2.	VA	Residential	near Puill	p opyraue	Program	Periorinance	Indicators	(2012 - 2017)

²² NTG adjustment for 2012-2014 was 85% per the program planning assumptions. Starting in 2015, the NTG adjustment was updated to 45.1% based on the 2015 Net-to-Gross Characterization Study.

²¹ Realization rate adjustment for 2012-2014 was 107%. Starting in 2015, the realization rate adjustment was updated to 77.6% based on the 2015 Load Shape Study.

		Virginia									
Category	Item	2012	2013	2014	2015	2016	2017	Program Total (2012- 2017)			
	Cum. % Toward Planned Savings (Net)	6%	69%	33%	5%	145%	N/A	30%			
	Avg. Savings per Participant (Gross)	2,319	2,023	1,553	571	569	482	1,044			
	Avg. Savings per Participant (Net)	2,103	1,835	1,409	200	199	169	758			
Installed Demand	Total Gross Deemed Demand	59	2,394	2,169	472	624	130	5,848			
Reduction	Realization Rate Adjustment (89%) ²³	-10	-405	-367	-53	-70	-15	-918			
	Adjusted Gross Demand	49	1,989	1,802	419	554	115	4,930			
	Net-to-Gross Adjustment (45%) ²⁴	-7	-298	-270	-230	-304	-63	-1,174			
	Net Adjusted Demand	42	1,691	1,532	189	250	52	3,756			
	Planned Demand (Net)	1,068	2,904	5,284	5,284	267	0	14,807			
	Cum. % Toward Planned Demand (Net)	4%	58%	29%	4%	94%	N/A	25%			
	Avg. Demand per Participant (Gross)	0.69	0.73	0.59	0.11	0.12	0.11	0.33			
	Avg. Demand per Participant (Net)	0.49	0.51	0.42	0.04	0.05	0.05	0.21			
Program Performance	Cum. \$Admin. per Cum. Participant (Gross)	\$1,466	\$61	\$28	\$18	\$15	\$26	\$35			
	Cum. \$Admin. per Cum. kWh/year (Gross)	\$0.63	\$0.03	\$0.02	\$0.03	\$0.03	\$0.05	\$0.03			
	Cum. \$Admin. per Cum. kW (Gross)	\$2,125	\$85	\$47	\$161	\$126	\$227	\$105			
	Cum. \$EM&V per Cum.	2%	15%	13%	18%	11%	19%	13%			

²⁴ NTG adjustment for 2012-2014 was 85% per the program planning assumptions. Starting in 2015, the NTG adjustment was updated to 45.1% based on the 2015 Net-to-Gross Characterization Study.

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					Virginia			
Category	Item	2012	2013	2014	2015	2016	2017	Program Total (2012 2017)
	Cum. \$Rebate per Cum. Participant (Gross)							

Figure 4-3. VA Residential Heat Pump Upgrade Cumulative Participation Compared to Planned and Over Time Figure 4-4. VA Residential Heat Pump Upgrade Cumulative Net Adjusted Annualized Savings (kWh/year) Compared to Planned and Over Time



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		North Carolina						
Category	Item	2014	2015	2016	2017	Program Total (2014-2017)		
Operations	Direct Rebate							
and	Direct Implementation							
Costs (\$)	Direct EM&V				La La La La			
	Indirect Other (Administrative)	\$1,847	\$7,845	\$8,235	\$2,527	\$20,454		
Total Costs	Total							
(\$)	Planned							
	Variance							
	Cumulative % of Planned	14%	70%	64%	191%	55%		
Participants	Total (Gross)	44	597	665	118	1,42		
	Planned (Gross)	1,200	1,200	252	0	2,65		
	Variance	-1,156	-603	413	118	-1,22		
	Cumulative % of planned (Gross)	4%	50%	264%	· N/A	54%		
Installed	Total Gross Deemed Savings	72,449	282,170	317.574	63.092	735.28		
Energy Savings	Realization Rate Adjustment (78%) ²⁵	4,854	-63,206	-71,137	-14,133	-143,62		
(kWh/year)	Adjusted Gross Savings	77,303	218,964	246,438	48,960	591,66		
	Net-to-Gross Adjustment (45%) ²⁶	-11,595	-120,211	-135,294	-26,879	-293,98		
	Net Adjusted Savings	65,708	98,753	111,143	22,081	297,68		
	Planned Savings (Net)	1,038,000	1,038,000	49,858	0	2,125,85		
	Cum. % Toward Planned Savings (Net)	6%	10%	223%	N/A	14%		

Table 4-3. NC Residential Heat Pump Upgrade Program Performance Indicators (2014-2017)

²⁵ Realization rate adjustment for 2012-2014 was 107%. Starting in 2015, the realization rate adjustment was updated to 77.6% based on the 2015 Load Shape Study.

²⁶ NTG adjustment for 2012-2014 was 85% per the program planning assumptions. Starting in 2015, the NTG adjustment was updated to 45.1% based on the 2015 Net-to-Gross Characterization Study.

