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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)

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

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APPENDIX D METHODOLOGIES

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EVALUATION, MEASUREMENT, AND VERIFICATION REPORT FOR VIRGINIA ELECTRIC AND POWER COMPANY (DOMINION ENERGY)

Appendix D
Methodologies, and Detailed Avoided Emission, Non-Energy Impacts, and Bill Savings Results

Date: June 15, 2022

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Table of Contents

1 EXECUTIVE SUMMARY 3

2 LIST OF PROGRAM ACRONYMS 5

3 GROSS AND NET ENERGY SAVINGS AND DEMAND REDUCTION IMPACTS 6
3.1 Calculating the Value of Resources Saved 6
3.1.1 Savings Estimation for DR programs 6
3.1.2 Savings Estimation for EE programs 7
3.1.3 Gross Savings 10
3.1.4 Transmission and Distribution System Losses 12
3.1.5 Adjusted Gross Savings 12
3.1.6 Net Savings Estimation 17
3.1.7 Life Cycle or Lifetime Savings 19

4 VIRGINIA CLEAN ECONOMY ACT REQUIREMENTS NON-ENERGY METRICS 24
4.1 Bill Savings 24
4.1.1 Introduction 24
4.1.2 Methodology 24
4.1.3 Results 27
4.2 Non-Energy Impacts 29
4.2.1 Introduction 29
4.2.2 Methodology 30
4.2.3 Results 32
4.3 Avoided Emissions 33
4.3.1 Introduction 33
4.3.2 Methodology 34
4.3.3 Results 38
4.4 Benefit/cost and avoided cost methodology review 40
4.4.1 Benefit/cost review 40
4.4.2 QC Workbook and Calculation Review 45
4.4.3 Avoided Costs Review 46

OFFICIAL COPY
Jun 15 2022

List of Figures

Figure 3-1. Overall Evaluation Process for Demand Response Programs....7
Figure 3-2. Overall Evaluation Process for Energy Efficiency Programs....8
Figure 3-3. Hourly Lifetime Savings Calculation Process....21
Figure 3-4. Illustrative Hourly Savings Load shape for an Example Non-residential Measure in Virginia....23
Figure 4-1. Bill Savings Estimation Process....25
Figure 4-2. Data Sources Utilized by LCC Tool to Estimate Measure-Level NEIs....30
Figure 4-3. PJM DC 2021 Monthly Marginal Operating Emissions Rate....35
Figure 4-4. PJM DC July 2021 Hourly Marginal Operating Emissions Rate....36
Figure 4-5. PJM January vs. July 2021 Weekday Hourly Marginal Operating Emissions Rate....36
Figure 4-6. Dominion Energy 2021 Virginia Emissions by Active Programs....39
Figure 4-7. Dominion Energy 2021 Virginia Emissions by Most Active Programs....39

List of Tables

Table 3-1. Primary Impact Evaluation Methods to Measure Net Energy and Demands Savings....9
Table 3-2. Realization Rates and Sources by Program....13
Table 3-3. Status of Unintended Outcomes Considered in DNV Impact Evaluations....17
Table 3-4. Net-to-Gross Factors and Sources by Program....18
Table 3-5. Calculations Based on Day Type....22
Table 4-1: Bill Savings by Program and Rate Schedule....27
Table 4-2. Included Programs and Measures and Number of Records Analyzed....29
Table 4-3. Annualized Net Present Value NEI by Program and End Use by Active Virginia Programs in 2021....32
Table 4-4. Annualized Net Present O&M Value per Annual Electric Savings by Active Virginia Programs in 2021....33
Table 4-5. Overall Annualized Net Present Value NEI by End Use....33
Table 4-6. Hourly Emission Rates Excerpt....37
Table 4-7. Virginia Monthly Emissions by Active 2021 Programs....38
Table 4-8. LMT Benefit-Cost Outputs by Cost-Effectiveness Measure....42
Table 4-9. LMT Inputs and Sources....43
Table 4-10. LMT Program Review and Test Cases....44
Table 4-11. Description of DNV Calculation Verification and Documentation Sections....45
Table 4-12. Avoided Costs for Transmission and Distribution....46

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Jun 15 2022

1 EXECUTIVE SUMMARY

Dominion Energy is required to utilize the services of a third party to perform evaluation, measurement, and verification services to review the utility's total customer bill savings that the programs and portfolios produce per the Virginia Clean Economy Act Code Section 56-596.2 C. This report details the process that DNV used to review Dominion Energy's total bill savings, non-energy impacts, avoided emissions, and avoided costs for their energy efficiency programs that were active in Virginia in 2021.

For total bill savings, DNV calculates the annual bill impacts by program and rate schedule for the programs that were active in Virginia in 2021. DNV used an algorithm that incorporated the participant population from program tracking data, pre-participation billing data, and the unitized rate class hourly load shapes from the Dominion Energy Load Research team matched with each of the participant customers based on rate schedule. The estimated post-participation load shape was calculated as the pre-participation load minus the savings for each hour with a savings shape and a pre-participation load shape for each customer. The difference between the pre-participation and post-participation billing parameters was the difference due to the program, and the bill impact is the rate components applied to those differences, across all billing parameters, with and without the program. The total bill savings was calculated at roughly $26.7 million per year resulting from the Company's programs in Virginia that were active in 2021.

For non-energy impacts (NEIs), DNV calculates annual operations and maintenance (O&M) related non-energy impacts utilizing an engineering cost-estimating approach and DNV's proprietary "Life Cycle Cost" tool. It relies upon an engineering life cycle cost-based approach to inventory O&M cost data and to estimate the cost change impacts of Dominion Energy's select energy-efficiency measures and projects in Virginia for programs that were active in 2021. The total annualized net present value of the life cycle NEIs for upgraded lighting, HVAC, and drive/motor, from the programs that were available in Virginia in 2021, totaled an estimated $17.8 million per year.

For avoided emissions, DNV calculated impacts by applying the hourly emissions rates to the hourly demand side management (DSM) savings for each EE program that was active in Virginia in 2021, splitting the overall Dominion Energy emissions savings by state based on each state's annual 2021 usage savings percentage. The parameters included the 2021 emissions levels from the WattTime.org, using the PJM DC-area historical emissions data, and the hourly 2021 DSM cumulative energy savings from load shapes already developed by program to determine the hourly DSM kWh energy savings to produce the emissions impacts, in metric tons of CO_2 units.

Overall, emissions impacts (in metric tons CO_2 avoided) were a total of 344,873 metric tons of CO_2 emissions avoided from the Virginia programs that were active in 2021 (inclusive of those participants from the program start through 2021). They contributed 97.8% of all Dominion Energy system-wide emissions impacts from the DSM program savings that persist in 2021. Impacts were distributed fairly evenly across the year, reflecting the large savings impacts of lighting measures (from programs such as the Non-Residential Lighting Systems & Controls and Residential Efficient Products Marketplace programs), some heating-oriented (winter seasonal, such as the Residential Income and Age Qualifying Home Improvement Program) and some cooling-oriented (summer-seasonal, such as from the Non-Residential Prescriptive Program).

For the benefit-cost analyses, DNV reviewed the Company's new LMT software system that models and calculates cost-effectiveness tests for Dominion Energy DSM programs.

For the avoided cost, DNV reviewed Dominion Energy's two main avoided costs that are the inputs for Strategist analyses. These costs include avoided transmission ($/kW) and avoided distribution ($/kW) that are summed to calculate the total transmission and distribution (T&D) demand credit (benefit), for each year in each program.

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DNV's analyses showed that Dominion Energy's approach to benefit-cost testing and avoided costs follows standard practice. The Strategist model is a well-vetted and comprehensive tool that is appropriate for this use. Inputs to the modeling process are well documented and appear appropriate to the programs.

These activities are meant to fulfill the requirements from the Virginia Clean Economy Act, Code Section 56-596.2 C, which states:

> "B. Utilities shall utilize the services of a third party to perform evaluation, measurement, and verification services to determine a utility's total annual savings as required by this subsection, as well as the annual and lifecycle net and gross energy and capacity savings, related emissions reductions, and other quantifiable benefits of each program; total customer bill savings that the programs and portfolios produce; and utility spending on each program, including any associated administrative costs. The third-party evaluator shall include and review each utility's avoided costs and cost-benefit analyses. The findings and reports of such third parties shall be concurrently provided to both the Commission and the utility, and the Commission shall make each such final annual report easily and publicly accessible online. Such stakeholder process shall include the participation of representatives from each utility, relevant directors, deputy directors, and staff members of the State Corporation Commission who participate in approval and oversight of utility efficiency programs, the office of Consumer Counsel of the Attorney General, the Department of Mines, Minerals and Energy, energy efficiency program implementers, energy efficiency providers, residential and small business customers, and any other interested stakeholder who the independent monitor deems appropriate for inclusion in such process. The independent monitor shall convene meetings of the participants in the stakeholder process not less frequently than twice in each calendar year during the period beginning July 1, 2019 and ending July 1, 2028. The independent monitor shall report on the status of the energy efficiency stakeholder process, including(i) (a) the objectives established by the stakeholder group during this process related to programs to be proposed, (ii) (b) recommendations related to programs to be proposed that result from the stakeholder process, and (iii) (c) the status of those recommendations, in addition to the petitions filed and the determination thereon, to the Governor, the State Corporation Commission, and the Chairmen of the House Committee on Labor and Commerce and Senate Committee on Commerce and Labor Committees on July 1, 2019, and annually thereafter through July 1, 2028."

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2 LIST OF PROGRAM ACRONYMS

Program Acronym and Phase	Program Name
AC (Phase I)	Residential Smart Cooling Rewards
DG (Phase II)	Non-Residential Distributed Generation
EAL3 (Phase IV)	Residential Income and Age Qualifying
SBIP (Phase V)	Non-Residential Small Business Improvement
CNRP (Phase VI)	Non-Residential Prescriptive
RAR2 (Phase VII)	Residential Appliance Recycling
REEC (Phase VII)	Residential Efficient Products Marketplace
RTHO (Phase VII)	Residential Home Energy Assessment
RCEB (Phase VIII)	Residential Customer Engagement
REVEE (Phase VIII)	Residential Electric Vehicle Energy Efficiency and Demand Response
RHRF (Phase VIII)	Residential Retrofit
RHVC (Phase VIII)	Residential HVAC Health and Safety
RKTS (Phase VIII)	Residential Kits
RMHP (Phase VIII)	Residential Manufactured Housing
RMFP (Phase VIII)	Residential Multifamily
RNCR (Phase VIII)	Residential New Construction
RTEE/RTEB (Phase VIII)	Residential Thermostat Purchase and WeatherSmart^{SM}
CHV3 (Phase VII)	Non-Residential Heating and Cooling Efficiency
CLT3 (Phase VII)	Non-Residential Lighting System & Controls
CSW2 (Phase VII)	Non-Residential Window Film
CTSM (Phase VII)	Non-Residential Small Manufacturing
CTSO (Phase VII)	Non-Residential Office
CEEP (Phase VIII)	Non-Residential Midstream Energy Efficiency Products
CMFP (Phase VIII)	Non-Residential Multifamily
CNCR (Phase VIII)	Non-Residential New Construction
SBI2 (Phase VIII)	Non-Residential Small Business Improvement Enhanced
RTDR (Phase VIII)	Residential Thermostat Rewards
REVDR (Phase VIII)	Residential Electric Vehicle Rewards

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3 GROSS AND NET ENERGY SAVINGS AND DEMAND REDUCTION IMPACTS

3.1 Calculating the Value of Resources Saved

In the life of a Dominion Energy DSM program, there are three stages of savings estimates that the Company provides the Commission:

1. Planning. Program design forecasted savings estimates that are derived from program designers and/or implementers. These are a generalized savings estimate on a per-participant basis, forecasted, and submitted to the Commission in the initial program approval filing.
2. Tracking. Participant-specific deemed savings currently calculated by DNV, using deemed savings calculations documented in the DE TRM, for actual program participants using a combination of customer-specific inputs (from customer applications collected either directly from customers or installation vendor while onsite) and DNV assigned deemed factors. The DE TRM is independently produced by DNV and updated annually. These savings have been referred to as “deemed savings” estimates.
3. Evaluated. Net savings calculated by DNV based on primary impact evaluation data and analysis.

All programs and measures begin with a stage 1 (planning) estimate. For most measures, a tracking value or calculation is then developed and used for ongoing tracking and annual reporting if there is no primary evaluation conducted (stage 2). For measures with stage 3 evaluation conducted, the evaluated savings are reported for that year, and the evaluation results are used to update the tracking calculations going forward. For some measures (e.g., Demand Response), stage 3 evaluation is conducted from the outset and are the only reported savings provided.

In this process, DNV has produced the savings for stages 2 and 3 throughout the life of each of the Company’s DSM portfolios to date and is under contract to continue to do so through 2024 via the DSM Phase VIII programs. The tracked (stage 2) savings are not based on primary evaluation analysis, but are calculated using a combination of the customer-specific information and deemed factors listed below:

- The utility’s customer-specific information collected from customer application data, where available and reliable (e.g., equipment size, equipment type), collected either from the customer or installation vendor
- Virginia-specific information (e.g., Virginia building code requirements)
- Information from other sources that are adjusted to be both utility- and Virginia-specific, where applicable (e.g., for weather specific to the Company’s territory)
- Adjustment factors from prior evaluations.

3.1.1 Savings Estimation for DR programs

The evaluation approach differs slightly depending on the type of program (EE or peak shaving/DR). For DR programs, DNV has historically and will continue to analyze customer-specific load data for an affected group of participant premises in comparison with a control group (non-participants from the Company’s customer population), on an annual basis. Figure 3-1 illustrated the evaluation process for demand response programs. These estimates are fully customer- and utility-specific and do not rely on any deemed factors from outside sources.

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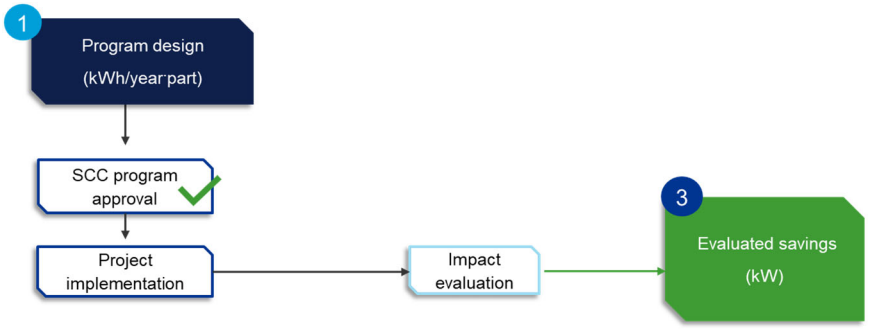
Figure 3-1. Overall Evaluation Process for Demand Response Programs



Generally, this approach for evaluating EE and DR programs is consistent with industry best practices for EM&V of these types of programs.

3.1.2 Savings Estimation for EE programs

The three broadly recognized categories of EM&V methods are:

- Deemed savings
- Measurement and verification
- Consumption data analysis with a comparison group.

DNV uses deemed savings methods for tracked savings (Stage 2) to determine and report deemed participant-specific savings when a program is initially launching. This process ensures that program progress can be reported on an annual basis for the Commission's use, even before there is sufficient program participation to conduct an impact evaluation that will yield meaningful results.

Then, when there is enough participation in the program to reliably produce statistically valid results, or roughly two to three years after program launch, DNV will conduct primary impact evaluations of the programs that will yield the most value from the evaluation information. The impact evaluation will include primary data collection and analysis (or either direct EM&V and/or a comparison group impact analysis). This process is illustrated in Figure 3-2 for energy efficiency programs. If a program will go through a primary data collection evaluation (Stage 3), those evaluations will collect customer-specific data that will be used in combination with other variables to estimate savings.

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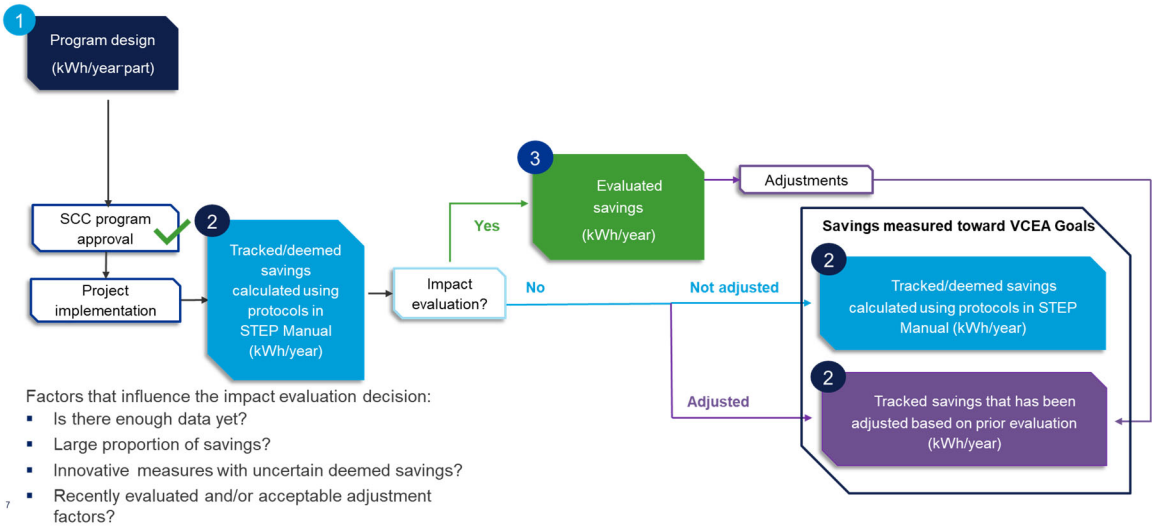
Figure 3-2. Overall Evaluation Process for Energy Efficiency Programs



For measures with particularly uncertain deemed savings estimates, DNV may conduct impact evaluations (i.e., primary data collection and analysis) after the first year and annually, assuming the program budget is sufficient to warrant that level of evaluation.