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				North Carolina	à	
Category	Item	2014	2015	2016	2017	Program Total (2014-2017)
	Avg. Savings per Participant (Gross)	1,647	473	478	535	516
	Avg. Savings per Participant (Net)	1,493	165	167	187	209
Installed	Total Gross Deemed Demand	10	58	69	14	160
Demand Reduction	Realization Rate Adjustment (89%) ²⁷	-3	-6	-8	-2	-19
(kW)	Adjusted Gross Demand	16	51	61	13	141
	Net-to-Gross Adjustment (45%) ²⁸	-2	-28	-33	-7	-71
	Net Adjusted Demand	14	23	27	6	70
	Planned Demand (Net)	348	348	18	0	714
	Cum. % Toward Planned Demand (Net)	4%	7%	153%	N/A	10%
	Avg. Demand per Participant (Gross)	0.44	0.10	0.10	0.12	0.11
	Avg. Demand per Participant (Net)	0.31	0.04	0.04	0.05	0.05
Program Performance	Cum. \$Admin. per Cum. Participant (Gross)	\$42	\$13	\$12	\$21	\$14
	Cum. \$Admin. per Cum. kWh/year (Gross)	\$0.03	\$0.03	\$0.03	\$0.04	\$0.03
	Cum. \$Admin. per Cum. kW (Gross)	\$96	\$136	\$120	\$174	\$128
	Cum. \$EM&V per Cum. Total Costs (\$)	34%	11%	7%	14%	12%
	Cum. \$Rebate per Cum. Participant (Gross)					

²⁷ Realization rate adjustment for 2012-2014 was 83%. Starting in 2015, the realization rate adjustment was updated to 88.8% based on the 2015 Load Shape Study.

²⁸ NTG adjustment for 2012-2014 was 85% per the program planning assumptions. Starting in 2015, the NTG adjustment was updated to 45.1% based on the 2015 Net-to-Gross Characterization Study.



Figure 4-5. NC Residential Heat Pump Upgrade Cumulative Participation Compared to Planned and Over Time Figure 4-6. NC Residential Heat Pump Upgrade Cumulative Net Adjusted Annualized Savings (kWh/year) Compared to Planned and Over Time

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In Virginia and North Carolina, while the program continued to enroll new participants every year at a steady pace, the Residential Heat Pump Upgrade program did not meet its cumulative program goals for participation incremental net energy savings or peak demand reductions in both states (Figure 4-3 and Figure 4-4 in Virginia) (Figure 4-5 and Figure 4-6 in North Carolina). The penetration goals for this program in both states were significantly greater than actuals. For this program, the average Virginia program participant saved 758 kWh/year (net) and North Carolina participant saved 209 kWh/year (net). These are lower than the initial program planned average of 856 kWh/year (Table 4-1).

Average program net savings per participant were over 1,000 kWh/year in 2012 through 2014, but decreased significantly starting in 2015 to less than 500 kWh/year. This is due to updates to the STEP Manual gross energy savings baseline assignment. In 2012 through 2014, the baseline heat pump efficiencies were based on the existing conditions rather than federal minimum requirements. During that period, the federal minimum requirement for heat pump efficiencies was 13 SEER and 7.7 HSPF, a standard that was in place since 2006. In 2015, DNV GL updated the STEP Manual calculations to assume all baseline heat pump efficiencies to be the same as the new Federal minimum requirements that came into effect (14 SEER and 8.0 HSPF for packaged systems, and 8.2 HSPF for split systems), regardless of the existing heat pump conditions.

Additionally, this approach assumed that all existing heat pumps were replaced when the equipment failed or burnt-out. For this program in particular, approximately 68% of the existing heat pump units had failed (representing 65% of gross energy savings as shown in Figure 4-9 below). Had these customers not participated in this program, they would still have been required to install a heat pump that met the Federal minimum requirements. For them, assuming a baseline heat pump efficiency consistent with the new Federal minimum requirements for estimating gross energy savings was an accurate representation of their gross energy savings.

For the approximately 32% of the existing heat pumps that were still operational at the time of replacement (early replacement), this approach yielded potentially conservative estimated gross savings. The gross energy savings for the early replacement heat pumps that were replaced sooner than the end of the existing heat pump life may be more accurately represented and calculated using the actual existing heat pump equipment efficiencies rather than the Federal minimum standard for the first few years of the new installation. However, over the course of the measure life, using the existing system efficiency would yield an overestimated gross energy savings from the heat pump replacement. In some locations, outside of Virginia and North Carolina, to more accurately estimate program savings for these situations, a dual baseline may be applied. In those cases, a measure would have two mutually exclusive estimated savings applied at different times of the equipment measure life. One would be calculated using baseline system efficiency for the existing heat pump. It would be applied in the first year that the measure was installed and every subsequent year until the assumed end of the baseline heat pump equipment life. The second estimated savings is calculated using the Federal minimum standard heat pump efficiency. That estimate is applied for all subsequent years after the end of the baseline heat pump equipment life, through the end of the measure life. However, as an EM&V policy, DNV GL does not apply dual baselines for deemed savings in the STEP Manual for any program. Therefore, it was determined that it would be most appropriate to use the Federal minimum standard as the single baseline to apply to all participating heat pumps in this program over the course of the program measure life.

Over the program life in Virginia, total program spending was 45% of planned. This was a product of discrepancies with program design from a consultant not involved with program implementation. Program

administrative costs per participant (\$1,466) started high in the first year (2012) when the program was initially ramping up and had fewer participants compared to other program years. After 2012, administrative costs per participant were generally decreasing with slight fluctuation, and averaged at \$35 per participant over the program life. Administrative costs per gross kWh/year averaged \$0.03/kWh/year over the program life. Rebate amount per participant averaged \$218 per participant.

Virginia program administrative costs per gross kWh/year saved and the rebate amount per participant both remained steady over the program life. Administrative costs per gross kW saved fluctuated over time between \$85/kW and \$227/kW, not accounting for the first year where the low participation makes it difficult to compare with others. The average program life administrative cost per gross kW saved was \$105/kW. Lastly, EM&V costs for this program in Virginia averaged to 13% of total program costs. Part of the EM&V cost was driven by consecutive years of long-term impact evaluation metering studies. The study results were utilized in all other residential programs that had heat pump related measures. The metering evaluation results were also leveraged to meet part of the PJM EE resource verification requirements for bidding this program as an EE resource in what is now known as the Capacity Performance Market.

In North Carolina, these program spending performance indicators behaved similar to the same indicators in Virginia over time. Program administrative costs per participant averaged to \$14 per participant over the program life. Average administrative costs per gross kWh/year saved and rebate amount per participant were \$0.03/kWh/year and \$218 per participant, respectively. These are the same as in Virginia. Average administrative costs per gross kW was \$128/kW, averaged across the program life. And the EM&V costs were 12% of the total program costs.

4.1.2.2 Additional Virginia Program Participant Data

Figure 4-7 (next page) shows the distribution of the gross annual energy savings by the existing heat pump SEER values over the program life in Virginia. The majority of the energy savings was in 2013 from the replacement of existing heat pumps with 10 SEER to below SEER 11 (almost 25% of total program gross annual energy savings). In every year, existing heat pumps in this SEER range consistently accounted for the majority of that year's gross annual energy savings. In total, the existing heat pumps in this SEER range (10–10.9) produced 56% of the total program gross annual energy savings.



Figure 4-7. VA Residential Heat Pump Upgrade Program Existing Heat Pump SEER Value as % of Total Gross Annual Energy Savings (2012-2017)



Figure 4-8 provides insight into Virginia program savings by dwelling for the entire program life (2012–2017) in Virginia. Most rebated heat pump units are installed in single-family homes (92%) and

account for the overwhelming proportion of gross energy savings (88%) and gross peak demand reduction (93%).





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Figure 4-9 shows the condition of the replaced units each year of the program life as a percentage of gross annualized energy savings (kWh/year), whether it was an operating or failed system. Over the program life, replacement of failed systems represents the majority (approximately 65%) of gross energy savings.



Figure 4-9. VA Residential Heat Pump Upgrade Program Gross Energy Savings (kWh/year) by Condition of Replaced Unit as % of Total (2012-2017)

4.1.2.3 Additional North Carolina Program Participant Data

Figure 4-10 (next page) shows the distribution of the gross annual energy savings by the existing heat pump SEER values over the program life in North Carolina.

The majority of the energy savings was in 2016 from the replacement of existing heat pumps with 10 SEER to below SEER 11 (21% of total program gross annual energy savings). Every year, existing heat pumps in this SEER range consistently accounted for the majority of that year's gross annual energy savings, similar to program results in Virginia.

In total, the existing heat pumps in this SEER range produced 53% of the total program gross annual energy savings, again similar to the program results in Virginia.

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Figure 4-10. NC Residential Heat Pump Upgrade Program Existing Heat Pump SEER Value as % of Total Gross Annual Energy Savings (2014-2017)

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Figure 4-11 provides insight into North Carolina program savings by dwelling type and system condition. Most rebated heat pump units are installed in single-family detached homes (99%) and account for the overwhelming proportion of gross energy savings (98%) and gross demand reduction (99%).



Figure 4-11. NC Residential Heat Pump Upgrade Program Performance Indicators by Dwelling Type as % of Total (2014-2017)

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Similar to Virginia, the majority (approximately 65%) of the gross annualized energy savings of replaced heat pumps failed prior to being replaced (Figure 4-12) in North Carolina.



Figure 4-12. NC Residential Heat Pump Upgrade Program Gross Energy Savings (kWh/year) by Condition of Replaced Unit as % of Total (2014-2017)

4.2 Residential Heat Pump Tune-up – Virginia and North Carolina



The Residential Heat Pump Tune-Up Program provides qualifying residential customers with an incentive to have a participating contractor tune-up their existing heat pumps once every five years to achieve maximum operational performance. Participant enrollment began in August 2012 in Virginia and January 2014 in North Carolina. The Residential Heat Pump

Tune-Up Program follows the same eligibility guidelines in both states.

A properly tuned system should increase efficiency, reduce operating costs, and prevent premature equipment failures. Customers are eligible for one tune-up per heat pump during the five-year program time period. Existing units must be in operation for at least six months to be eligible for the tune-up rebate. Units must be in working order prior to and after tune-up. To be eligible for the program, customers must live in a

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single-family residence, apartment, condominium, or manufactured home with electric heating and cooling, and must own the home or be able to obtain permission from the owner to perform the repairs or improvements recommended. Homes with gas- or oil-fired supplementary heat do not qualify.

This program is implemented through a contractor network, so customers must contact a participating contractor to be eligible for the rebate. Customers are not considered participants until a completed application form is processed and a rebate is issued. This process can take several months, as customers have 45 days to submit their rebate application and the Company has 90 days to process it.