DNV will follow the directive in the Final Order in SCC Case No. PUR-2020-00156, specifically Attachment A to identify the programs that will receive primary impact evaluation (stage 3 savings estimates) in a given year. Not all programs will be evaluated through a primary impact evaluation, as it will not be cost-effective to do so. For the DSM Phase I through IX programs, these impact evaluation approaches are described in greater detail in their program EM&V plans listed in Appendix E.

Programs selected for evaluation in each year will be prioritized based on several factors, including but not limited to the uncertainty or variability of realized savings, its contribution to portfolio savings, program costs relative to all programs, the elapsed time since the last evaluation, or to address targeted research questions.

If a program will go through a primary data collection evaluation (Stage 3), those evaluations will collect customer-specific data that will be used in combination with other variables to estimate savings. A high-level summary of the primary data collection evaluation methods that will be used for each program is listed in Table 3-1.

Currently, tracking savings estimates (Stage 2), and primary impact evaluations (Stage 3) are guided by these objectives:

- Follow the “value of information” framework to identify the programs that should receive primary impact evaluations (e.g., programs with the largest proportion of the portfolio’s savings, programs with savings estimates with the greatest uncertainty, programs with potential for future growth)
- Optimize the cost of measurement
- Produce savings that are not overly conservative or high, to achieve the Virginia State Corporation Commission’s guidance to determine actual savings estimates
- Keep the process as simple as it needs to be, and not overcomplicate the calculations and issues in an attempt to gain a false sense of accuracy
- Provide transparency in our deemed savings methodology in the DE TRM, and our evaluations

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- Specify the impact evaluation approaches that will be taken in our EM&V plans, before program launch, to allow for flexibility in the plan as the program may not be adopted by the market the way it was originally planned

In addition to the impact evaluation method, **Table** 3-1 indicates whether a net-to-gross survey is required. While other methods of determining a net-to-gross ratio are available, our proposed net-to-gross method for the current programs is based on surveys of customers, vendors, distributors, or manufacturers, as applicable. For some programs, a net-to-gross adjustment is not needed because the impact evaluation method provides net savings directly. This is the case, for example, for the load analysis conducted for the Residential Smart Cooling Rewards, as well as for the energy consumption analysis for the Residential Customer Engagement Program.

Table 3-1. Primary Impact Evaluation Methods to Measure Net Energy and Demands Savings

DSM Phase	Program	Impact Evaluation Method	Net-to-Gross Surveys Required?	Preference Order for Collection of EM&V Data (1, 2, 3)
I	Residential Smart Cooling Rewards	Whole premise hourly load analysis	No	1 – customer specific
II	Non-Residential Distributed Generation	Whole premise hourly load analysis	No	1 – customer specific
IV	Residential Income & Age Qualifying Home Improvement Program	Whole premise monthly consumption analysis	No	1 – customer specific
V	Non-Residential Small Business Improvement Program	Measurement and verification (metering)	Yes	1 – customer specific
VI	Non-Residential Prescriptive Program	Measurement and verification (metering)	Yes	1 – customer specific
VII	Non-Residential Heating and Cooling Efficiency Program	Measurement and verification (metering)	Yes	1 – customer specific
	Non-Residential Lighting Systems & Controls Program	Measurement and verification (metering)	Yes	1 – customer specific
	Non-Residential Office Program	Measurement and verification (metering)	Yes	1 – customer specific
	Non-Residential Small Manufacturing Program	Measurement and verification (metering)	Yes	1 – customer specific
	Non-Residential Window Film Program Measures	Measure verification with deemed calculation	Yes	1 – customer specific
	Residential Appliance Recycling Program	Measurement and verification (metering)	Yes	1 – customer specific
	Residential Efficient Products Marketplace Program	Measure verification with deemed calculation	Yes	1 – customer specific
	Residential Home Energy Assessment Program	Whole premise monthly consumption analysis	Yes	1 – customer specific
VIII	Non-Residential Heating & Cooling Efficiency	Whole premise monthly consumption analysis	Yes	1 – customer specific
	Non-Residential Midstream Energy Efficiency Products	Measurement and verification (metering)	Yes	1 – customer specific

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DSM Phase	Program	Impact Evaluation Method	Net-to-Gross Surveys Required?	Preference Order for Collection of EM&V Data (1, 2, 3)
	Non-Residential Multifamily Program	Whole premise monthly consumption analysis	Yes	1 – customer specific
	Non-Residential New Construction Program	Measurement and verification (metering)	Yes	1 – customer specific
	Non-Residential Small Business Improvement Enhanced Program	Measurement and verification (metering)	Yes	1 – customer specific
	Residential Customer Engagement Program	Whole premise monthly consumption analysis	No	1 – customer specific
	Residential Electric Vehicle Rewards	Whole premise hourly load analysis	No	1 – customer specific
	Residential Electric Vehicle Energy Efficiency and Demand Response Program	Whole premise monthly consumption analysis	Yes	1 – customer specific
	Residential Energy Efficiency Kits Program	Measure verification with deemed calculation	Yes	1 – customer specific
	Residential HVAC Health and Safety	Whole premise monthly consumption analysis	Yes	1 – customer specific
	Residential Home Retrofit Program	Whole premise monthly consumption analysis	Yes	1 – customer specific
	Residential Manufactured Housing Program	Whole premise monthly consumption analysis	Yes	1 – customer specific
	Residential Multifamily Program	Whole premise monthly consumption analysis	Yes	1 – customer specific
	Residential New Construction Program	Measurement and verification (metering)	Yes	1 – customer specific
	Residential Smart Thermostat Purchase and WeatherSmart Program	Whole premise monthly consumption analysis	Yes	1 – customer specific
	Residential Thermostat Rewards	Whole premise hourly load analysis	No	1 – customer specific

3.1.3 Gross Savings

Gross savings are calculated using deemed calculations documented in the Dominion Energy Technical Reference Manual (DE TRM, Appendix F, formerly the Standard Tracking and Engineering Protocol Manual or the STEP Manual). It has been included as an appendix to the annual EM&V report since 2010. The DE TRM is contains the deemed engineering equations used to calculate kilowatt and kilowatt-hour savings for each of the measures and program that the Company implements in Virginia and North Carolina for a given program year. It is updated annually.

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In the absence of a TRM that is issued by regulators in Virginia or North Carolina and that applies to all utility programs in each state, DNV derives deemed savings equations from the Mid-Atlantic Technical Reference Manual (Mid-Atlantic TRM).[1] The Mid-Atlantic TRM is used in states that border Virginia and elsewhere in the mid-Atlantic region of the United States (e.g., Maryland, District of Columbia, Delaware). For program measures that are not available in the Mid-Atlantic TRM, DNV assesses recent TRMs in the region, and nationally, if necessary, to identify the most appropriate source or sources for deriving the deemed savings equations and/or inputs.

Each TRM contains the sources for every deemed savings equation and input, including titles, version numbers, publication dates, and page numbers of all source documents, as appropriate.

As much as practicable, DNV currently produces kilowatt and kilowatt-hour savings estimates using utility-specific program participant data as inputs to the equations described above.

To gather utility-specific program data, DNV provides the Company with a list of the EM&V data variables and other data requirements that are necessary for estimating deemed savings, and for documenting the measure baseline. DNV develops this list, keeping in mind when it may be impractical to collect specific data variables (e.g., equipment name plate may be sun-bleached and illegible). The Company's program managers, analysts, and information technology ("IT") staff ensures that the program data is generated, and the Company's IT staff defines the information management system needed to ensure delivery of the data to DNV monthly.

When utility-specific data are unavailable or impracticable to collect, DNV uses proxy utility-specific program participant data to assign assumed inputs derived from Virginia-specific data or data from non-Virginia jurisdictions, and with appropriate citation to the source documents.

DNV applies the combination of program-generated utility-specific data, and other default inputs to the deemed equations documented in the TRM to calculate the kilowatt and kilowatt-hour savings for each implemented measure and aggregates it at the measure level, where appropriate, and reports it in the annual EM&V report for each program, without adjustment for free-ridership values. DNV reports the savings after adjustments for free-ridership based on either initial program design assumed free-ridership value or evaluated free-ridership value determined through EM&V. We will continue to report savings in this manner.

The protocols are limited to calculating per-unit annual energy savings and demand reductions at the measure level. The measure-level savings are aggregated up to the program level and reported through this document. The protocols do not include the calculation for the value of resources saved. To calculate the value of the resource savings for reporting and other purposes, the energy savings reported in this document can then be increased by the amount of the transmission and distribution (T&D) losses to reflect the energy savings at the system level. Energy savings at the system level can be multiplied by the appropriate avoided costs to calculate the value of the benefits.

System savings = Savings at measure x T&D loss factor

Value of resources saved = System savings x System avoided costs

The durations of expected savings of installed measures are specified in terms of average expected measure life in years by program. They are discussed in more detail in Section 3.1.7, Life Cycle or Lifetime Savings , below.

[1] Mid-Atlantic Technical Reference Manual (TRM) V10, https://neep.org/mid-atlantic-technical-reference-manual-trm-v10.

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3.1.4 Transmission and Distribution System Losses

These protocols calculate gross annual energy savings at the measure level, which should be increased by transmission and distribution (T&D) system losses to determine gross annual energy savings at the system level. The T&D loss factor multiplied by the savings calculated from the protocols will result in savings at the supply level.

The T&D electric loss factor is approximately 1.05 as a system-wide average (for both energy and demand), to be applied to savings at the customer meter. This loss factor was provided to DNV by Dominion Energy. It was developed internally for Dominion Energy's programs as part of its IRP process.

3.1.5 Adjusted Gross Savings

As indicated in Section 3.1.3, once an impact evaluation (Stage 3 analysis) is conducted, the tracked or deemed savings (Stage 2 results) that are produced using the TRM can then be adjusted based on those results. The adjustment factor is called a "gross realization rate" or "realization rate." Until an impact evaluation is conducted, the realization for any program is assigned a default of 100%. Table 3-2 lists the realization rates by program for all of the Company's DSM programs that have undergone impact evaluations and produced realization rates.

Table 3-2. Realization Rates and Sources by Program

DSM Phase	Program	Realization Rate	Source
Energy Efficiency Residential Programs			
I	Residential Low Income	2012: 47%	Case No. PUE-2010-00084. April 1, 2012. Appendix E-1. Low Income Program Billing Analysis Report
		2013: 75%	Case No. PUE-2011-00093. April 1, 2013 Appendix E-1. Low Income Program Billing Analysis Report
		2014: 62%	Case No. PUE-2011-00093. April 1, 2013 Appendix E-1. Low Income Program Billing Analysis Report
II	Residential Duct Sealing	Gross energy savings realization rate: 49% with a relative precision of approximately ±23% at a 90% confidence level Gross demand reduction realization rate: 43% with a precision of ±23% at a 90% confidence level.	Case No. PUE-2013-00072. April 1, 2015. Appendix J-1. Residential Duct Sealing Program Load Shape and Net Savings Analysis Evaluation Report
II	Residential Heat Pump Tune-Up	Gross energy savings realization rate: 99% with a precision of ±33% at a 90% confidence level.	Case No. PUE-2013-00072. April 1, 2015. Appendix I-1. Residential Heat Pump Tune-up Program Load Shape and Net Savings Analysis Evaluation Report
II	Residential Heat Pump Upgrade	2012-2014: Gross energy savings realization rate: 107% with a relative precision of approximately ±10.2% at a 90% confidence level. Gross demand reduction realization rate: 83% with a precision of ±11.8% at a 90% confidence level.	Case No. PUE-2013-00072. April 1, 2015. Appendix H-1. Residential Heat Pump Upgrade Program Load Shape and Net Savings Analysis Evaluation Report
		2015 and beyond: Gross energy savings realization rate: 78% with a relative precision of approximately ±7.5% at a 90% confidence level. Gross demand reduction realization rate: 89% with a precision of ±2.2% at a 90% confidence level.	Case No. PUE-2014-00071. April 1, 2016. Appendix G-2. Residential Heat Pump Upgrade Program Load Shape and Impact Analysis
II	Residential Home Energy Check-up	154%	Case No. PUE-2013-00072. April 1, 2015. Appendix G-1. Residential Home Energy Check-up Program Impact Evaluation and Customer Satisfaction Report
VII	Residential Efficient	100%	Case No. PUR-2019-00201. May 14, 2021. Appendix J.1. Impact Evaluation of the

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DSM Phase	Program	Realization Rate	Source
	Products Marketplace		Residential Efficient Products Marketplace Program
Energy Efficiency-Non-Residential Programs			
I	Commercial Lighting	Gross energy savings realization rate: 179% for the peak season from June through September, with a relative precision of approximately ±6.1% at a 90% confidence level 177% during the off-peak season from October through May, with a relative precision of approximately ±6.4% at a 90% confidence level. Gross demand reduction realization rate: 98% with a precision of ±1.4% at 90% confidence	Case No. PUE-2010-00084. October 1, 2011 Appendix B-1. Commercial Lighting Program. Load Shape and Net Savings Analysis Evaluation Report
I	Commercial HVAC	Gross energy savings realization rate: 35% for the summer system peak season from June through September, with a relative precision of approximately ±19% at a 90% confidence level. 63% during the off-peak season from October through May, with a relative precision of approximately ±20% at a 90% confidence level Gross demand reduction realization rate: 169% for the summer system peak season from June through September, with a precision of ±17% at 90% confidence. 97.0% during the off-peak season from October through May, with a relative precision of approximately ±19.3% at a 90% confidence level.	Case No. PUE-2010-00084. April 1, 2012 Appendix C-1. Commercial HVAC Program. Load Shape and Net Savings Analysis Evaluation Report
II	Non-Residential Duct Testing and Sealing	Gross energy savings realization rate: 87% with a relative precision of approximately ±10% at a 90% confidence level Gross demand reduction realization rate: 94% with a relative precision of ±6% at a 90% confidence level	Case No. PUE-2013-00072. April 1, 2015. Appendix L-1. Non-Residential Duct Sealing and Testing Program Load Shape and Net Savings Analysis Evaluation Report
II	Non-Residential Energy Audit	Gross energy savings realization rate: Walk-in door closer: 89.8% with a relative precision of approximately ±6.1% Smart strips: 70.0% with a relative precision of approximately ±8.3% Electric commutated motors: 78.6% with a relative precision of approximately ±<1.0% LED display case lighting: 97.5% with a relative precision of approximately ±<1.0% Occupancy sensor: 93.1% with a relative precision of approximately ±<1.0% Door gaskets: 99.2% with a relative precision of approximately ±4.0% Strip curtains: 36.1% with a relative precision of approximately ±22.1%	Case No. PUE-2013-00072. April 1, 2015. Appendix K-1. Non-Residential Energy Audit Program Load Shape and Net Savings Analysis Evaluation Report

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DSM Phase	Program	Realization Rate	Source
		Gross demand reduction realization rate: Walk-in door closer: 91.2% with a relative precision of approximately ±5.5% Electric commutated motors: 78.6% with a relative precision of approximately ±<1.0% LED display case lighting: 97.5% with a relative precision of approximately ±<1.0% Occupancy sensor: 51.2% with a relative precision of approximately ±<1.0% Door gaskets: 99.2% with a relative precision of approximately ±4.0% Strip curtains: 35.3% with a relative precision of approximately ±21.9%	
VI	Non-Residential Prescriptive	Gross energy savings realization rate: AC tune-up: 117% with a relative precision of approximately ±14% Auto closer: 89% with a relative precision of approximately ±20% Condenser coil cleaning: 41% with a relative precision of approximately ±58% Convection oven: 100% Door gasket: 107% with a relative precision of approximately ±6% Duct test and seal: 80% with a relative precision of approximately ±31% ECM at evaporator fan: 100% Electric fryer: 100% Evaporator fan control: 100% Freezer and refrigerator: 116% with a relative precision of approximately ±22% Griddle: 100% Hot food holder: 100% Ice maker: 100% Low now sweat door film: 100% Night cover: 100% Steam cooker: 100% Strip curtains: 151% with a relative precision of approximately ±58% VSD at kitchen exhaust fan: 186% Gross energy savings realization rate: AC tune ups: 99% with a relative precision of approximately ±0% Auto closers: 77% with a relative precision of approximately ±52%	Case No. PUR-2019-00201. May 14, 2021. Appendix X.1. Impact Evaluation of the Non-Residential Prescriptive Program

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DSM Phase	Program	Realization Rate	Source
		Condenser coil clean: 62% with a relative precision of approximately ±115% Convection oven: 100% Door gasket: 107% with a relative precision of approximately ±6% Duct test and seal: 77% with a relative precision of approximately ±21% ECM at evaporator fan: 100% Electric fryer: 100% Evaporator fan control: 100% Freezer and refrigerator: 116 with a relative precision of approximately ±22% Griddle: 100% Hot food holder: 100% Ice maker: 100% Low no sweat door film: 100% Night cover: 100% Steam cooker: 100% Strip curtain: 151 with a relative precision of approximately ±58% VSD at kitchen exhaust fans: 93%	
Peak Shaving Programs			
II	Non-Residential Distributed Generation	2013: 102% 2014: 101% 2015: 93% 2016: 106% 2017: 108% 2018: 97% 2019: 113% 2020: 106% 2021: 111%	See Appendix I. Impact Evaluation of 2021 Dispatch Events

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3.1.6 Net Savings Estimation

The TRM protocols are designed to estimate gross savings program impacts, or more specifically, the total amount of annual energy savings and demand reductions related to program activity. However, the amount of energy savings and demand reductions that can be attributed to the program is not the same as the estimated gross savings. This is because any given program's design can have intended and unintended outcomes. The amount of energy savings and demand reductions that can be attributed to the program is referred to as net savings, which is the magnitude of the impact of the program's intended outcomes. The most common unintended outcomes of an energy efficiency (EE) or peak shaving program can be characterized as any combination of the following:

- **Free-ridership:** program participants who consume the incentive but were not influenced by the program through which the measure is delivered, thereby reducing gross savings.
- **Participant "like" spillover:** past program participants who subsequently install those same program-eligible EE measures, but do not consume the incentive, having been already influenced by the program through which the measure is delivered, thereby increasing gross savings.
- **Participant "unlike" spillover:** past program participants who subsequently install other EE measures not offered through the program, but who have been influenced by the original program, thereby increasing gross savings.
- **Non-participant spillover:** program non-participants who were influenced by the program through which the measure is delivered and implement the measure without consuming the program incentive, potentially increasing gross savings. The influence may happen upstream at the design or specification stage without the customer's input or knowledge. This is also commonly referred to as "free drivers."
- **Leakage:** program non-participants who receive the measure and consume the incentive but install the measure outside of Dominion Energy's service territory, thereby reducing gross savings.
- **Snapback:** program participants who receive the measure and consume the incentive but alter behavior in such a way that the participants' or non-participants' energy and demand are higher than the baseline for the given measure.