The contractor must verify that it performed the following functions before administering the rebate:

- Thermostat has been checked for proper operation
- Air filter has been inspected
- Condensate drain has been inspected
- Evaporator coil has been inspected
- Evaporator fan and motor have been inspected
- All accessible refrigerant lines have been inspected
- Condenser coil has been inspected
- Condenser fan motor has been inspected
- Checked system for proper refrigerant charge level

Over the program life, slightly over half (54%) of all tune-ups in Virginia and North Carolina were rebated to the contractor directly, with customer permission. When this occurred, the contractor had to demonstrate that the customer was provided the rebate benefit on their invoice to the customer. This allowed for an "instant" rebate for the customer without having to wait multiple weeks for a check to arrive via the standard rebate process. Table 4-4 provides a breakdown of the percent of rebated tune-ups given directly to contractors by state. Compared to other residential programs that offer this option to customers, this program has the lowest percentage of rebates issued to contractors directly.

Table 4-4. Percent of 2012-2017 Residential Heat Pump Tune-Up Program Tune-Ups Rebated toContractors Directly

State	Percent of Heat Pump Tune-Ups Rebated	Percent of Rebates Given to Contractor
VA	94%	57%
NC	6%	10%
Total	100%	54%

In 2016, Dominion Energy announced the program closed to new participants in both states. To be eligible for a rebate, the service must have been completed by a participating contractor by December 24, 2016 and rebate applications received by February 7, 2017. This report section shows those final enrollments of 2017. The rebate form submission and processing time all together can add up to 135 days before a participant shows up in the tracking and reporting system. This report section shows those final enrollments in 2017 that were serviced in the last months of 2016.

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4.2.1 Methods for the Current Reporting Period

For the current period, the approach included reviewing the tracking data and estimating gross energy and peak demand savings using STEP Manual calculations with the estimated realization rate from the 2014 billing analysis.

Table 4-5 outlines Dominion Energy's initial program planning assumptions that were used to design the program.

Table 4-5. Residential Heat Pump Tune-Up Program Planning Assumptions System-wide

Item	Description
Target Market	Residential customers with eligible HVAC systems
NTG Factor	90%
Measure Life	5 years
Average Energy Savings (kWh) per Participant per Year	762 kWh per participant per year
Average Peak Demand Reduction (kW) per Participant	0.23 kW per participant per year
Average Rebate (US \$) per Participant	\$90 per participant

4.2.2 Assessment of Program Progress Towards Plan

The next section describes the program's progress towards planned participants, energy savings, and peak demand reductions.

4.2.2.1 Key Virginia and North Carolina Program Data

Table 4-6, Figure 4-13, and Figure 4-14 on the next pages summarize key indicators of progress over time from August 2012 to December 31, 2017 for Virginia.

Following that, Table 4-7, Figure 4-15, and Figure 4-16 summarize key indicators of progress over time from January 2014 to December 31, 2017 for North Carolina.

Detailed monthly program indicators for Virginia are provided in Appendix A.2 and for North Carolina in Appendix B.2.

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					Virginia			
Category	Item	2012	2013	2014	2015	2016	2017	Program Total (2012-2017)
Operations	Direct Rebate							
and Management	Direct Implementation							
Costs (\$)	Direct EM&V							
	Indirect Other (Administrative)	\$179,541	\$339,952	\$229,172	\$124,325	\$103,917	\$26,250	\$1,003,156
Total Costs	Total							
(\$)	Planned							
	Variance							
	Cumulative % of Planned	60%	69%	73%	60%	50%	79%	62%
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Participants	Total (Gross)	1,209	15,636	24,687	24,114	19,008	2,472	87,126
	Planned (Gross)	10,203	27,830	42,293	42,293	22,958	0	145,577
	Variance	-8,994	-12,194	-17,606	-18,179	-3,950	2,472	-58,451
	Cumulative % of planned (Gross)	12%	56%	58%	57%	83%	N/A	60%
Installed Energy	Total Gross Deemed Savings	364,856	4,605,801	6,269,989	5,067,124	4,035,338	500,799	20,843,906
Savings (kWh/year)	Realization Rate Adjustment (99%) ³⁰	-2,919	-36,846	-50,160	-40,537	-32,283	-4,006	-166,751
	Adjusted Gross Savings	361,937	4,568,954	6,219,829	5,026,587	4,003,055	496,793	20,677,155
	Net-to-Gross Adjustment (90%)	-36,194	-456,895	-621,983	-502,659	-400,306	-49,679	-2,067,715
	Net Adjusted Savings	325,743	4,112,059	5,597,846	4,523,928	3,602,750	447,114	18,609,439
	Planned Savings (Net)	7,024,000	19,102,880	32,227,266	32,227,266	2,595,483	0	93,176,895

Table 4-6. VA Residential Heat Pump Tune-Up Program Performance Indicators (2012-2017)²⁹

²⁹ Planned impacts were specified for a 12-month period and the program rolled out on August 1, 2012, which prevents a meaningful comparison between planned and actual program growth.

³⁰ The Realization Rate Adjustment was updated to 99% based on the 2015 Impact Evaluation and Customer Satisfaction Report.

	Virginia							
Item	2012	2013	2014	2015	2016	2017	Program Total (2012-2017)	
Cum. % Toward Planned Savings (Net)	5%	22%	17%	14%	139%	N/A	20%	
Avg. Savings per Participant (Gross)	302	295	254	210	212	203	239	
Avg. Savings per Participant (Net)	269	263	227	188	190	181	214	
					-			
Total Gross Deemed Demand	250	3,160	3,198	5,435	3,003	391	15,437	
Realization Rate Adjustment (99%) ³¹	-2	-25	-26	-43	-24	-3	-123	
Adjusted Gross Demand	248	3,135	3,173	5,392	2,979	387	15,313	
Net-to-Gross Adjustment (90%)	-25	-314	-317	-539	-298	-39	-1,531	
Net Adjusted Demand	223	2,822	2,855	4,852	2,681	349	13,782	
Planned Demand (Net)	2,053	5,585	9,727	9,727	869	0	27,962	
Cum. % Toward Planned Demand (Net)	11%	51%	29%	50%	309%	N/A	49%	
Avg. Demand per Participant (Gross)	0.21	0.20	0.13	0.23	0.16	0.16	0.18	
Avg. Demand per Participant (Net)	0.18	0.18	0.12	0.20	0.14	0.14	0.16	
Cum. \$Admin. per Cum. Participant (Gross)	\$149	\$22	\$9	\$5	\$5	\$11	\$12	
Cum. \$Admin. per Cum. kWh/year (Gross)	\$0.49	\$0.07	\$0.04	\$0.02	\$0.03	\$0.05	\$0.05	
Cum. \$Admin. per Cum. kW (Gross)	\$719	\$108	\$72	\$23	\$35	\$67	\$65	
Cum. \$EM&V per Cum.	1%	3%	2%	2%	3%	10%	3%	

 31 The Realization Rate Adjustment was updated to 99% based on the 2015 Impact Evaluation and Customer Satisfaction Report.

Category

Installed Demand

Reduction

Program

Performance

Total Costs (\$)

Cum. \$Rebate per Cum. Participant (Gross)

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Figure 4-13. VA Residential Heat Pump Tune-Up Cumulative Participation Compared to Planned and Over Time Figure 4-14. VA Residential Heat Pump Tune-Up Cumulative Net Adjusted Annualized Savings (kWh/year) Compared to Planned and Over Time



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Category	Item	2014	2015	2016	2017	Program Total (2014-2017)
Operations	Direct Rebate					
and Management	Direct Implementation					
Costs (\$)	Direct EM&V					
	Indirect Other (Administrative)	\$3,186	\$15,540	\$6,321	\$2,018	\$27,065
Total Costs	Total					
(\$)	Planned					
Category perations nd lanagement costs (\$) otal Costs \$) 'articipants rarticipants nstalled nergy Savings kWh/year)	Variance					
	Cumulative % of Planned	25%	106%	45%	95%	61%
Participants	Total (Gross)	581	3,307	1,274	125	5,287
	Planned (Gross)	2,777	2,777	1,542	0	7,096
	Variance	-2,196	530	-268	125	-1,809
	Cumulative % of planned (Gross)	21%	119%	83%	N/A	75%
Installed	T. 10	454 057	040.001	222 670	22.050	1 252 275
Energy	Total Gross Deemed Savings	154,857	843,691	322,679	32,050	1,353,277
Savings	(99%)	-1,239	-6,750	-2,581	-256	-10,826
(kWh/year)	Adjusted Gross Savings	153,618	836,942	320,098	31,793	1,342,451
	Net-to-Gross Adjustment (90%)	-15,362	-83,694	-32,010	-3,179	-134,245
	Net Adjusted Savings	138,256	753,248	288,088	28,614	1,208,206
	Planned Savings (Net)	2,116,074	2,116,074	174,326	0	4,406,474
	Cum. % Toward Planned Savings (Net)	7%	36%	165%	N/A	27%
	Avg. Savings per Participant (Gross)	267	255	253	256	256
	Avg. Savings per Participant (Net)	238	228	226	229	229

North Carolina

Table 4-7. NC Residential Heat Pump Tune-Up Program Performance Indicators (2014–2017)

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		North Carolina						
Category	Item	2014	2015	North Carolina 2016 2017 F 5 241 25 1 5 -2 0 1 0 239 25 1 2 -24 -2 1 8 215 22 1 9 58 0 1 6 368% N/A 1 9 0.19 0.20 1 7 0.17 0.18 1 9 \$\$ \$\$ \$\$ 16 12 \$\$ \$\$ \$\$ \$\$ 5 \$\$ \$\$ \$\$ \$\$ 5 \$\$ \$\$ \$\$ \$\$ 12 \$\$ \$\$ \$\$ \$\$ 12 \$\$ \$\$ \$\$ \$\$ 13% \$\$ \$\$ \$\$ \$\$ 14 \$\$ \$\$ \$\$ \$\$ 15 \$\$ \$\$	Program Total (2014-2017)			
Installed	Total Gross Deemed Demand	80	625	241	25	971		
Demand Reduction	Realization Rate Adjustment (99%)	-1	-5	-2	0	-8		
(KVV)	Adjusted Gross Demand	79	620	239	25	963		
	Net-to-Gross Adjustment (90%)	-8	·8 -62 -24 -2 '1 558 215 22 '9 639 58 0	-96				
	Net Adjusted Demand	71	558	215	22	867		
	Planned Demand (Net)	639	639	58	0	1,336		
	Cum. % Toward Planned Demand (Net)	11%	87%	368%	N/A	65%		
	Avg. Demand per Participant (Gross)	0.14	0.19	0.19	0.20	0.18		
	Avg. Demand per Participant (Net)	0.12	0.17	0.17	0.18	0.16		
Program Performance	Cum. \$Admin. per Cum. Participant (Gross)	\$5	\$5	\$5	\$16	\$5		
	Cum. \$Admin. per Cum. kWh/year (Gross)	\$0.02	\$0.02	\$0.02	\$0.06	\$0.02		
	Cum. \$Admin. per Cum. kW (Gross)	\$40	\$25	\$26	\$81	\$28		
	Cum. \$EM&V per Cum. Total Costs (\$)	6%	1%	3%	8%	3%		
	Cum. \$Rebate per Cum. Participant (Gross)							