Table 3-3 summarizes unintended outcomes that are considered in DNV's net-to-gross studies.

Table 3-3. Status of Unintended Outcomes Considered in DNV Impact Evaluations

Unintended Outcome Category	Status of Impact Evaluations
Free ridership	Included in all previous impact evaluations
Participant "Like" Spillover	Included only in the previous Non-Residential Energy Audit program impact evaluation
Participant "Unlike" Spillover	Not included at this time
Non-participant Spillover	Not included at this time
Leakage	Not included at this time
Snapback	Not included at this time

The combination of all adjustments described above is typically referred to as the net-to-gross (NTG) factor. The NTG factor is summarized by program in **Error! Reference source not found.** In this report, default NTG ratios are the ex ante values specified by Dominion Energy. These values will be updated over time as NTG is measured for each program. NTG factors typically change as programs mature and extend beyond the early adopters to the mass market.

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NTG factors may be estimated a number of ways. The energy efficiency evaluation industry discussions around various approaches are described in "Chapter 21, Estimating Net Savings – Common Practices," from the Uniform Methods Project for the U.S. Department of Energy and the "Energy Efficiency Program Impact Evaluation Guide."[2]

Table 3-4. Net-to-Gross Factors and Sources by Program

DSM Phase	Program	Net-to-Gross Ratio	Source
Energy Efficiency-Residential Programs			
I	Residential Lighting	65%	Dominion Energy program design assumption
I	Residential Low Income	94%	KEMA, April 2011 for Dominion Virginia Power
II	Residential Duct Sealing	80%	Dominion Energy program design assumption
II	Residential Heat Pump Tune-Up	90%	Dominion Energy program design assumption
II	Residential Heat Pump Upgrade	45%	DNV, April 2016 for Dominion Virginia Power
II	Residential Home Energy Check-up	82%	DNV, April 2016 for Dominion Virginia Power
IV	Residential Appliance Recycling	77%	Dominion Energy program design assumption
IV	Residential Income and Age Qualifying Home Improvement	105%	DNV, May 2022 for Dominion Virginia Power
V	Residential Retail LED Lighting	85%	Dominion Energy program design assumption
VII	Residential Appliance Recycling	60%	Dominion Energy program design assumption
VII	Residential Efficient Products Marketplace	Varies by measure	DNV, May 14, 2021 for Dominion Energy
VII	Residential Home Energy Assessment	80%	Dominion Energy program design assumption
VIII	Residential Customer Engagement	100%	Dominion Energy program design assumption
VIII	Residential Electric Vehicle Energy Efficiency and Demand Response	80%	Dominion Energy program design assumption
VIII	Residential Energy Efficiency Kits	60%	Dominion Energy program design assumption
VIII	Residential HVAC Health and Safety	80%	Dominion Energy program design assumption
VIII	Residential Home Retrofit	90%	Dominion Energy program design assumption
VIII	Residential Manufactured Housing	90%	Dominion Energy program design assumption
VIII	Residential New Construction	87%	Dominion Energy program design assumption
VIII	Residential Multifamily	90%	Dominion Energy program design assumption
VIII	Residential Smart Thermostat (Energy Efficiency)	80%	Dominion Energy program design assumption
VIII	Residential Smart Thermostat (Behavioral)	95%	Dominion Energy program design assumption
Energy Efficiency-Non-Residential Programs			
I	Commercial Lighting	50%	KEMA, October 2011 Commercial Lighting Program: Load Shape and Net Savings Analysis Evaluation Report
I	Commercial HVAC	45%	KEMA, April 2012 Commercial HVAC Program: Load Shape and Net Savings Analysis Evaluation Report
II	Non-Residential Duct Testing and Sealing	97%	DNV, April 2015 for Dominion Virginia Power
II	Non-Residential Energy Audit	Varies by measure	DNV, April 2015 for Dominion Virginia Power
III	Non-Residential Heating and Cooling	70%	Dominion Energy program design assumption
III	Non-Residential Lighting Systems & Controls	70%	Dominion Energy program design assumption
III	Non-Residential Window Film	80%	Dominion Energy Program design assumption
V	Non-Residential Small Business Improvement	93%	Dominion Energy Program design assumption

2 Violette, Daniel M.; Rathbun, Pamela. (2017). Chapter 21: Estimating Net Savings – Common Practices: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68578. http://www.nrel.gov/docs/fy17osti/68578.pdf; State and Local Energy Efficiency (EPA) Action Network (SEE Action), Energy Efficiency Program Impact Evaluation Guide Evaluation, Measurement, and Verification Working Group December 2012, https://www.energy.gov/sites/default/files/2013/11/f5/emv_ee_program_impact_guide.pdf.

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DSM Phase	Program	Net-to-Gross Ratio	Source
VI	Non-Residential Prescriptive	Varies by measure	DNV, May 14, 2021 for Dominion Energy
VII	Non-Residential Heating and Cooling	70%	Dominion Energy program design assumption
VII	Non-Residential Lighting Systems & Controls	70%	Dominion Energy program design assumption
VII	Non-Residential Window Film	80%	Dominion Energy program design assumption
VII	Non-Residential Small Manufacturing	90%	Dominion Energy program design assumption
VII	Non-Residential Office	90%	Dominion Energy program design assumption
VIII	Non-Residential Midstream Energy Efficiency Products	90%	Dominion Energy program design assumption
VIII	Non-Residential New Construction	90%	Dominion Energy program design assumption
VIII	Non-Residential Small Business Improvement Enhanced	93%	Dominion Energy program design assumption
VIII	Non-Residential Multifamily	90%	Dominion Energy program design assumption
Peak Shaving Programs			
I	Residential Smart Cooling Rewards	100%	KEMA, October 2011 Operability Study replaced net-to-gross. Required by PJM and not applicable in 2019
II	Non-Residential Distributed Generation	100%	
VIII	Residential Electric Vehicle Rewards	93%	Dominion Energy program design assumption
VIII	Residential Thermostat Rewards	N/A	N/A

3.1.7 Life Cycle or Lifetime Savings

3.1.7.1 Measure Lives

Starting in 2021, DNV has been calculating gross and net life cycle or lifetime savings using a bottom up load shape approach that applies hourly end use load shapes to the gross and net annualized savings calculated using the methods described in the above sections, over each measure's measure life for all of the Company's programs with persistent savings as of year-end 2021 (i.e., all Phase I through VIII programs). The resulting program life cycle or lifetime savings for all DSM programs are presented in Appendix M for Virginia and North Carolina, at the annual level.

Prior to 2021, the measure lives that DNV used to calculate life cycle or lifetime savings that were reported in prior EM&V reports for the Phase I through VII programs were the program design measure-lives that were a single aggregated value per program at the program-level. They were estimates that were filed with the SCC and NCUC when each program was considered for approval. These program-level lives generally represented an average of the measure-level lives for individual measure weighted by the savings projected to be contributed from those measures at the time of the program design.

Since it's more common than not that the actual measure mix in a program is different than what is assumed at the program design, starting in 2021 and with the Phase VIII programs and for all future phases of programs, DNV modified the measure life assignment to be at the measure-level. DNV assigns them based on independent research in other TRMs. Measures in the Phase I through VII programs continues and will continue to use the program-level measure lives until those programs' savings expire.

These measure life values by program and measure are documented in the DE TRM, in Appendix F.

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3.1.7.2 Hourly Load Shape Development

Since 2013, each year DNV develops annualized 8,760 DSM impact load shapes for each active DSM program, based on the year-end participants. These load shapes were used by the Company's Demand-side Planning team to represent the per-participant level incremental energy contribution that would be multiplied to forecasted program participation, for the purposes of the Company's Integrated Resource Plan (IRP).

This task consists of building end use measure load shapes based on the ratio of annual energy usage to peak demand developed by DNV using the methods described in the previous sections, resulting in estimated total annualized energy savings impacts reported in Appendices K and L, the Program Performance Indicator Tables of this report for each DSM program and measure. Based on the sector (residential or non-residential), end use (e.g., cooling, lighting), measure type (e.g., replacement equipment efficiency improvement, technology replacement). and ratio of annual usage to peak reported for each program, an end use load shape best matching the characteristics and load usage pattern of each measure is selected from a library of available end use load shapes from a load shape library that DNV has compiled over many years. The sources for the load shape library vary, including (in order of priority):

1. Any metered load data collected for the Company's service territory, especially as part of any impact evaluation projects,
1. Load shapes from regional or national sources that can be adjusted (e.g., for weather), and
2. Engineering models

The selection is based on the closest fit of the candidate end use load shape annual usage to peak ratio as those reported for each program in Appendices K and L. The load shapes are developed and stored using a ratio format that consists of a set of four sets of ratios that, when combined, completely describes an 8,760 (or 8,784) hourly annual load shape in a way that enables scalability to any target annual energy usage and is independent of the calendar year the load shape would be applied to. The four sets of ratios are:

1. **Monthly usage allocation**: Percentage of annual usage assigned to each month
2. **Weekend to weekday ratio (WEWD)**: Ratio of a typical weekend day usage to a typical weekday usage (by month). A value of 1.0 means that weekend day and weekday usage are assumed to be equal
3. **Peak day adjustment factor (PDAF)**: Ratio of the daily usage for a peak day versus that of a typical weekday (by month). For example, a value of 1.5 means that peak day consumption is 50% higher than for a typical weekday for the same period. These factors are primarily driven by daily weather sensitivity.
4. **Per-unit day-type load shapes**: Hourly load shape represented in per-unit of daily maximum, for each type of day (i.e., peak day, weekday, weekend day) for each month.

The advantage of creating a summarized version of hourly load shapes is that it facilitates the ability to adjust, scale, and otherwise calibrate each of the four load shape parameters independently to match that of the target customer or end use group more closely, but it can also capture sufficient variation in loads.

The annualized load shapes are developed from each program assuming the participants are contributing to the DSM impacts all year as a hypothetical full-year impact. And as described above, they were and continues to be used by the Company's DSP team to multiply with forecasted program participants to forecast the impact of DSM in future years in the Company's IRP.

3.1.7.3 Load shape-based Phase-in and Phase-out Process

Starting with the 2021 lifetime savings calculation, DNV is leveraging these same load shape ratios to backward apply them to all past years' of annualized gross and net savings through those measures' lives at the hourly level. These outputs are

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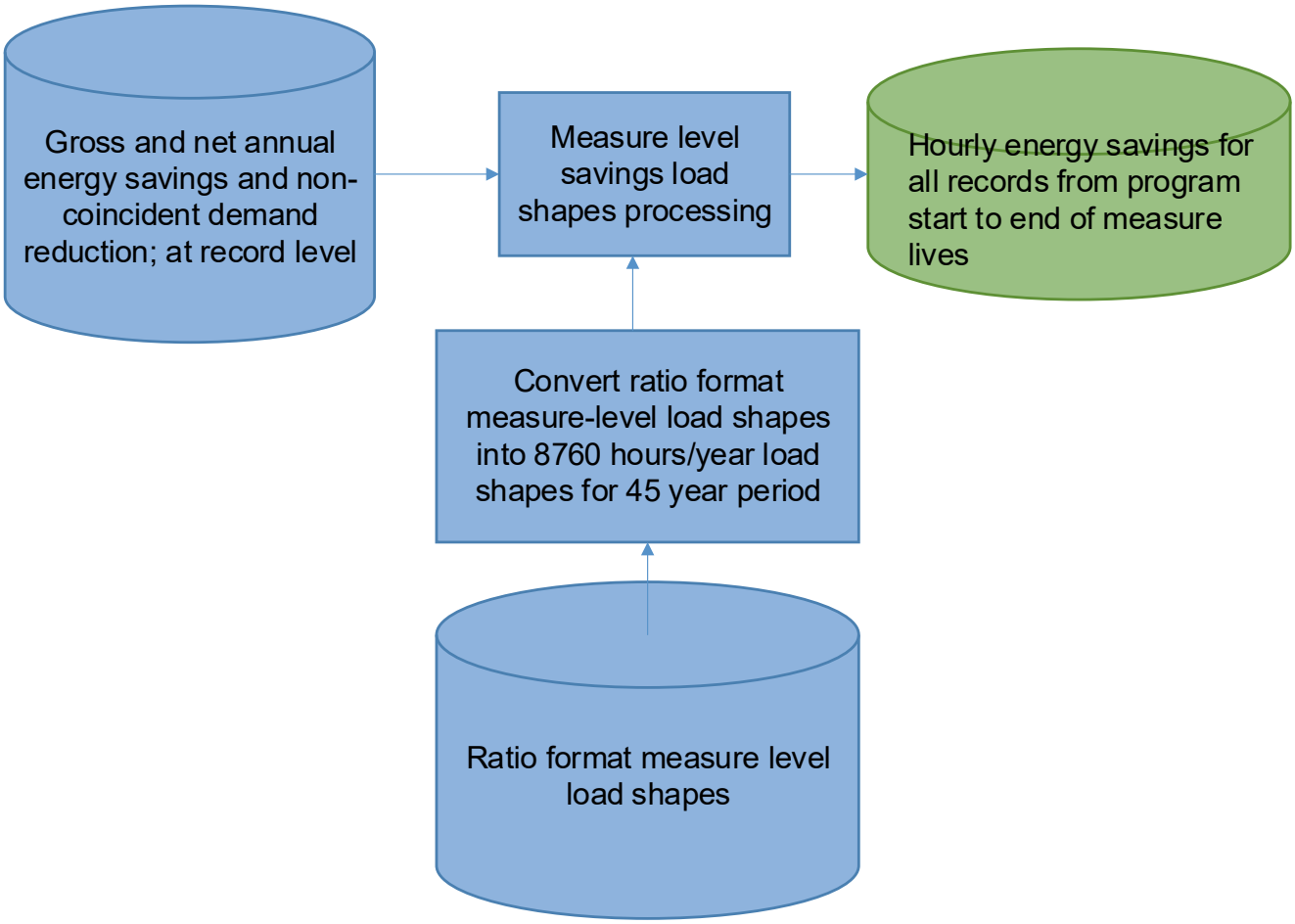
known as the fixed hourly savings. The fixed hourly savings values are used by the Company's Demand-side Planning team to estimate the savings impacts of the Company's DSM programs on the system. This new approach more accurately accounts for the DSM impacts at a more granular hourly level. This method is an improvement from the prior method of calculating lifetime savings that approximated lifetime savings equally across all 12 months of the year, from the month that a customer enrolled through the end of the measure life. For example, using the updated load shape-based lifetime savings approach, a participant adopting a new lighting measure (e.g., LEDs) to replace their existing lighting, will start contributing to system load reduction at the start of the month that the LEDs are installed and continue only until the measure life (e.g., 10 years) expires. And DNV is outputting the savings from these LED at the hourly-level, reflecting any potential daily or seasonal variations from such a lighting measure. Figure 3-3 is a high-level illustration of the process that is described in sections below.

Figure 3-3. Hourly Lifetime Savings Calculation Process.



First, DNV creates a library of base load shape indexes that serves as the foundation for estimating hourly savings over the life of a given measure. Applying hourly savings at the measure level allows for the savings load shapes to be aggregated in the result reports by other characteristics such as program that the measure was implemented in, program participant's rate schedule, and state in which the measure was implemented.