Figure 4-15. NC Residential Heat Pump Tune-Up Cumulative Participation Compared to Planned and Over Time Figure 4-16. NC Residential Heat Pump Tune-Up Cumulative Net Adjusted Annualized Savings (kWh/year) Compared to Planned and Over Time



By the end of the program life, 87,126 heat pumps were tuned-up in Virginia through the Residential Heat Pump Tune-Up program, and 5,287 in North Carolina. This resulted in 18,609,439 kWh/year of cumulative annualized net energy savings in Virginia and 1,208,206 kWh/year in North Carolina. In both states, the average net annualized energy savings for each heat pump was slightly over 220 kWh/year. This was below the initial program planning assumption of 762 kWh/year (shown earlier in Table 4-5). One contributing factor to this difference may be in a difference between the initial program assumptions regarding the heat pump efficiencies and the efficiency values assumed in the EM&V gross annualized energy savings calculations (STEP Manual). The EM&V gross energy savings calculations assume heat pump efficiencies are the same as federal minimum efficiencies provided in the most recent version of the Mid-Atlantic Technical Reference Manual, which may be more efficient than that of the heat pumps that were tuned-up.

While the program continued to have steady enrollment in both states, it did not meet cumulative participation and net annualized energy savings goals. However, in 2016 it did meet incremental annual net energy savings goals in both states. It is worth noting that the program spending over the years also did not meet goals cumulatively.

In Virginia and over its life, the program spent 60% of its plan. Program administrative costs per participant, per gross kWh/year saved, and rebate cost per participant cost all remained steady over time. Administrative costs per participant averaged to \$12 per participant, average administrative cost per gross kWh/year saved was \$0.05/kWh/year, and average rebate cost per participant cost was \$90. Average administrative costs per gross kW was \$65/kW. It had fluctuated over the course of the program life. And EM&V costs were 3% of total program costs. This program had one impact evaluation in the middle of the program life, and all subsequent net savings calculations were based off the realization rate (99%) from that study.

In North Carolina, the trends for these program performance indicators were similar to Virginia. Administrative costs per participant averaged to \$5 per participant, average administrative cost per gross kWh/year saved was \$0.02/kWh/year, and average rebate cost per participant cost was \$90. Average administrative costs per gross kW was \$28/kW. It had fluctuated over the course of the program life. And EM&V costs were 3% of total program costs.

4.2.2.2 Additional Virginia Program Participant Data

Figure 4-17 on the next page shows the distribution of gross energy savings, peak demand reduction, and number of heat pump tune-ups by system capacity in Virginia over the program life. Systems with cooling capacities of 2 tons to 2.49 tons made up the largest percent of gross energy savings (29%). Overall, the results show that, of the residential tune-ups that occurred in Virginia over the program life, the majority (92%) were below 3.5 tons, which also made up 86% of the energy and peak demand savings.



Figure 4-17. VA Residential Heat Pump Tune-Up Program Performance Indicators by System Capacity as % of total (2012-2017)

Figure 4-18 provides the percentage of gross energy savings, peak demand reduction, and tune-ups by dwelling type for Virginia over the program life.

Almost three-fourths of the gross energy savings (73%) attributed to the program were achieved in singlefamily (including single-family attached) dwellings, and most of the remaining savings (25%) came from tune-ups performed in multi-family dwellings. There was a larger diversity of dwelling types that contained these participating heat pumps in Virginia than in North Carolina. For example, while there were relatively few participants who lived in garden apartments, mobile homes, and townhouse/duplex in Virginia, they were still represented in the participant group over the program life. These dwelling types were not represented in the North Carolina participant group, shown in Figure 4-21. This may be a function of the difference in the Company's service territory in both states. In North Carolina, the Company serves the northeastern section of the state, and makes the program available to all eligible customers there.

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Comparatively, in Virginia, the Company serves and makes this program available to eligible customers in almost the entire state which contains a more diverse set of customers.

Figure 4-18. VA Residential Heat Pump Tune-Up Program Performance Indicators by Dwelling Type as % of Total (2012-2017)

These heat pumps in Virginia were mostly 15 years old or younger, as shown in Figure 4-19 (next page). About one-third of the participating heat pumps (31%) were 5 years old or younger, representing the same proportion (30%) of the program gross annual energy savings. The next third of the participating heat pumps were 6 years old to 10 years told at the time of the tune-up, and producing 33% of the program gross annual energy savings. The remaining third of the program participants and savings were from tuning up heat pumps more than 10 years old at the time of the tune-up.

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Figure 4-19. VA Residential Heat Pump Tune-Up Program Performance Indicators by Equipment Age at the Time of the Tune-Up as % of Total (2012-2017)

4.2.2.3 Additional North Carolina Program Participant Data

Figure 4-20 shows the distribution of gross energy savings, peak demand reduction, and the number of heat pump tune-ups by system capacity in North Carolina over the program life.

North Carolina participants with system capacities of 3 ton-3.49 ton represented the largest percentage of gross energy savings (25%). Expanding on that range, systems within 2.0 ton-3.5 ton combined for approximately 72% of tune-ups and 69% of both energy and peak demand savings in North Carolina over the program life. This is the same tonnage range with the greatest enrollment and gross energy savings as in Virginia.

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Figure 4-20. NC Residential Heat Pump Tune-Up Program Performance Indicators by System Cooling Capacity as % of Total (2014-2017)

Figure 4-21 provides the percentage of gross total energy savings, peak demand reduction, and tune-ups by dwelling type in North Carolina over the program life. Almost all tune-ups were performed at single-family homes (97%), higher than in Virginia. This may be a result of the different service areas, and populations in those areas, that the Company serves in Virginia versus North Carolina. There were fewer participating heat pumps in multi-family dwelling types in North Carolina than in Virginia (shown in Figure 4-18).

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Figure 4-21. NC Residential Heat Pump Tune-Up Program Performance Indicators by Dwelling Type as % of Total (2014-2017)

The age of the participating heat pumps in North Carolina (Figure 4-22) over the program life are slightly younger than the participating heat pumps in Virginia (shown previously in Figure 4-19). Three-fourths of the participating heat pumps (73%) and approximately the same proportion of gross energy savings (72%) in North Carolina were from heat pumps that were 10 years old or younger at the time of the tune-up.

Compared to Virginia, more than 90% of the participants and the savings were from heat pumps that were 15 years old or younger. This again, may be due to the different Dominion Energy service territory population in Virginia and North Carolina. In North Carolina, the Company serves the northeastern section of the state, and makes the program available to all eligible customers there. Comparatively, in Virginia, the Company serves and makes this program available to eligible customers in almost the entire state which contains a more diverse set of customers.

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Figure 4-22. NC Residential Heat Pump Tune-Up Program Performance Indicators by Equipment Age at the Time of the Tune-Up as % of Total (2014-2017)

4.3 Residential Duct Sealing – Virginia and North Carolina

The Residential Duct Sealing Program (formerly the Residential Duct Testing and Sealing Program) began on August 1, 2012 in Virginia and on January 1, 2014 in North Carolina. It was designed to promote general repair of poorly performing duct and air distribution systems. In 2014, a prescriptive option was added to the program, which boosted overall participation.

The savings are signed, sealed and delivered

The program follows the same eligibility guidelines in both states. Qualifying customers must have a heat pump and are eligible to receive an incentive for having a contractor seal ducts in existing homes using program approved methods. The repairs are expected to reduce the average duct leakage of a home's conditioned floor area to 15% or less of the total duct system leakage.³² Vendors may test for duct leakage and demonstrate adherence to the program requirements in a number of ways (e.g., duct blaster testing and modified blower door testing) or use the prescriptive path, which allows contractors to use the duct sealing and repair checklist provided on the rebate application form in lieu of duct leakage testing.

To be eligible for this program, residential customers must live in a single-family residence or townhome at least five years old and must own the home or be able to secure permission from the owner to perform the repairs or improvements. Apartments, condos, mobile homes, homes with geothermal systems, and homes with non-electric heat are not eligible.

This program is implemented through a contractor network, so customers must contact a participating contractor to be eligible for the rebate. Customers are not considered participants until completed application forms are processed and rebates are issued. This process can take several months, as customers have 45 days to submit their rebate application and the Company has 90 days to process it.

In 2016, Dominion Energy announced the program was closed to new participants in both states. To be eligible for a rebate, the service must have been completed by a participating contractor by December 24, 2016 and rebate applications received by February 7, 2017. This report section shows those final enrollments in 2017. The rebate form submission and processing time all together can add up to 135 days before a participant shows up in the tracking and reporting system. This report section shows those final enrollments in 2017 that were serviced in the last months of 2016.

Over the program life, a large majority of the sealed heat pump systems (88%) in Virginia and North Carolina were rebated to the contractors directly, with customer permission (Table 4-8).

State	Percent of Duct Sealing Heat Pumps Rebated	Percent of Rebates Given to Contractors
VA	85%	87%
NC	15%	96%

Table 4-8. Percent of 2012-2017	Residential Duct Sealin	g Heat Pumps Rebated to C	ontractors
Directly			

4.3.1 Methods for the Current Reporting Period

100%

For the current period, the approach included reviewing the tracking data and estimating gross energy and peak demand reduction using STEP Manual calculations with the realization rate estimated from on-site duct testing and verification performed by DNV GL in 2014. Table 4-9 outlines Dominion Energy's initial program planning assumptions that were used to design the program.

88%

Total

³² Based on the Dominion Residential Duct Sealing Program application. Accessed on March 8, 2017.