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Overall, this process ingests annual measure load shapes stored in the ratio format described above. It then expands the ratios into a normalized 8,760 hours per year format for the duration of each measure's lifetime. In this expansion step, a data frame with the following elements is first created:

- Date
- Time stamp
- Day type
- Count of days per month (DPM), and
- Annual intervals

The day type assignments for each day of each month from the applicable measure load shape are then used to calculate daily usages for each day of the year and the applicable per-unit hourly load shapes are used to generate each hour's loads downstream for each applicable future calendar year over the course of the measure life. From these inputs, the following are calculated:

$$Usage_{month} = Ratio_{month} \times Annual\ Usage$$
$$Daily\ Usage_{weekday} = \frac{1}{Count_{DPM} \times \frac{5}{7} + Count_{DPM} \times \frac{2}{7} \times Ratio_{WEWD}} \times Interval_A \times Ratio_{month}$$
$$Daily\ Usage_{peak\ day} = Total_{weekday} \times Ratio_{Peak}$$
$$Daily\ Usage_{weekend} = Total_{weekday} \times Ratio_{WEWD}$$

Where:

$Ratio_{Month}$	=	Ratio of monthly energy usage to total annual energy usage
$Count_{DPM}$	=	Count of days per month
$Ratio_{WEWD}$	=	Ratio of weekend to weekday daily energy usage
$Interval_A$	=	Annual Intervals (e.g., 8,760 for non-leap years and 8,784 for leap years)

From here, a daily usage total is calculated using Daily $Usage_{weekday}$, Daily $Usage_{peak\ day}$, Daily $Usage_{weekend}$. See Table 3-5 or the calculations based on day type for each month.

Table 3-5. Calculations Based on Day Type

Day Type	Count per Month	Day Usage Calculation
1	1	= Peak Day Usage
2	Remainder of weekdays	= Weekday Usage
3	Actual	= Weekend Usage
4	1	= Weekday Usage−(Peak Day Usage−Weekday Usage) (Low Day)
5	2	= Weekday Usage−(Peak Day Usage−Weekday Usage) × (⅔)
6	4	= Weekday Usage−(Peak Day Usage−Weekday Usage) × (⅓)
7	2	= (Peak Day Usage−Weekday Usage) × (⅔) + Weekday Usage
8	4	= (Peak Day Usage−Weekday Usage) × (⅔) + Weekday Usage

The applicable day type hourly per-unit load shapes (i.e., Daily $Usage_{Peak}$, Daily $Usage_{Weekday}$, and Daily $Usage_{Weekend}$) are then applied to the corresponding daily usages (Peak load shape to peak day (day type 1), weekend load shape to weekend days (day type 3), and weekday load shape to all the remaining weekdays (day types 2, 4, 5, 6, 7, and 8) as shown in **Error! Reference source not found.**.

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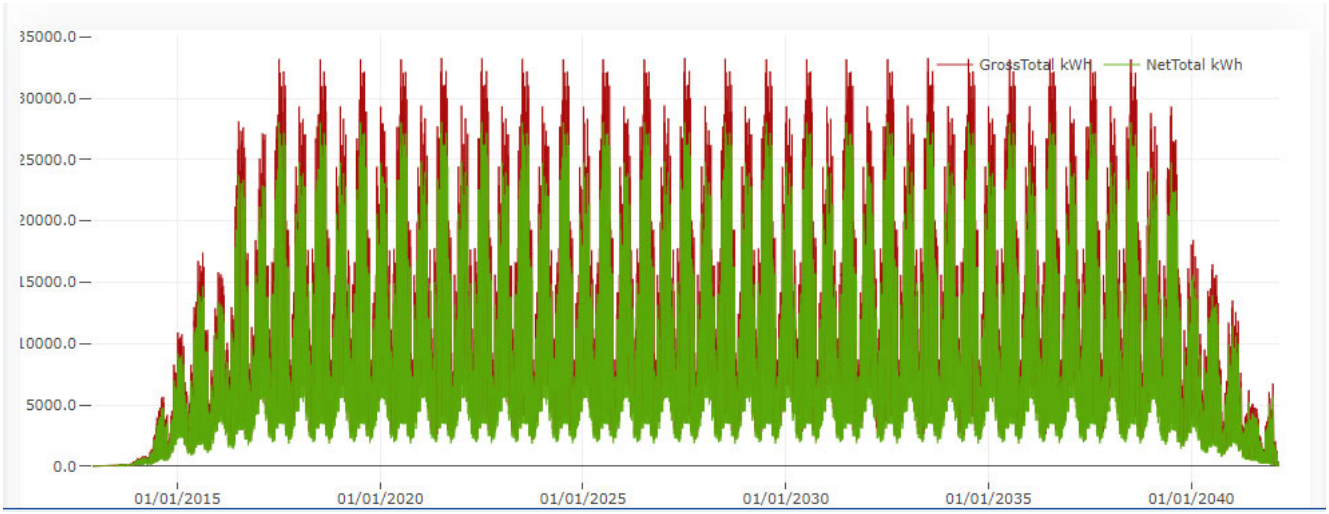
In the second stage of this process, the normalized base load shape ratios output from the prior step are applied to the gross and net measure-level annual savings for each year of the measure life. For example, if a measure for a given program is installed on April 28, 2010, and has a 10-year measure time, the hourly normalized ratio is applied to the annual savings from April 28, 2010 to April 28, 2020. This produces hourly savings at the measure level for the full the measure life.

The third stage of this process involves loading the measure-level hourly savings for gross savings and net savings into DNV's Envisage interval data storage and processing platform, where they can be aggregated as needed for mapping to any combination of program, rate schedule, and state-levels for enhanced reporting purposes.[3] See Figure 3-4 for an example program loadshape hourly energy saving for a non-residential program measure in Virginia.

Figure 3-4. Illustrative Hourly Savings Load shape for an Example Non-residential Measure in Virginia



Lastly, these hourly outputs are used as inputs by the Company's Demand-side Planning team's Integrated Resource Plan (IRP) tools to model the contributions of DSM on the Company's system, and aggregated at the annual level and presented in Appendix M of this report.

3 Envisage is DNV's flexible data storage and processing platform

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4 VIRGINIA CLEAN ECONOMY ACT REQUIREMENTS NON-ENERGY METRICS

The following additional non-energy metric are also reported in this EM&V report, as required by the Virginia Clean Economy Act.

- Related emissions reductions,
- Total customer bill savings that the programs and portfolios produce,
- Other quantifiable benefits of each program,
- Utility spending on each program, including any associated administrative costs, and
- Review each utility's avoided costs and cost-benefit analyses

The methodologies, assumptions, calculations, and methodology pros and cons for the emissions, customer bill savings, non-energy impacts, and avoided cost and cost-benefit analyses are described in detail in later sections in this appendix.

4.1 Bill Savings

4.1.1 Introduction

Dominion Energy is required to utilize the services of a third party to perform evaluation, measurement, and verification services to review the utility's total customer bill savings that the programs and portfolios produce per the Virginia Clean Economy Act Code Section 56-596.2 C. The following sections highlight the process that DNV used to review Dominion Energy's total bill savings for their energy efficiency programs.

To meet the requirements described above related to customer bill savings (also referred to as bill impacts) resulting from Dominion Energy's programs, DNV used data from several sources to estimate each participating customer's pre-participation energy use and load shape, then applied the estimated energy savings from the Dominion Energy Business Intelligence tracking data (i.e., program tracking data) along with the savings load shape to estimate the post-participation energy use and load shapes. The difference between the pre-participation and post-participation billing parameters was calculated. Then rates and riders were applied to the differences in billing parameters and the results were reported as the bill impacts. This analysis was performed and reported by rate schedule and program, then aggregated across the rate schedules and programs to get the estimated total bill impacts for all program participants.

4.1.2 Methodology

DNV calculates the bill impacts by program and rate schedule per the algorithm as follows, and illustrated Figure 4-1:

1. The participant population is defined by rate schedule and program using the program tracking data. This represents the total population of participating customers and is the starting point for the analysis. This database includes the account number, the premise ID, the rate schedule the customer is served under, the program in which the customer was a participant, and the estimated kWh/year savings that the customer achieved through participation in the program.
2. This participant population data is matched with the pre-participation billing data provided by Dominion Energy, using premise ID to match the physical location of each customer to maximize the number of customers with billing data.
3. Rate class hourly load shapes from the Dominion Energy Load Research team are unitized and then matched with each of the participant customers based on rate schedule. Since most of the participating customers do not have interval data available, we must use the average load shape for the rate class as their assumed load shape. This is done by distributing each customer's annual billing energy across the year based on the rate class unitized load shape.

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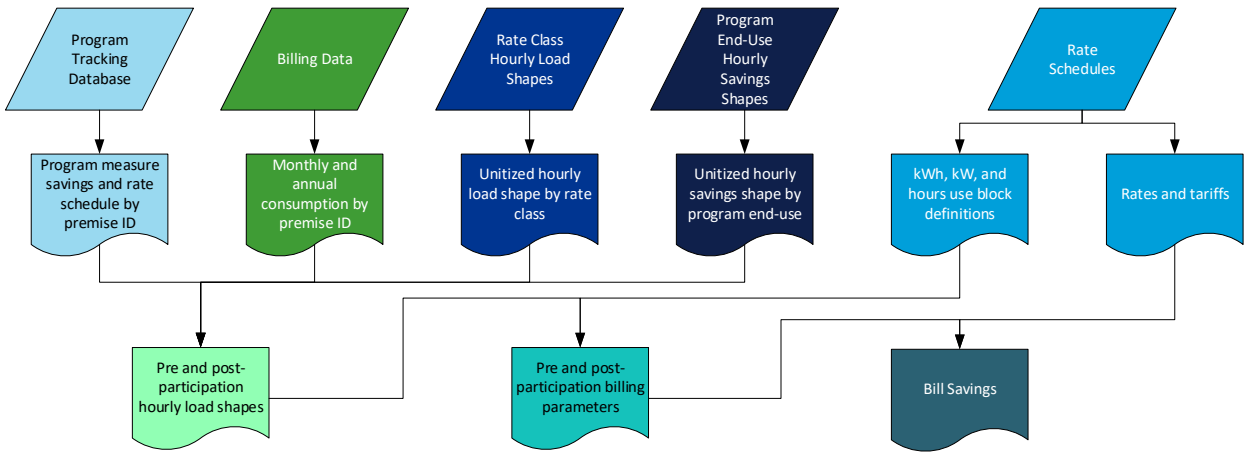
4. The unitized measure-specific hourly savings shapes are calibrated to the savings for each measure installed for each customer. These calibrated hourly savings shapes are totaled for each customer, and that savings shape is then used to distribute the savings across the hours of the year.
5. With a savings shape and a pre-participation load shape for each customer, an estimated post-participation load shape can be calculated as the pre-participation load minus the savings for each hour. Using these load shapes, both the pre-participation and the post-participation billing parameters for each month can be calculated, based on the requirements of the rate schedule for which the customer is enrolled. The difference between the pre-participation and post-participation billing parameters is the difference due to the program, and the bill impact is the rate components applied to the difference in the calculated bills, across all billing parameters, with and without the program. The rates involve many different types of charges, but the billing parameters needed include:
   a. Monthly kWh energy and peak kW demand, for all hours and for time-of-use (TOU) periods (e.g., on-peak, intermediate, and off-peak). Seasonal differences in rates are applied to the individual months based on seasonal definitions.
   b. Monthly kWh consumption for each block, with the blocks defined in the rate schedule (e.g., Schedule 1), or defined based on hours use applied to peak kW (i.e., using kWh per kW to define the blocks). Seasonal differences in rates are applied based on seasonal definitions.
   c. Monthly kW demand for each block for rate schedules with kW blocks (e.g., Schedule 6).
   d. On-peak and off-peak kWh consumption based on the different day classifications (i.e., Day type A, B, or C) and seasons for experimental rate schedules (e.g., Schedule 10).
   e. All fixed monthly charges are ignored since they will be assessed the same way before and after participation, so will not affect the calculation of bill impacts.
6. After the changes in all appropriate billing parameters are calculated, those billing parameters are summed across customers by program and rate schedule, and then rates and riders from the tariffs are applied to the totals of the billing parameters to get the bill impact by rate schedule and program.

Figure 4-1. Bill Savings Estimation Process



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7. Not all participants could be matched with billing data. The bill impacts for those not matched were estimated in one of two ways:
    a. For customers in the Residential Efficient Products Marketplace lighting program, the measures were not associated with individual customers since this is an upstream program. For customers in the Residential New Construction program, the homes were at varying sales stages from builders to residential homeowners at the time of the rebate, however the savings occur once sold and occupied. For these two programs, the participants were all assumed to be on Schedule 1 (i.e., residential). Because Schedule 1 has a kWh block rate, the savings kWh was split between the two blocks based on the proportion of residential customers with billing data available that had consumption in the upper block versus only in the lower block. The two kWh block rates were applied to the estimated energy savings by block, and then summed to get the total bill impacts.
    b. For all other program and rate schedule combinations, an average bill impact per kWh of savings was calculated for those that did have billing data, and that was multiplied by the reported savings for those customers on that program and rate schedule that did not have billing data to get an estimated bill impact. The total bill impact for each program and rate schedule combination was then the sum of the bill impacts for those with and without billing data.

Many assumptions had to be made to allow the estimation of load shapes, the calculation of billing parameters, and the application of rates and riders to those billing parameters. The following assumptions were made:

- The impacts are “first-year impacts” – they correspond to the first year of customer savings after measures have been installed, regardless of what the actual date of installation is. The savings estimates are based on a calendar year, using the calendar for 2021.
- The impacts are based on deemed savings, which represent weather normalized savings, not savings for a particular year with actual weather.
- The impacts use the modeled measure savings shapes created by DNV, which are intended to be based on normal weather.
- Because individual customer load shapes are not available, we used 2020 rate class average load shapes from the Company’s Load research to estimate before-savings customer load shapes for calculating customer demands and TOU billing parameters. The 2020 load shapes were adjusted to reflect the 2021 calendar. These load shapes were then unitized and applied to each customer’s annual consumption to provide an estimated customer load shape.
- Individual customer annual energy is allocated across months based on monthly customer billing data for calculating block energy rates.
- Customer billing energy is for the prior year, before the program year (i.e., 2020 billing consumption for 2021 participants), so appropriately reflects pre-participation consumption
- For the TOU rate, the calendar of day categories (e.g., A, B, and C) are from 2021, so that it matches the calendar for the adjusted load shapes.
- We made the simplifying assumption that each program’s bill impact is the only impact for that customer and did not combine all savings for all programs for each customer. This only affects the bill impacts related to block rates for customers participating in multiple programs. This also allows the reporting of information by rate schedule and program.
- No participants are receiving power from an alternate supplier.
- All billing periods are assumed to match calendar months since billing cycle data is unavailable.
- Not all rate schedules were included in the analysis – those with very few customers were not calculated

Additional rate schedule-specific assumptions had to be made to allow the calculation of the impacts for certain rate schedules. These rate schedule-specific assumptions include:

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- For Residential, Schedule 1, we assume that participants are not net-metered.
- For Schedule GS-3, no customers are non-exempt of distribution charges (though there is no actual charge difference, as this rate is $0.000).
- For Schedule GS-3 and Schedule GS-4, rkVA did not change as a result of the program.
- For Schedule 10, we assumed the contract demand was the same as the measured demand.
- For Schedule GS-4, all participants are assumed to be receiving service at Primary voltage.
- For Schedule 5, the kWh blocks were based on the levels in the tariff, and not reset based on the customers' kW demands.

4.1.3 Results

The bill savings due to the program was calculated as the rate components for each rate applied to the difference between the pre-participation and post-participation billing parameters across all billing parameters, with and without the program. The total bill savings were calculated at $26,684,651.

Table 4-1: Bill Savings by Program and Rate Schedule

Program	Rate Schedule	Billing Data ($)	No Billing Data ($)	Total ($)
Non-residential Heating and Cooling Efficiency – DSM Phase VII	Schedule GS-1	1,362	404	1,766
	Schedule GS-2 ND	45,872	170	46,042
	Schedule GS-2T	6,798	—	6,798
Non-residential Lighting Systems & Controls – DSM Phase VII	Schedule 5C	47,726	—	47,726
	Schedule 5P	936	—	936
	Schedule GS-1	346,802	12,456	359,258
	Schedule GS-2 ND	1,383,038	27,045	1,410,083
	Schedule GS-2T	440,253	—	440,253
Non-residential Prescriptive – DSM Phase VI	Schedule 10 (Secondary)	42,101	—	42,101
	Schedule 5	146	—	146
	Schedule 5C	328	—	328
	Schedule 5P	418	—	418
	Schedule GS-1	47,513	32,478	79,991
	Schedule GS-2 ND	900,332	—	900,332
	Schedule GS-2T	920,213	—	920,213
	Schedule GS-3	164,450	—	164,450
Non-residential Window Film – DSM Phase VII	Schedule GS-1	267	96	364
	Schedule GS-2 ND	9,138	—	9,138
	Schedule GS-2T	38	—	38
Non-residential Small Manufacturing – DSM Phase VII	Schedule GS-2 ND	13,345	—	13,345
Non-residential Office – DSM Phase VII	Schedule GS-2 ND	2,023	—	2,023
	Schedule GS-2T	32,159	—	32,159

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Program	Rate Schedule	Billing Data ($)	No Billing Data ($)	Total ($)
Residential Income and Age Qualifying Home Improvement – DSM Phase IV	Schedule 1	49,469	182	49,651
Residential Customer Engagement – DSM Phase VIII	Schedule 1	6,638,794	85	6,638,880
Residential Efficient Products Marketplace (non-lighting) – DSM Phase VII	Schedule 1	325,241	17,158	342,399
Residential Efficient Products Marketplace (lighting) – DSM Phase VII	Schedule 1	11,373,234	—	11,373,234
Residential Electric Vehicle (EE and DR) – DSM Phase VIII	Schedule 1	1,192	43	1,235
Residential Retrofit – DSM Phase VIII	Schedule 1	21,786	58	21,844
House Bill 2789 (Heating and Cooling / Health and Safety Component) – DSM Phase VIII	Schedule 1	144,118	633	144,751
	Schedule GS-1	69	–	69
Residential Kits – DSM Phase VIII	Schedule 1	350,820	19,748	370,569
Residential Multifamily – DSM Phase VIII	Schedule 1	37	—	37
Residential Manufactured Housing – DSM Phase VIII	Schedule 1	100	—	100
Residential New Construction – DSM Phase VIII	Schedule 1	215,269	—	215,269
Residential Thermostat Purchase and Thermostat Behavioral – DSM Phase VIII	Schedule 1	185,532	3,304	188,836
Residential Home Energy Assessment – DSM Phase VII	Schedule 1	2,413,268	2,509	2,415,777
Non-residential Small Business Improvement Enhanced – DSM Phase VIII	Schedule 5	1,839	—	1,839
	Schedule 5C	17,243	—	17,243
	Schedule 5P	123	—	123
	Schedule GS-1	73,132	4,854	77,986
	Schedule GS-2 ND	141,569	84	141,653
	Schedule GS-2T	17,079	—	17,079
Non-residential Small Business Improvement – DSM Phase V	Schedule 5	18,426	—	18,426
	Schedule 5C	20,547	—	20,547
	Schedule 5P	15,540	—	15,540
	Schedule GS-1	65,149	4,049	69,198
	Schedule GS-2 ND	60,298	2,057	62,355
	Schedule GS-2T	2,104	—	2,104
Total		**26,557,237**	**127,413**	**26,684,651**

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4.2 Non-Energy Impacts

4.2.1 Introduction

Dominion Energy is required to utilize the services of a third party to perform evaluation, measurement, and verification services to review the other quantifiable benefits of the program (i.e., non-energy impacts) per the Virginia Clean Economy Act Code Section 56-596.2 C. The following sections highlight the process that DNV used to review Dominion Energy's NEIs for their energy efficiency programs.

This was the second year DNV conducted this analysis for the portfolio, and it targeted the same three end use categories as the previous year: lighting upgrades, HVAC upgrades, and variable-frequency/variable-speed drives (VFD/VSD) at motors. The targeted categories are limited to upgrades where high-efficiency equipment replaced existing equipment or was added to existing equipment.

Table 4-2 lists the programs, end use categories, and measures included in this analysis along with a count of the 2021 records included. Measures included those delivered by programs active in 2021 that yielded annual gross deemed electric savings greater than zero kWh/year using the methodology established in the DE TRM Version 2021.

Table 4-2. Included Programs and Measures and Number of Records Analyzed

Program – DSM Phase	End Use	Measure	#Records
Residential Programs			
Income and Age Qualifying Home Improvement – DSM Phase IV	Lighting	40W-equivalent LED 60W-equivalent LED	1,722
Efficient Products Marketplace – DSM Phase VII	Lighting	LED A-Line Fixture and Retrofit Kit LED Reflector LED Specialty	297,172
Home Energy Assessment – DSM Phase VII	HVAC Lighting	Heat Pump Upgrade LED	20 108,616
Home Retrofit – DSM Phase VIII	HVAC Lighting	Heat Pump Upgrade Lighting	2 16
HVAC Health and Safety – DSM Phase VIII	HVAC	Heat Pump Upgrade	752
Energy Efficiency Kits – DSM Phase VIII	Lighting	Lighting	481
Multifamily – DSM Phase VIII	Lighting	Lighting	6
Manufactured Housing – DSM Phase VIII	Lighting	Lighting	5
Non-Residential Programs			
Lighting Systems and Controls – DSM Phase VII	Lighting	LED Lamp T8/T5 Lamp	1,239
Heating and Cooling Efficiency – DSM Phase VII	HVAC Drive/Motor	Heat Pump Upgrade Unitary AC Upgrade Chiller Upgrade VFD at space-conditioning motor	199 75
Small Business Improvement – DSM Phase V	Lighting	LED Lamp T8/T5 Lamp	209
Small Business Improvement Enhanced – DSM Phase VIII	Lighting	LED Lamp	239

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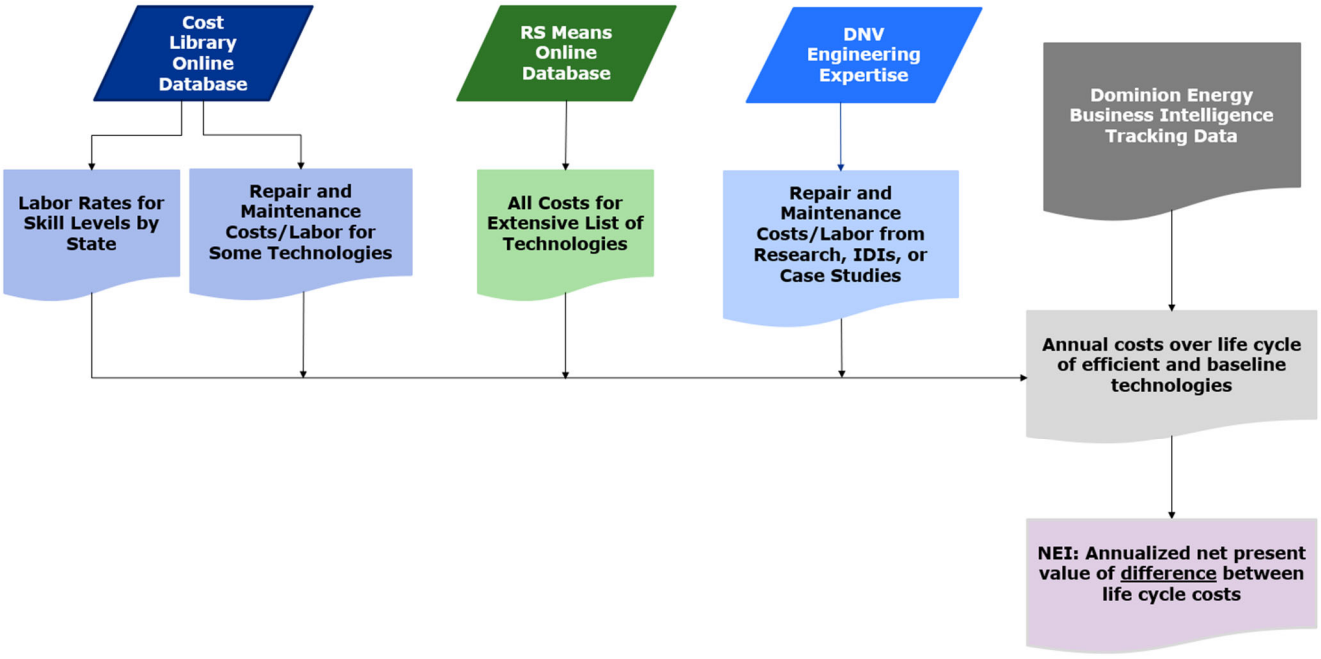
Program – DSM Phase	End Use	Measure	#Records
Midstream Energy Efficiency Products – DSM Phase VIII	HVAC	Chiller Upgrade	1
Total			**410,754**

To determine non-energy impacts, the annualized net present value ($/kWh) of the operations and maintenance costs (O&M) of specific measures were analyzed by program and end use. As this program year was the second to analyze such impacts, the assumptions and limitations of the analysis are detailed in the following sections.

4.2.2 Methodology

DNV calculates non-energy impacts utilizing our Life Cycle Cost (LCC) tool that leverages data gathered from two third-party sources—Cost Library by CBRE Whitestone and RS Means by Gordian—and, in some cases, primary research conducted by DNV. Both sources are commonly used by cost estimators for new construction. We have fine-tuned this method through lessons learned on previous projects and via institutional knowledge and expertise. Our data sources are shown in Figure 4-2.

Figure 4-2. Data Sources Utilized by LCC Tool to Estimate Measure-Level NEIs



Using the LCC tool requires employing the steps described as follows:

- Identify measure description from tracking data including detailed measure description, program-level expected useful life (EUL), equipment size, and annual electric savings, etc.
- Identify measures from the existing LCC data sources that match most closely to each tracking data record.
  - This step requires an engineering review of all measures in the tracking data alongside each of the available data sources contained in the LCC tool. Each data source contains replacement, repair, and maintenance cycles and costs for a finite set of measures. The engineering review identifies measures contained in the published data that

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most closely align with the tracked measures. Once the closest measure is identified, the source for the data (Cost Library, RS Means, or DNV research) is identified.

- Auto-populate replacement, repair, and maintenance costs from the relevant existing data source for the best match to an identified published measure.

Assumptions used for the NEI analyses:

- **Labor rate**: The labor rate tells the LCC Tool whether to select union or non-union labor rates from the existing data source. For this analysis, union labor rates were used.
- **Measure life**: While each of the published data sources contains information regarding the "Replacement Years," to identify the expected life of the measure as documented by the published life-cycle data, these values are not used for this analysis. Instead, the program-specific planned savings-weighted measure lives were used. This assumption has a substantial impact on the annualized net present value of the life cycle costs—the shorter the assumed equipment life the higher the annualized net present value of the life cycle costs. Alternative approaches include using either the measure lives in the published data source leveraged or those established in the related Technical Reference Manual (TRM) that were cited within the Dominion Energy TRM for each given measure. Where a partial year was assumed for the final year of the program's EUL, we rounded to the nearest whole year.
- **First Costs**: The costs of purchasing and installing the upgraded equipment —including any heavy equipment rental rates—are included in the analysis results.
- **Incentives:** The first costs are not offset by the amount of the incentive offered by the program.
- **Repair Costs:** The costs of materials and labor to perform periodic repairs are included in the analysis.
- **Maintenance Costs:** The costs of materials and labor to perform periodic maintenance are included in the analysis.
- **Discount Rate:** We assume a discount rate of 6.4% to determine the annualized net present value of the life cycle costs for each efficient and baseline technology. The discount rate applied was provided by the Company's Integrated Strategic Planning Team and represents the customer discount rate.
- **Timing of Costs Incurred:** Costs are assumed to be incurred at the beginning of each year within the lifetime of the equipment.
- **Records Excluded:** A record was excluded whenever one or more of the following conditions were met:
  - A measure record yielded zero annual gross deemed savings (kWh/year) per the STEP Manual methodology
  - If only one of two equipment types—efficiency or baseline—could be matched to the data in the LCC tool
  - If a given record was missing a value for quantity (i.e., number of units installed, number of existing lamps, number of new lamps)
- **End Use Category:** There were specific assumptions established that varied by end use as listed.
  - For measures classified as HVAC or Drive/Motor, the size or capacity of the new equipment provided in the Dominion Energy Business Intelligence tracking data is assumed to be the size or capacity of the old unit that was replaced (a one-to-one replacement). This is aligned with the methodology established in the STEP Manual for estimating gross annual electric savings.
  - On the other hand, lighting measure analyses accommodated differing efficient- and baseline-case wattages and quantities for this analysis.
  - For variable-frequency/variable-speed drive (VFD/VSD) installed at a motor, the baseline is assumed to be the same motor without a VFD/VSD.

A known limitation of the secondary data sources:

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- **Efficient Equipment:** Neither Cost Library nor RS Means provide cost differences between standard and high-efficiency equipment for many types of equipment. In those cases where the same cost data were used for both the efficient and baseline cases, the resulting NEI was always zero.

4.2.3 Results

The combined annualized net present value of the non-energy impacts provided by active 2021 programs totaled approximately $17.8 million for the lighting, HVAC, and VFD upgrades, combined. These include the first costs of purchasing and installing the equipment, repair costs, and maintenance costs over the life of each program. The NEIs by program and end use are shown in Table 4-3. The program-level NEIs are summarized in Table 4 5. Finally, the end use-specific NEIs are summarized in Table 4 6.

Table 4-3. Annualized Net Present Value NEI by Program and End Use by Active Virginia Programs in 2021

Program – DSM Phase	End Use	Annual $NEI	Annual $NEI/kWh
Residential Programs			
Income and Age Qualifying Home Improvement – DSM Phase IV	Lighting	28,069	0.1174
Efficient Products Marketplace – DSM Phase VII	Lighting	9,990,555	0.1095
Home Energy Assessment – DSM Phase VII	HVAC	0	0.0000
	Lighting	7,167,260	0.3280
Home Retrofit – DSM Phase VIII	HVAC	0	0.0000
	Lighting	1,485	0.7691
HVAC Health and Safety– DSM Phase VIII	HVAC	-3,057	-0.0123
Energy Efficiency Kits – DSM Phase VIII	Lighting	62,345	0.5404
Multifamily – DSM Phase VIII	Lighting	244	2.5947
Manufactured Housing – DSM Phase VIII	Lighting	104	0.2708
Non-Residential Programs			
Lighting Systems and Controls – DSM Phase VII	Lighting	496,523	0.0223
Heating and Cooling Efficiency – DSM Phase VII	HVAC	51,002	0.4376
	Drive/Motor	-103,304	-0.2600
Small Business Improvement – DSM Phase V	Lighting	40,418	0.0234
Small Business Improvement Enhanced – DSM Phase VIII	Lighting	87,033	0.0403
Midstream Energy Efficiency Products – DSM Phase VIII	HVAC	0	0.0000
Total		**17,818,677**	**0.1270**

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Table 4-4. Annualized Net Present O&M Value per Annual Electric Savings by Active Virginia Programs in 2021

Program – DSM Phase	Annual $NEI	Annual $NEI/kWh
Residential Programs		
Income and Age Qualifying Home Improvement – DSM Phase IV	28,069	0.1174
Efficient Products Marketplace – DSM Phase VII	9,990,555	0.1095
Home Energy Assessment – DSM Phase VII	7,167,260	0.3278
Home Retrofit – DSM Phase VIII	1,485	0.4475
HVAC Health and Safety– DSM Phase VIII	-3,057	-0.0123
Energy Efficiency Kits – DSM Phase VIII	62,345	0.5404
Multifamily – DSM Phase VIII	244	2.5947
Manufactured Housing – DSM Phase VIII	104	0.2708
Non-Residential Programs		
Lighting Systems and Controls – DSM Phase VII	496,523	0.0223
Heating and Cooling Efficiency – DSM Phase VII	-52,302	-0.1018
Small Business Improvement – DSM Phase V	40,418	0.0234
Small Business Improvement Enhanced – DSM Phase VIII	87,033	0.0403
Midstream Energy Efficiency Products – DSM Phase VIII	0	0.0000
Total	**17,818,677**	**0.1270**

Table 4-5. Overall Annualized Net Present Value NEI by End Use

End Use	Annual $NEI	Annual $NEI/kWh
Drive/Motor	-103,304	-0.2600
HVAC	47,946	0.1188
Lighting	17,874,036	0.1281
Total	**17,818,677**	**0.1270**

4.3 Avoided Emissions

4.3.1 Introduction

Dominion Energy is required to utilize the services of a third party to perform evaluation, measurement, and verification services to determine the utility's related emissions reductions per the Virginia Clean Economy Act Code Section 56-596.2 C. The following sections highlight the process that DNV used to review Dominion Energy's emission reductions for their energy efficiency programs. The objective of this activity was to estimate the emissions effects of program activities affecting the 2021 calendar year because of program participants for years up to and including 2021 that would impact 2021 emissions levels.

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The level of accuracy of these estimates is subject to the level of accuracy of the source data on hourly emissions, which was obtained from WattTime.org, an independent private non-profit company.[4] WattTime's marginal emissions rate data is proprietary, available via subscription. WattTime does not rely upon any data from utilities to model the emissions.

The accuracy of the load shapes applied to the emissions levels is based on the Dominion Energy deemed savings developed by DNV based on the engineering models from the Standard Tracking and Engineering Protocol Manual Version 2021 (STEP Manual). Full hourly load shapes per year are developed by DNV based on best available data from (in decreasing priority order):

1. Metered program data on samples of program-specific participants and non-participants
2. Comparable end use profiles from other programs
3. Load shape library of public end use load studies compiled by DNV

All load shapes are calibrated to the total annualized (or the first year) energy savings by end use measure to ensure that the ratio of energy to demand match as closely as possible to the deemed energy savings and demand reductions to produce the same annual usage impacts and match the peak demand impacts as closely as possible.

Some key assumptions in the analysis are:

- Emissions data from the WattTime.org site, using the PJM DC Historical emissions factors for 2021, was considered most applicable to the Dominion Energy service territory.
- Emissions rates for Virginia and North Carolina are considered to be the same, although energy savings for the Virginia jurisdiction are over 95% of the total for Dominion Energy.
- Emissions data for 2021 would apply to all savings measures contributing to in 2021.
- The split between Virginia and North Carolina jurisdiction emissions savings was based on the split in 2021 annual cumulative kWh savings by state.

4.3.2 Methodology

DNV calculates emissions impacts by applying the hourly emissions rates to the hourly DSM program savings for each program, splitting the overall Dominion Energy emissions savings by state based on each state's annual 2021 usage savings percentage. The steps involved were the following:

1. Obtained the 2021 emissions levels from the WattTime.org, using the PJM DC Historical emissions data, which is stored as UTC time zone.
2. Convert the UTC time zone data to East Coast local time, accounting for DST conversions
3. Used the hourly 2021 DSM cumulative energy savings from load shapes already developed by program
4. Multiplied the 2021 hourly emissions rates (lbs. CO_2 per MWh) by the hourly DSM kWh/year energy savings to produce the emissions impacts, in metric tons of CO_2 units.
5. Calculated the percentage split between Virginia and North Carolina State energy impacts for 2021.
6. Applied State percentages to overall Dominion Energy emissions factors to calculate state-specific emissions.

Emissions data was obtained from Watttime.org, which consists of Marginal Operating Emissions Rate (MOER), measured in lbs. CO_2/MWh. Data was obtained for 2018 through 2021 and compared, to identify any trends in the pattern.