Table /	4 0	Decidential	Duck Cooling	Ducana	Diamaina	Accumuliance	Custom wide
able "	+-9.	Residential	Duct Seam	i program	Planning	Assumptions	System-wide

Item	Description
Target Market	Residential customers
NTG Factor	80%
Measure Life	18 years
Average Energy Savings (kWh) per Participant per Year	524 kWh per participant per year
Average Coincident Peak Demand Reduction (kW) per Participant	0.33 kW per participant per year
Average Rebate (US \$) per Participant	\$128 per participant

4.3.2 Assessment of Program Progress Towards Plan

The next section describes the program's progress towards planned participants, energy savings, and peak demand reductions.

4.3.2.1 Key Virginia and North Carolina Program Data

The next six pages contain Table 4-10, Figure 4-23, and Figure 4-24, which summarize key indicators of progress over time from August 2012 through December 31, 2017 for Virginia, and Table 4-11, Figure 4-25, and Figure 4-26, which summarize key indicators from January 1, 2015 through December 31, 2017 for North Carolina.

Detailed monthly program indicators are provided for Virginia in Appendix A.3 and for North Carolina in Appendix B.3.

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	Sec. and the second second	
Ext	\$306,208	\$12,428
raoro		
dinar		
s Ali		
ensi	58%	110%
tive]	3,299	264
Info	16,720	0
-ma	-13,421	264
tion	20%	N/A
Reda		1
actec	1,934,698	145,638
-	-978,957	-73,693
	955,741	71,945

Program

Total

Table 4-10. VA Residential Duct Sealing Program Performance Indicators (2012-2017)

2012

2013

2014

(2012 - 2017)Operations Direct Rebate and **Direct Implementation** Management Direct EM&V Costs (\$) Indirect Other \$107,619 \$88,535 \$47,393 \$29,028 \$21,206 (Administrative) Total Costs (\$) Total Planned Variance Cumulative % of Planned 83% 57% 57% 56% 40% Participants 8 Total (Gross) 108 401 1,860 658 Planned (Gross) 1,267 3,456 5,249 5,249 1,499 Variance -1,259 -3,348 -4,848 -3,389 -841 Cumulative % of planned 1% 3% 8% 35% 44% (Gross) Installed Total Gross Deemed 10,093 120,772 264,570 1,024,299 369,325 Savings³³ Energy Savings **Realization Rate** -5,107 -61,111 -133,872 -518,295 -186,879 Adjustment (49%)³⁴ (kWh/year) 59,661 Adjusted Gross Savings 4,986 130,697 506,004 182,447 Net-to-Gross Adjustment -997 -11,932 -26,139 -101,201 -36,489 -14,389 -191,148 (80%)404,803 Net Adjusted Savings 3,989 47,729 104,558 145,957 57,556 764,592

Virginia

2015

2016

2017

³⁴ The realization rate adjustment was updated to 49% based on the 2015 Impact Evaluation and Customer Satisfaction Report.

Category

Item

³³ Gross deemed savings and gross deemed demand were retroactively corrected for a calculation error in 2015 found during EM&V quality control (QC) activities in 2016.

					Virginia			
Category	Item	2012	2013	2014	2015	2016	2017	Program Total (2012-2017)
	Planned Savings (Net)	533,000	1,449,268	2,750,476	2,750,476	178,861	0	7,662,081
	Cum. % Toward Planned Savings (Net)	1%	3%	4%	15%	82%	N/A	10%
	Avg. Savings per Participant (Gross)	1,262	1,118	660	551	561	552	586
	Avg. Savings per Participant (Net)	499	442	261	218	222	218	232
Installed Demand	Total Gross Deemed Demand	12	138	217	839	302	119	1,627
Reduction	Realization Rate Adjustment (43%) ³⁵	-7	-79	-125	-483	-174	-69	-936
	Adjusted Gross Demand	5	59	92	357	129	51	692
	Net-to-Gross Adjustment (80%)	-1	-12	-18	-71	-26	-10	-138
	Net Adjusted Demand	4	47	74	285	103	41	553
	Planned Demand (Net)	330	898	1,732	1,732	60	0	4,752
	Cum. % Toward Planned Demand (Net)	1%	5%	4%	16%	172%	N/A	12%
	Avg. Demand per Participant (Gross)	1.45	1.28	0.54	0.45	0.46	0.45	0.49
	Avg. Demand per Participant (Net)	0.49	0.43	0.18	0.15	0.16	0.15	0.17
Program	Cum. \$Admin. per Cum. Participant (Gross)	\$13,452	\$820	\$118	\$16	\$32	\$47	\$93
Performance	Cum. \$Admin. per Cum. kWh/year (Gross)	\$10.66	\$0.7	\$0.2	\$0.03	\$0.06	\$0.09	\$0.16
	Cum. \$Admin. per Cum. kW (Gross)	\$9,287	\$642	\$219	\$97	\$70	\$104	\$188

³⁵ The realization rate adjustment was updated to 43% based on the 2015 Impact Evaluation and Customer Satisfaction Report.

		Virginia						
Category	Item	2012	2013	2014	2015	2016	2017	Program Total (2012-2017)
	Cum. \$EM&V per Cum. Total Costs (\$)	2.1%	13.5%	19%	15%	15%	21%	12%
	Cum. \$Rebate per Cum. Participant (Gross)							

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