[4] WattTime is a non-profit company that offers technology solutions that make it easy for anyone to achieve emissions reductions without compromising cost, comfort, or function.

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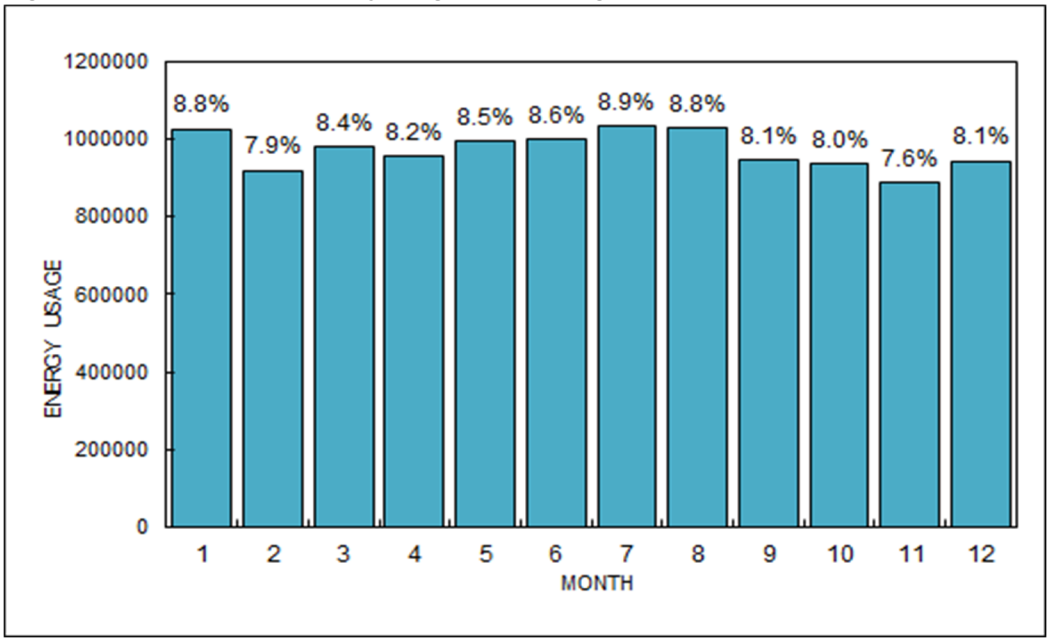
For the monthly pattern, the 2021 emissions for the PJM DC Area showed only a slight summer-seasonal pattern, shown in Figure 4-3.

Figure 4-3. PJM DC 2021 Monthly Marginal Operating Emissions Rate



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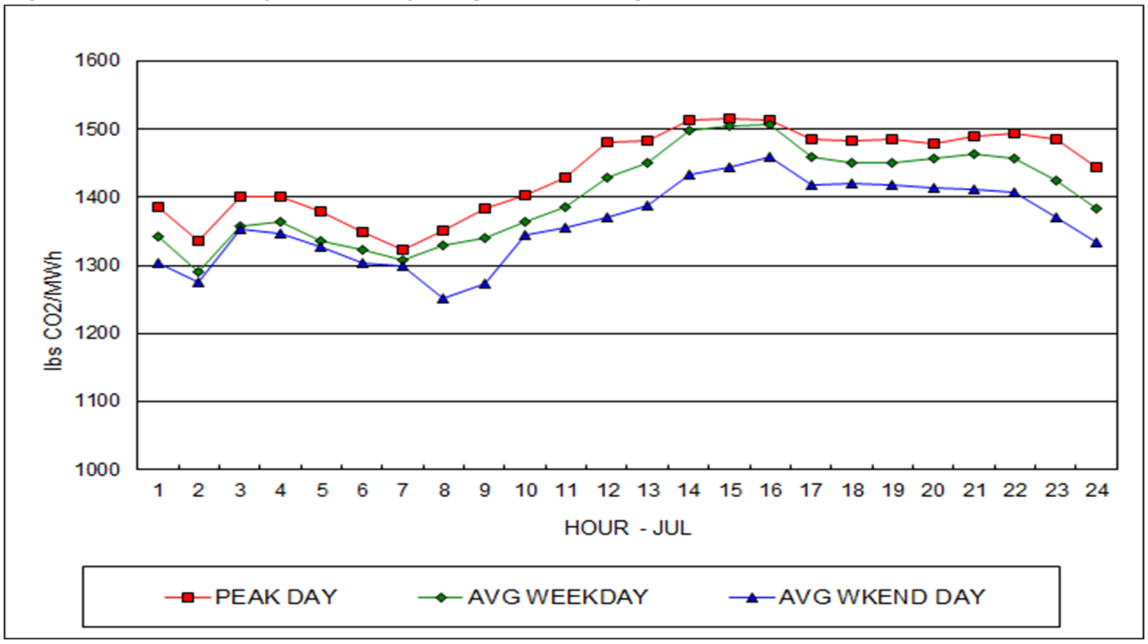
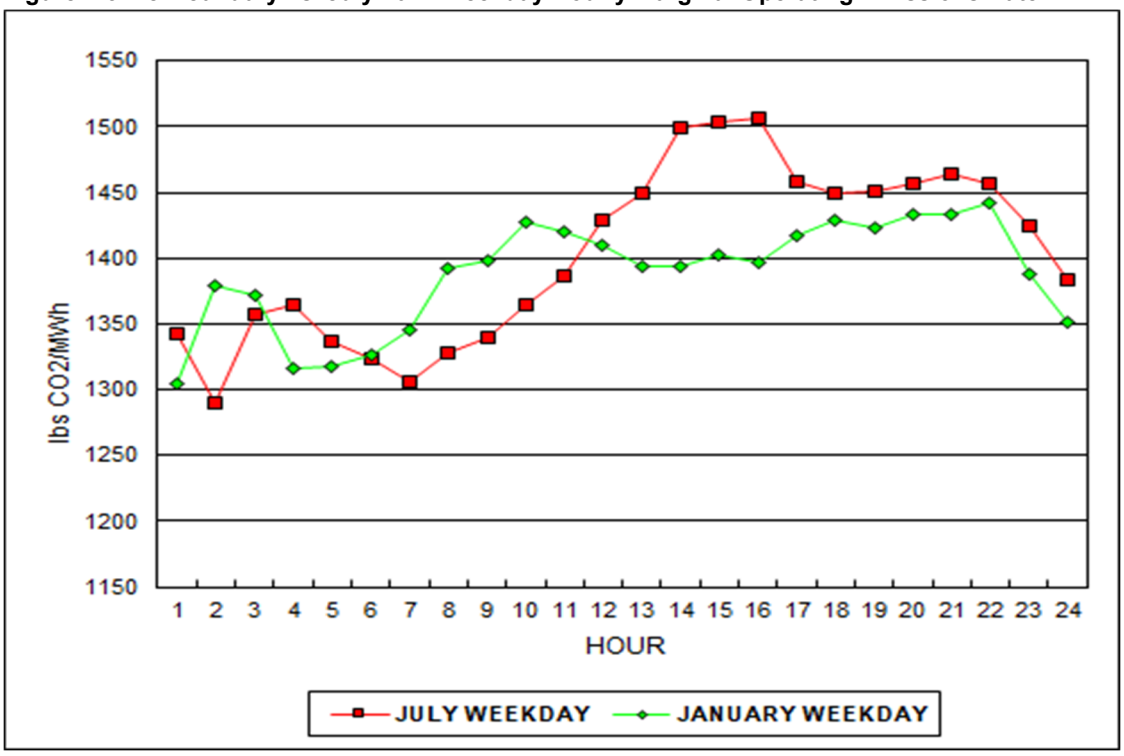
For the peak month (July), the day type hourly pattern showed slightly higher afternoon emissions rates, as demonstrated in Figure 4-4.

Figure 4-4. PJM DC July 2021 Hourly Marginal Operating Emissions Rate



Comparing winter vs. summer showed no comparable evening peak for winter, but slightly lower afternoon emission rates instead for average weekdays as shown in Figure 4-5.

Figure 4-5. PJM January vs. July 2021 Weekday Hourly Marginal Operating Emissions Rate



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Comparing 2018, 2019, and 2020 showed slightly similar seasonality. As a result, the 2021 emissions rates were considered sufficient for evaluating the overall emissions impacts.

Table 4-6 below indicates the CO_2 Avoided Rates from the DC MOER for the first 12 hours of 2021. Units are lbs. CO_2 per MWh, which were then converted to metric tons CO_2 per kWh.

Table 4-6. Hourly Emission Rates Excerpt

Date	Hour Ending	Month	MOER Lbs. CO_2/MWH (local time)	Metric Tons CO/kWh (local time)
1/1/2021	1	1	1,275	0.00058
1/1/2021	2	1	1,334	0.00061
1/1/2021	3	1	1,345	0.00061
1/1/2021	4	1	1,312	0.00060
1/1/2021	5	1	1,276	0.00058
1/1/2021	6	1	1,311	0.00059
1/1/2021	7	1	1,311	0.00059
1/1/2021	8	1	1,287	0.00058
1/1/2021	9	1	1,330	0.00060
1/1/2021	10	1	1,374	0.00062
1/1/2021	11	1	1,356	0.00062
1/1/2021	12	1	1,345	0.00061

Hourly load shapes by DSM program previously developed were used, having already been calibrated to the annualized or first-year deemed savings developed through the TRM. Percentage split between Virginia and North Carolina were calculated based on annual usage by state.

Calculation approach

Hourly emissions rates (MOER) were applied to hourly estimates of program-level kWh and the resulting units are in metric tons of CO_2. Each hour of 2021 emissions were multiplied by the same hour of the 2021 usage impacts. Percentages by state were then applied to produce separate emissions impacts for Virginia.

It should be noted that separate load shapes are not typically produced by state; therefore, any differences in program participation mix, in terms of types of customer and measures implemented by state, will not be reflected. However, given the dominance of Virginia participation (over 95%) in program impacts, and fairly consistent pattern of emissions across months and hours, it was not considered worthwhile to develop state-specific hourly load impacts and resulting emissions impacts.

4.3.3 Results

Overall, avoided emissions impacts (in metric tons CO2 Avoided) totaled 344,873 metric tons CO_2 avoided per year for the programs that were active in Virginia in 2021 (see Table 4-7 and Figure 4-6). Overall, monthly program impacts (as shown in Figure 4-7) were distributed fairly evenly across the year, reflecting the combination of lighting (evenly distributed), some heating-oriented (winter seasonal and some cooling-oriented programs.

Table 4-7. Virginia Monthly Emissions by Active 2021 Programs

Dominion Emissions Impacts (Metric Tons CO2) from DSM Programs Virginia Totals														
Program	Month (2021)												Annual	Pct by
For 2021	1	2	3	4	5	6	7	8	9	10	11	12	2021	Program
DOM-2021-CTSM	6.17	5.54	5.87	5.65	5.67	5.83	5.77	5.68	5.45	5.40	5.17	5.67	67.88	0.02%
DOM-2021-CSW2	15.03	13.29	16.78	16.96	17.00	19.71	19.15	19.99	17.31	16.17	14.76	13.69	199.83	0.06%
DOM-2021-CNRP	3,418.71	3,104.32	3,406.88	3,606.56	4,367.13	5,535.06	6,119.03	5,998.76	4,560.94	3,442.66	3,046.07	3,143.18	49,749.30	14.43%
DOM-2021-CLT3	2,707.17	2,486.96	2,660.68	2,574.69	2,619.00	2,716.12	2,781.95	2,780.77	2,545.89	2,467.06	2,381.65	2,530.30	31,252.26	9.06%
DOM-2021-CHV3	362.69	305.37	194.46	77.31	47.36	75.57	89.45	86.64	50.89	66.99	136.59	253.79	1,747.12	0.51%
DOM-2021-CEEP	2.34	2.14	2.35	2.65	3.52	5.11	5.77	5.63	3.88	2.40	2.05	2.10	39.93	0.01%
DOM-2021-CTSO	21.45	21.04	29.71	41.84	70.27	113.97	158.96	141.73	109.50	43.81	31.81	26.67	810.76	0.24%
DOM-2021-REVEE	0.75	0.75	0.75	0.78	0.77	0.46	0.51	0.62	0.56	0.50	0.47	0.58	7.51	0.00%
DOM-2021-RHRF	20.87	16.74	12.14	5.93	3.80	7.63	11.43	9.60	5.65	9.66	8.84	13.83	126.14	0.04%
DOM-2021-REEC	15,833.59	14,371.95	13,712.21	12,085.33	12,433.55	12,600.78	13,086.36	13,111.47	12,129.29	12,340.91	12,925.03	15,166.88	159,797.36	46.34%
DOM-2021-RCEB	4,688.24	4,758.68	3,302.11	2,062.52	2,654.88	3,262.57	3,615.91	3,348.64	2,555.63	1,952.37	2,913.32	3,494.47	38,609.33	11.20%
DOM-2021-EAL3	725.67	619.70	538.86	445.63	406.15	399.30	421.28	402.54	358.26	391.77	485.13	587.78	5,782.08	1.68%
DOM-2021-RHVCCHVLI	147.32	114.56	78.25	43.70	29.01	45.02	63.63	53.46	31.65	46.23	61.14	96.62	810.60	0.24%
DOM-2021-SBI2	120.19	110.64	118.94	117.27	123.85	138.05	144.51	144.07	123.80	111.31	105.85	112.42	1,470.90	0.43%
DOM-2021-RAR2	99.76	90.10	102.62	105.76	109.85	121.56	133.17	126.92	110.19	101.76	90.31	92.77	1,284.78	0.37%
DOM-2021-RTEE/RTEB	227.20	173.82	114.77	67.10	41.76	48.83	63.71	53.68	33.97	52.00	93.33	148.24	1,118.41	0.32%
DOM-2021-RTHO	1,495.65	1,335.76	1,383.23	1,327.23	1,397.28	1,445.20	1,528.36	1,511.23	1,350.33	1,316.53	1,259.46	1,346.74	16,697.01	4.84%
DOM-2021-RNCR	85.36	75.07	72.81	75.28	89.88	141.59	186.07	164.38	106.00	72.42	65.66	74.14	1,208.66	0.35%
DOM-2021-RMHP	0.04	0.03	0.04	0.03	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.42	0.00%
DOM-2021-RMFP	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.20	0.00%
DOM-2021-RKTS	202.51	184.10	175.78	154.30	158.15	159.88	166.45	166.34	153.56	156.71	164.78	193.55	2,036.11	0.59%
DOM-2021-SBIP-wRef	2,641.70	2,580.55	2,812.70	2,680.93	2,600.43	2,958.56	2,883.92	3,039.59	2,667.14	2,403.74	2,324.23	2,462.88	32,056.37	9.30%
4/25-5/2/22 Indicator Tables														
Virginia Totals	32,822.42	30,371.13	28,741.96	25,497.47	27,179.37	29,800.86	31,485.46	31,171.80	26,919.97	25,000.45	26,115.71	29,766.35	344,872.95	100.0%
Percent by Month	9.5%	8.8%	8.3%	7.4%	7.9%	8.6%	9.1%	9.0%	7.8%	7.2%	7.6%	8.6%		

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Figure 4-6. Dominion Energy 2021 Virginia Emissions by Active Programs

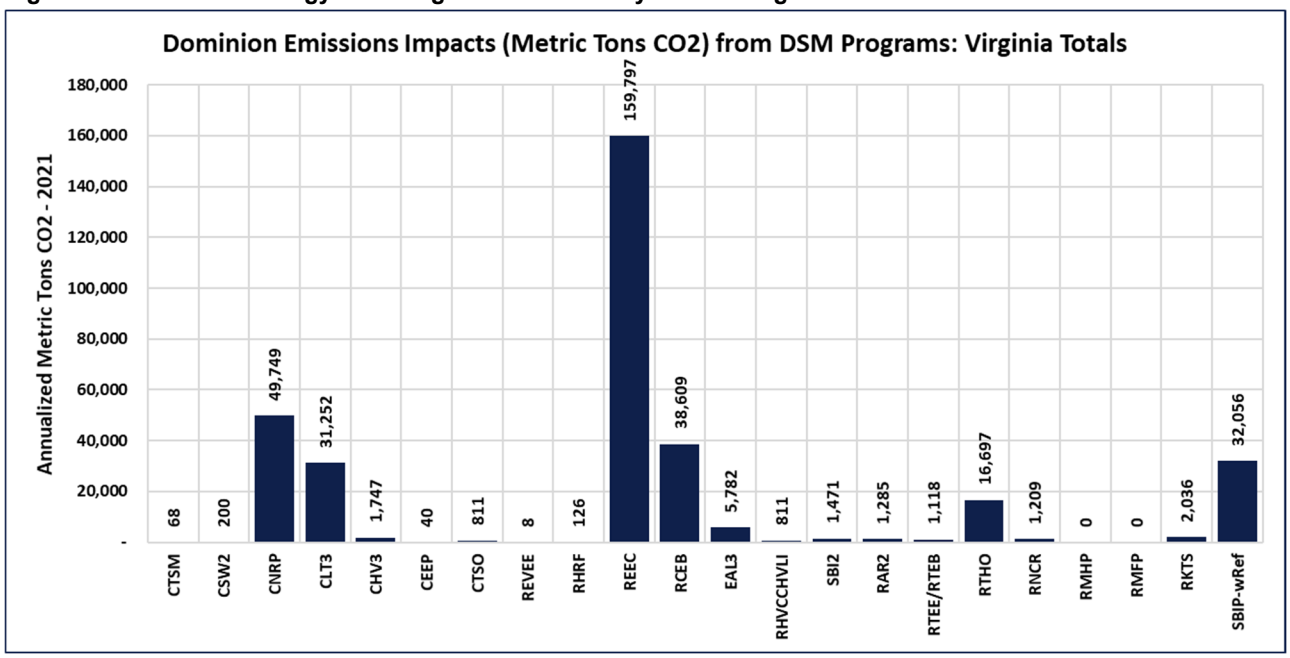
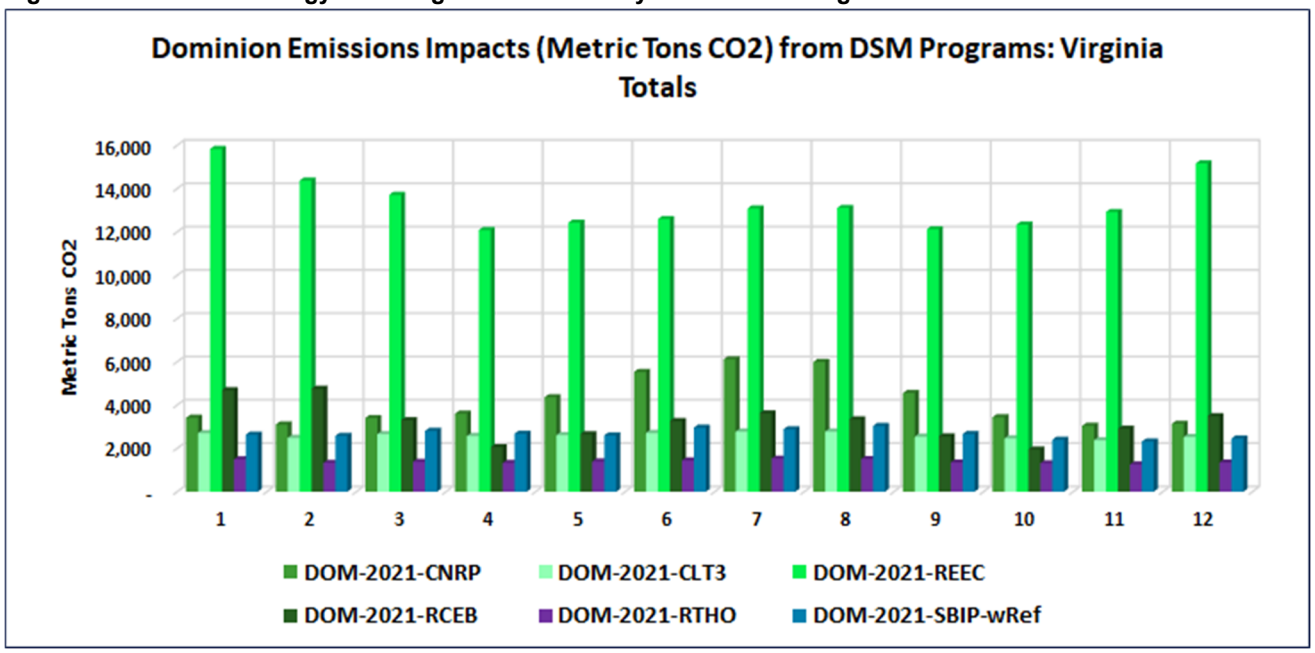


Figure 4-7. Dominion Energy 2021 Virginia Emissions by Most Active Programs



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4.4 Benefit/cost and avoided cost methodology review

Dominion Energy is required to "utilize the services of a third party to perform evaluation, measurement, and verification services to review the utility's avoided costs and cost-benefit analyses" per the Virginia Clean Economy Act Code Section 56-596.2 C. The following sections highlight the process that DNV used to review Dominion Energy's avoided costs and cost-benefit analyses for their energy efficiency programs, specifically focusing on the Load Modifier Tool (LMT) modeling software, development of model inputs, and internal modeling processes and concepts.

DNV interviewed Dominion Energy staff on their benefit-cost modeling approach and newly developed LMT. DNV walked through LMT with DE's Demand-side Planning team to reviewed inputs, processes, internal documentation, and model results for a sample of programs. DNV also completed a separate review using an LMT QC workbook to document individual program reviews and verify model results for sample of DSM Phase IX programs.

4.4.1 Benefit/cost review

4.4.1.1 Summary of DNV's LMT Review

DNV was tasked by the Dominion Energy (DE) Demand Side Planning (DSP) Group to conduct a review of the new Load Modifier Tool (LMT) that has been developed as a replacement of the existing Strategist modeling tool. LMT was developed for the DE DSP team to support cost-benefit calculations reflecting both the option for hourly load across the year (8760 hours per typical non-leap year) or annual savings and avoided costs, rather than just annual savings and avoided costs supported by the Strategist tool that has been used in the past. This review aimed to:

1. Verify the updated 8760 load shape calculation method within LMT compared to the annualized method used in Strategist,
2. Perform a calculation review to ensure that correct assumptions are included, and accurate results are produced.
3. Ensure that the tool has accurately developed the cost-benefit scores used in the DSM Phase IX Residential Income and Age Qualifying Home Improvement Enhanced Program approval filing in North Carolina, in November 2021.

Due to the high-level nature of this review and complexities related to data access and IT security, DNV did not use the LMT directly or review any underlying code. DNV reviewed the LMT through multiple discussions with the DE DSP team to understand updated methodology, input assumptions and data sources, and the new 8760 calculation method. DNV also performed a full calculation review of the LMT using result outputs and DE's Microsoft Excel quality check (QC) workbook to verify sources and compare replicated calculations with LMT outputs for a sample of DSM programs.

DNV did not identify any major issues that were present for all reviewed programs and cases, but did highlight observations and recommendations related to LMT documentation, process improvements, and general approaches to the overall input and results framework.

4.4.1.2 Overview of LMT and Dominion Energy's benefit-cost modeling approach

Dominion Energy previously used the Strategist resource planning software to model and calculate cost-effectiveness tests for their demand side management (DSM) programs. They have since implemented a newly developed LMT that aims to provide a more accurate and granular approach to calculate 8760 program impacts when assessing individual program cost-effectiveness.

LMT is used to calculate cost-benefit scores for candidate DSM programs using a variety of program assumptions specific to the individual program being screened (e.g., program costs, supply-side costs, participation, program load shapes, etc.), together with global assumptions that are applied to all programs (e.g., avoided costs, customer rates, discount rates, etc.). LMT replaces the previous Strategist screening tool, last used in the 2020 DSM Update filing in Virginia. Strategist

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previously used an average week method. In contrast, the LMT uses an hourly (8760) method to incorporate system and DSM program impact load shapes into Plexos (the Company's energy market simulation software), to determine equivalent annual supply side costs for each program.

LMT has the ability to incorporate all program-specific assumptions, global assumptions, and program load shapes into a desktop-based application format. Users can select individual programs to run cost-effectiveness tests and implement test cases to understand the impact of different input assumptions. This allows DE to quickly calculate costs and benefits, from the perspective of various market stakeholders, and screen potential programs simultaneously. The LMT is able to do so by processing in parallel with Plexos for individual program screenings. The LMT program load shapes must be incorporated into Plexos to produce updated equivalent supply side costs. Individual costs and benefits calculated and used within LMT are shown in Table 4-8 in addition to the four different cost-effectiveness tests to which they are applied. The four cost-effectiveness tests are:[5]

- **Participant Cost Test (PCT):** "measure of the quantifiable benefits and costs to the customer due to participation in a program".
- **Utility Cost Test (UCT):** "measures the net costs of a demand-side management program as a resource option based on the costs incurred by the program administrator (including incentive costs) and excluding any net costs incurred by the participant"
- **Total Resource Cost (TRC) Test:** "measures the net costs of a demand-side management program as a resource option based on the total costs of the program, including both the participants' and the utility's costs"
- **Ratepayer Impact Measure (RIM):** "measures what happens to customer bills or rates due to changes in utility revenues and operating costs caused by the program"

[5] California Standard Practice Manual. Economic Analysis of Demand-side Programs and Projects. October 2001. https://www.raponline.org/wp-content/uploads/2016/05/cpuc-standardpractice-manual-2001-10.pdf

Table 4-8. LMT Benefit-Cost Outputs by Cost-Effectiveness Measure

Test Category / Test	PCT	UCT	TRC	RIM	Methodology Description
Benefits					
Customer Bill Savings	P	-	-	-	NPV annual bill savings; annual bill savings equals number of participants × kWh savings per participant × rate per kWh
Other Customer Benefits	P	-	T	-	NPV other variable customer benefits (number of participants × variable customer benefits)
Production Cost Savings	-	U	T	R	NPV of avoided energy costs Avoided energy costs = per kWh avoided cost × kWh savings × (1+ line loss %)
Deferred T&D Capacity Costs	-	U	T	R	NPV T&D capacity cost change; equals T&D demand credit × kW reduction × (1+ line loss %)
Deferred Generation Capacity Costs	-	U	T	R	NPV of avoided capacity costs Avoided capacity costs = per kW avoided cost × kW reduction × (1+ line loss %)
Incentive Payments	P	-	-	-	NPV of incentive payments = annual new participation × per unit one-time incentive * (1 + ROE)
Costs					
Direct Customer Costs	P	-	T	-	NPV of incremental measure cost, net of free riders
Generation Capacity Cost Increase		-	-	-	Offsets to deferred generation capacity costs (see Deferred Generation Capacity Cost Benefits)
DSM Expenses	-	U	T	R	NPV of utility program marketing and admin expenses with ROE
Evaluation Expenses	-	U	T	R	NPV of program evaluation costs
Incentive Payment	-	U	-	R	NPV incentive payments; equal to annual new participation × per unit one-time incentive × (1 + ROE)
Utility Revenue Decrease	-	-	-	R	NPV reduction in utility revenue due to customer bill savings

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4.4.1.3 LMT Inputs and Data Sources

Table 4-9 lists all LMT inputs and data sources captured through discussions with the DE. It identifies internal DE teams that provided any global system-wide assumptions, and external vendors who provided program-specific assumptions and data. .

Table 4-9. LMT Inputs and Sources

LMT Tool Input	Units (/year)	Description	Source
Avoided Energy & Capacity Costs	$/kWh / $/kW	Annual avoided costs including reserve margin forecast pool requirements (FPR) of 10%	Conservation and Load Management Team (DE)
Avoided T&D Costs	$/kW	Annual avoided T&D costs and seasonal T&D splits for cost allocation	Conservation and Load Management Team (DE)
Customer Growth Rates	%	Growth rates for individual customer counts by segment, incorporated into annual participation	Integrated Strategic Planning (DE)
Customer Rates	$/kWh	Utility rates by customer class with built-in escalation, incorporated into customer bill savings	Integrated Strategic Planning (DE)
Drop Out Rate	Number of customers	Replacement in kind – driven by program life and equipment life	Calculated from annual new participants, program life, and equipment life
Energy Sales	kWh/unit	Annual kWh reduction per installed unit	Program-specific vendor
Fixed Expenses	$	Annual fixed program expenses	Program-specific vendor
Fixed Marketing Expense	$	Program marketing expenses (fixed marketing, program design, etc.), calculated w/ROE. Input is also used to capture miscellaneous utility fixed expenses not captured elsewhere.	Program-specific vendor, ROE obtained from IRP
Fixed Evaluation Expense	$	Program evaluation expenses (vendor M&V, support, etc.), calculated w/ROE	Program-specific vendor, ROE obtained from IRP
Free Riders Percentage	%	Percentage of free riders based on vendor assumptions and the in-service rate (100% for most measures)	From Net-to-Gross ratio, provided by vendor
New Participant Customer Benefit	$/unit	Benefits other than those from energy and demand savings	Program-specific vendor
New Participant Customer Cost	$/unit	Average incremental measure cost for each new participant	Program-specific vendor
New Participant Marketing Expense	$/unit	Average incremental marketing cost for each new participant	Program-specific vendor
New Participant Incentives	$/unit	One-time incentive paid by utility, adjusted for ROE	Program-specific vendor
Number of Participants	Number of customers	Annual penetration for each program year	Program-specific vendor
Other Rates	%	Discount rates (utility, customer, ROE), inflation rate, and line losses	Integrated Strategic Planning (DE)
Other Variable Customer Benefits	$/unit	Average maintenance savings per unit, adjusted for inflation. Zero for all reviewed programs	Program-specific vendor, if applicable

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LMT Tool Input	Units (/year)	Description	Source
Peak Reduction	kW/unit	Non-coincident peak energy savings per unit based upon the contribution at peak	Program-specific vendor
Penetration Factor	Number of customers	Total new participation per year	Program-specific vendor
Supply-Side Costs	$ (individual years and NPV)	Calculated in Plexos using program-specific load shapes, includes base and DSM costs to calculate program impacts	IRP team, Plexos (DE)

4.4.1.4 LMT Review Process Overview

The LMT was developed internally at DE. The DNV team did not interact with or use the tool directly. The DSP team provided a detailed walk-through of the individual screening process for a single program through active screen-sharing exercises to allow DNV to view the entire process. The DSP team identified how input files are organized and loaded into LMT, how input assumptions are changed, the process of calculating program-specific outputs, and the organization and export of output files. The DSP team also provided all relevant input, assumptions, load shape, and output files for all cases that DNV reviewed.

4.4.1.5 Programs and Test Cases Reviewed

DNV coordinated with the DSP team to test three different DSM programs in LMT. Given the high-level nature of this review, DNV did not use the tool directly or view underlying code. Therefore, the DSP team provided a detailed walk-through of the individual screening process using the Residential Income and Age Qualifying Enhanced Program (EAL4) as an example. The DSP team provided DNV with the input files for EAL4 and two other programs, program-specific load shapes, and LMT-generated outputs (results) for all programs in csv format. They also provided the same types of files for test cases that DNV specified. The three programs, including all test cases reviewed are detailed in **Table** 4-10.

Table 4-10. LMT Program Review and Test Cases

Program Name	Acronym	DSM Phase	Test Cases
Residential Income and Age Qualifying Enhanced	EAL4	IX	1. Base case (no input assumptions changed) 2. $1,000/unit one-time incentive
Commercial Data Center	CDAC	X	1. Base case (no input assumptions changed) 2. Updated fixed expenses ($100,000/year) in years 2021-2022 3. Updated avoided energy costs ($0.03/kWh in year 2022 escalating by 2.5% each year until 2070)
Commercial Battery Storage	CBS2	X	1. Base case (no input assumptions changed) 2. Updated utility discount rate (8.5% for all years 2022-2070) 3. Updated fixed costs and customer benefits (fixed expense – $200,000/year for all years 2023-2027, VA enrollment incentive = $25,000, NC enrollment incentive = $15,000)

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DNV reviewed programs that were actively being screened and tested within LMT for the December 2021 Phase X DSM filings with the Virginia State Corporation Commission. DNV selected three types of programs that were different from each other in their characteristics, to test the range of the LMT's capabilities. DNV selected both residential and non-residential energy efficiency programs to identify any potential variation in screening between the two. The CBS2 program was also selected to test a demand response program. This allowed DNV to compare the difference in how the LMT treated energy efficiency programs versus demand response programs in terms of load shape impacts and underlying calculations. These programs were tested using DE's existing QC workbook for LMT. This workbook was adapted by DNV to incorporate detailed calculation verification, documentation, and recommendation sections for each of the individual benefit/cost calculations contained within the workbook and performed within LMT. This review and documentation process is further detailed in the next section.

4.4.2 QC Workbook and Calculation Review

DNV created LMT QC Excel files for each program reviewed and used program files to QC specific test cases as well. These files were all built upon DE's existing workbooks and associated framework for calculating QCs for individual DSM program screenings in LMT. Each DE workbook contained the original individual program input worksheets used in LMT, output worksheets from the LMT screening calculations, and individual QC worksheets where QC calculations were stored.

DNV's updated versions of these workbooks contained the same overall structure and worksheets as the versions originally provided by DE, but added the following additional worksheets developed by DNV:

- Duplicate QC worksheets for calculation verification and comments (i.e., "(DNV) QC-Incentive Payments")
- 'DNV README' sheet for workbook documentation and overview, and
- 'DNV QC Summary' worksheet.

Program input worksheets contain both program-specific and global assumptions (applicable to all program screenings) that LMT uses directly in its calculations.

DNV did not alter the existing program input or output worksheets but duplicated each individual QC worksheet to incorporate calculation documentation, verification, and any additional comments, questions, or recommendations based on the overall review. On each individual DNV-provided QC worksheet, DNV added columns for:

- "Calculation Documentation"
- "Data Sources"
- "Observations / Comments / Questions"

A description of these is shown in Table 4-11.

Table 4-11. Description of DNV Calculation Verification and Documentation Sections

DNV QC: Calculation Verification and Documentation		
Calculation Documentation	**Data Sources**	**Observations / Comments / Questions**
Documents individual calculations and provides notes on relevant information included to verify that correct assumptions were made	Documents all data sources in each calculation and where they are located within the workbook and what the original source is (either a specific Dominion team or external source/vendor)	Provides any relevant DNV observations related to calculation recommendations, questions about calculations or data sources, and feedback related to process documentation

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Results contained in the individual LMT output worksheets were checked against DE's QC calculation results to verify correct LMT tool calculations. An overview of DNV's QC/calculation verification process is detailed below.

1. Compare each individual LMT output to the respective DE QC calculation check – if no differences are found, move to #2; if differences found, retrace calculation steps to identify the source of difference
2. Document each step of the calculation to verify that each individual input is accurate, and provide additional notes that help to clarify why specific inputs are correct (e.g., different discount rates)
3. Identify and document any discrepancies related to the application of cost-effective standards and assumptions (e.g., discount rates, NTGR)
4. Document each input/assumption source to identify correct sources are being used (internal team/external vendors) and to verify they are aligned with general cost-effectiveness testing assumptions.
5. Document any calculation and/or assumption issues, errors, or corrections that are needed to accurately calculate results
6. Provide additional feedback related to additional items such as documentation, workbook structure, etc.

4.4.3 Avoided Costs Review

Dominion Energy includes two main avoided costs in their inputs for LMT. These include avoided transmission ($/kW) and avoided distribution ($/kW) costs that are summed to calculate the total T&D demand credit (benefit) for each year in each program. The avoided costs consist of both forecasted locational marginal prices (LMP, $/kWh) and capacity prices ($/kW) provided by an external consultant for all generators in the PJM DOM zone. These costs are also verified internally by Dominion Energy using PLEXOS.

Dominion Energy's Integrated Strategic Planning Team produces the avoided costs used in the benefit/cost analysis. An external consultant provides a forecast of LMP ($/kWh) and capacity prices ($/kW) for all generators in the PJM DOM zone. PLEXOS market simulation software is used to optimize the mix of resources at any particular hour to find the least-cost option.

Avoided capacity costs measure the value in avoiding or delaying the construction of new generation capacity. The avoided-cost estimate factors in both the type of generation and the timing of when the additional capacity would be needed. Avoided costs used in Dominion Energy's benefit-cost calculations are shown in Table 4-12.

Because Virginia participates in the Regional Greenhouse Gas Initiative (RGGI), a carbon cap-and-trade program, the purchase of carbon allowances is an explicit cost to Dominion Energy and is embedded in their avoided cost. Dominion Energy's avoided-cost forecast assumes that there will be a federal cap-and-trade program beginning in 2026.

Table 4-12. Avoided Costs for Transmission and Distribution

Year	Avoided Capacity ($/kW-yr)	Avoided Transmission ($/kW)	Avoided Distribution ($/kW)	Total T&D Demand Credit ($/kW)
2021	41.45	35.11	20.12	55.23
2022	31.94	35.84	20.54	56.38
2023	39.13	36.59	20.96	57.55
2024	55.67	37.25	21.35	58.60
2025	57.46	37.93	21.74	59.67
2026	59.18	38.63	22.13	60.76
2027	60.93	39.33	22.54	61.87

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Year	Avoided Capacity ($/kW-yr)	Avoided Transmission ($/kW)	Avoided Distribution ($/kW)	Total T&D Demand Credit ($/kW)
2028	62.76	40.05	22.95	63.00
2029	64.65	40.78	23.37	64.15
2030	66.59	41.53	23.80	65.33
2031	68.56	42.29	24.23	66.52
2032	70.53	43.06	24.67	67.73
2033	72.53	43.85	25.12	68.97
2034	74.59	44.65	25.58	70.23
2035	76.71	45.47	26.05	71.52
2036	78.89	46.30	26.53	72.82
2037	81.11	47.14	27.01	74.15
2038	83.39	48.00	27.50	75.51
2039	85.70	48.88	28.01	76.89
2040	88.05	49.77	28.52	78.29
2041	91.26	50.68	29.04	79.72
2042	95.13	51.61	29.57	81.18
2043	99.09	52.55	30.11	82.66
2044	103.16	53.51	30.66	84.18
2045	107.32	54.49	31.22	85.71
2046	111.58	55.49	31.79	87.28
2047	115.93	56.50	32.37	88.87
2048	120.40	57.53	32.96	90.50
2049	124.99	58.59	33.57	92.15
2050	129.70	59.66	34.18	93.84
2051	133.05	60.75	34.81	95.55
2052	135.39	61.86	35.44	97.30
2053	137.77	62.99	36.09	99.08
2054	140.20	64.14	36.75	100.89
2055	142.66	65.31	37.42	102.73
2056	145.17	66.50	38.10	104.61
2057	147.73	67.72	38.80	106.52
2058	150.33	68.96	39.51	108.46
2059	152.97	70.22	40.23	110.45
2060	155.66	71.50	40.97	112.46
2061	155.66	72.81	41.71	114.52
2062	155.66	74.14	42.48	116.61
2063	155.66	75.49	43.25	118.74
2064	155.66	76.87	44.04	120.91
2065	155.66	78.27	44.85	123.12
2066	155.66	79.70	45.67	125.37
2067	155.66	81.16	46.50	127.66

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Year	Avoided Capacity ($/kW-yr)	Avoided Transmission ($/kW)	Avoided Distribution ($/kW)	Total T&D Demand Credit ($/kW)
2068	155.66	82.64	47.35	130.00
2069	155.66	84.15	48.22	132.37
2070	155.66	85.69	49.10	134.79

4.4.3.1 Review summary

Dominion Energy's approach to benefit-cost testing and avoided costs follows standard practice. The LMT builds upon the existing previous Strategist model. LMT is a well-vetted and comprehensive tool that is appropriate for this use. Inputs to the modeling process are well-documented and appear appropriate to the programs.

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APPENDIX E EVALUATION MEASUREMENT AND VERIFICATION PLANS

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

Appendix E

Evaluation, Measurement, And Verification (EM&V) Plans

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APPENDIX E. EVALUATION, MEASUREMENT, AND VERIFICATION (EM&V) PLANS

TABLE OF CONTENTS

E1. DEMAND-SIDE MANAGEMENT PORTFOLIO EVALUATION, MEASUREMENT, AND VERIFICATION APPROACH 3

E2. REFERENCES AND CITATIONS 5

E3. RESIDENTIAL APPLIANCE RECYCLING PROGRAM EM&V PLAN 6

E4. RESIDENTIAL EFFICIENT PRODUCTS MARKETPLACE PROGRAM EM&V PLAN 10

E5. RESIDENTIAL HOME ENERGY ASSESSMENT PROGRAM EM&V PLAN 15

E6. RESIDENTIAL CUSTOMER ENGAGEMENT PROGRAM EM&V PLAN 19

E7. RESIDENTIAL ELECTRIC VEHICLE PROGRAM (EE) EM&V PLAN 23

E8. RESIDENTIAL HOME RETROFIT PROGRAM EM&V PLAN 28

E9. RESIDENTIAL ENERGY EFFICIENCY KITS PROGRAM EM&V PLAN 32

E10. RESIDENTIAL MANUFACTURED HOUSING PROGRAM EM&V PLAN 36

E11. RESIDENTIAL/NON-RESIDENTIAL MULTIFAMILY PROGRAM EM&V PLAN 41

E12. RESIDENTIAL NEW CONSTRUCTION PROGRAM EM&V PLAN 47

E13. RESIDENTIAL SMART THERMOSTAT PURCHASE AND WEATHERSMART[SM] PROGRAM EM&V PLAN 51

E14. RESIDENTIAL SMART HOME PROGRAM EM&V PLAN 55

E15. RESIDENTIAL VIRTUAL AUDIT PROGRAM EM&V PLAN 59

E16. RESIDENTIAL WATER SAVINGS (EE) PROGRAM EM&V PLAN 63

E17. RESIDENTIAL HVAC HEALTH AND SAFETY PROGRAM EM&V PLAN 67

E18. RESIDENTIAL INCOME AND AGE QUALIFYING HOME IMPROVEMENT 73

E19. HB 2789 (SOLAR COMPONENT) PROGRAM EM&V PLAN 77

E20. SMALL BUSINESS IMPROVEMENT ENHANCED PROGRAM EM&V PLAN 81

E21. NON-RESIDENTIAL PRESCRIPTIVE PROGRAM EM&V PLAN 87

E22. NON-RESIDENTIAL HEATING AND COOLING EFFICIENCY PROGRAM EM&V PLAN 90

E23. NON-RESIDENTIAL LIGHTING SYSTEMS & CONTROLS PROGRAM EM&V PLAN 96

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E24. NON-RESIDENTIAL OFFICE PROGRAM EM&V PLAN 100

E25. NON-RESIDENTIAL SMALL MANUFACTURING PROGRAM EM&V PLAN 104

E26. NON-RESIDENTIAL WINDOW FILM PROGRAM EM&V PLAN 108

E27. NON-RESIDENTIAL MIDSTREAM EFFICIENCY PRODUCTS PROGRAM EM&V PLAN 112

E28. NON-RESIDENTIAL NEW CONSTRUCTION PROGRAM EM&V PLAN 118

E29. NON-RESIDENTIAL AGRICULTURAL PROGRAM EM&V PLAN 122

E30. NON-RESIDENTIAL BUILDING AUTOMATION PROGRAM EM&V PLAN 127

E31. NON-RESIDENTIAL BUILDING OPTIMIZATION PROGRAM EM&V PLAN 131

E32. NON-RESIDENTIAL CUSTOMER ENGAGEMENT PROGRAM EM&V PLAN 138

E33. NON-RESIDENTIAL PRESCRIPTIVE PROGRAM ENHANCED EM&V PLAN 143

E34. RESIDENTIAL SMART COOLING REWARDS PROGRAM EM&V PLAN 149

E35. NON-RESIDENTIAL DISTRIBUTED GENERATION PROGRAM EM&V PLAN 153

E36. RESIDENTIAL SMART THERMOSTAT REWARDS (DR) PROGRAM EM&V PLAN 157

E37. RESIDENTIAL ELECTRIC VEHICLE REWARDS PROGRAM (DR) EM&V PLAN 160

E38. RESIDENTIAL WATER SAVINGS (DR) PROGRAM EM&V PLAN 162

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E1. DEMAND-SIDE MANAGEMENT PORTFOLIO EVALUATION, MEASUREMENT, AND VERIFICATION APPROACH

This document contains the evaluation, measurement, and verification (EM&V) plans for the Dominion Energy DSM programs. The plans are organized in the following manner:

- Program Summary – high-level program description
- Measures – high-level description of proposed program measures
- Evaluation, Measurement, and Verification Overview – high-level description of EM&V approach
- Deemed Savings Approach – upon program approval, deemed savings calculation approach will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies, as appropriate
- Evaluated Savings Approach or Verified Savings Approach – program evaluation approach based on the guidelines set forth in the final order of SCC Case No. PUR-2020-00156 ("Final Order").[1]
- Lost Revenue Methodology – steps for calculating lost revenue
- Timeline and Scope of Work – description of the EM&V schedule and scope of work
- Document Revision History

The evaluation methods described in the following EM&V plans meet the standards of section A of 20 VAC 5-318-40 and The Final Order.[2] All evaluation methodologies align with Options A, B, C, or D from the International Performance Measurement and Verification Protocol (IPMVP) and the protocols defined in the U.S Department of Energy's Uniform Methods Project for Determining Energy Efficiency Savings for Specific Measures (UMP).[3] Other referred EM&V guidance and industry best-practices are provided in Section E2.

The Final Order states that program specific EM&V approaches, methods, and timing are guided by the value of information (VOI) framework outlined in The Final Order. The VOI framework assesses the extent to which various evaluation activities cost-effectively reduce uncertainty and mitigate risk. The following considerations are taken from The Final Order:

- The magnitude of portfolio uncertainty contributed by a particular program, measure, or parameter
- The potential contribution to uncertainty in a future portfolio, even if the current program is small
- Uncertainty as to whether a particular program or measure passes a basic benefit/cost screening test, or uncertainty in other key design questions
- The ability of empirical studies to reduce those uncertainties, and at what cost
- Overall budget constraints
- DNV's evaluation of uncertainty assessments and sensitivity analyses as described in Case No. PUR-2020-00156 Exhibit 21 (Feng Rebuttal) at pp. 15–16

EM&V of Dominion's DSM programs follow a two-stage approach. Following implementation, kilowatts and kilowatt-hour savings are estimated using a deemed calculation savings approach. In addition to the deemed savings approach, programs

[1] PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order, Appendix A. Virginia State Corporation Commission. Effective date, 10/27/2021.

[2] 20 VAC 5-318, Title 20. Virginia State Corporation Commission, Ch. 318, Final Reg. Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective date 01/01/2018.

3 Efficiency Value Organization. 2022. Core Concepts, International Performance Measurement and Verification Protocol. www.evo-world.org; Li, M.; Haeri, H.; Reynolds, A. (2018). The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-70472. http://www.nrel.gov/docs/fy18osti/70472.pdf

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are considered for follow-on evaluation to estimate adjusted gross savings and/or net adjusted savings according to the VOI framework outlined in The Final Order. Programs that adopt an evaluated savings approach will use the method most suitable to the program, program measures, and evaluation objectives, again, guided by VOI framework. The evaluated savings approaches described here include impact analyses, market studies, surveys, and process evaluations.

Deemed Savings Approach –References and Data

All deemed calculations are documented in the Dominion Energy Virginia and North Carolina Technical Reference Manual (DE TRM) which is included as an appendix to the annual EM&V report. The DE TRM is a collection of deemed engineering equations used to calculate kilowatt and kilowatt-hour savings for each measure implemented by the Company in Virginia and North Carolina. The DE TRM is updated annually.

In the absence of a state-wide technical reference manual (TRM) in Virginia and North Carolina, DNV will derive deemed savings calculations from the Mid-Atlantic Technical Reference Manual (Mid-Atlantic TRM).[4] The Mid-Atlantic TRM is used in states neighboring Virginia and elsewhere in the mid-Atlantic region of the United States. (e.g., Maryland, District of Columbia, Delaware). For program measures that are not available in the Mid-Atlantic TRM, DNV assesses regional technical reference manuals (TRM), and TRMs outside the region, if necessary, to identify the most appropriate source(s) for deriving the deemed savings calculations, variables, and and/or factors used in the DE TRM. Each TRM contains complete citations for all deemed savings calculations, variables, and factors.

As much as practicable, the DE TRM currently produces kilowatt and kilowatt-hour savings estimates using customer-specific participant data as inputs to the deemed savings calculations described above. In the absence of customer-specific data, utility specific data is used. When utility-specific data are unavailable or impracticable to collect, DNV uses proxy utility-specific program participant data to assign assumed inputs derived from Virginia-specific or North Carolina-specific data or data from non-Virginia or non-North Carolina jurisdictions, and with appropriate citation to the source documents.

To gather utility- and customer-specific program tracking and usage data, DNV provides the Company with a list of the EM&V data requirements that are necessary to estimate tracked savings and document the measure baseline, DNV develops this list, keeping in mind when it may be impractical to collect specific data variables (e.g., equipment nameplate information may be inaccessible or sun-bleached and illegible). The Company's program managers, analysts, and information technology ("IT") staff generate the program tracking data. The Company's IT staff defines the information management system that generates the data and delivers it to DNV on a monthly basis.

DNV applies the combination of program-generated utility-specific data, and other default inputs to the deemed calculations documented in the DE TRM to calculate and report the kilowatt and kilowatt-hour savings for each implemented measure and aggregates it at the measure level, where appropriate, without adjustment for free-ridership values. DNV reports the savings in the annual EM&V report after adjustments for free-ridership based on either the initial program design assumed free-ridership value, or the evaluated free-ridership value determined through EM&V.

[4] Northeast Energy Efficiency Partnerships, Maryland/Mid-Atlantic Technical Reference Manual, Version 10. May 2020 (prepared by Shelter Analytics). The manual can be found at https://neep.org/sites/default/files/media-files/trmv10.pdf.

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Jun 15 2022

E2. REFERENCES AND CITATIONS

In developing the EM&V plans for the Company's DSM programs, DNV consulted the following set of core EM&V standards and guidance documents.

Efficiency Valuation Organization (EVO). International Performance Measurement and Verification Protocol. The International Performance Measurement and Verification Protocol (IPMVP) provides an overview of current best practices for determining and verifying results of energy efficiency. It is one of the most recognized M&V protocols for demand-side energy activities. https://evo-world.org/en/products-services-mainmenu-en/protocols/ipmvp

U.S. Department of Energy. Uniform Methods Project. July 2018. Uniform Methods Project protocols provide standardized, common-practice M&V methods for determining gross energy savings for many of the most common residential and commercial measures and programs offered by administrators of energy efficiency programs in North America for utility customers. The UMP also includes cross-cutting protocols for topics such as net savings determination, metering, and persistence of savings determination. http://energy.gov/eere/about-us/ump-protocols

ASHRAE Guideline 14-2014: Measurement of Energy and Demand Savings. American Society of Heating, Refrigerating and Air-Conditioning Engineers. Guideline 14 provides a standardized set of energy, demand, and water-savings calculation procedures. This publication provides guidance on minimum acceptable levels of performance for determining energy and demand savings, using measurements, in commercial transactions. https://webstore.ansi.org/Standards/ASHRAE/ASHRAEGuideline142014

U.S. Department of Energy Federal Energy Management Program. M&V Guidelines: Measurement and Verification for Performance-Based Contracts, Version 4.0. November 2015. Prepared for DOE's Federal Energy Management Program, the purpose of this document is to provide guidelines and methods for documenting and verifying the savings associated with federal agency performance contracts. It contains procedures and guidelines for quantifying the savings resulting from energy efficiency equipment, water conservation, improved operations and maintenance, renewable energy, and cogeneration projects. https://www.energy.gov/sites/prod/files/2016/01/f28/mv_guide_4_0.pdf

Mid-Atlantic Technical Reference Manual, Version 10. The Mid-Atlantic TRM provides detailed deemed savings equations and common assumptions for prescriptive residential and non-residential DSM measures. Measures were chosen by consensus of the Mid-Atlantic TRM subcommittee and project team. For each measure, the TRM includes either specific deemed values, factors, or algorithms for calculating gross annual electric energy savings, gross electric summer coincident peak demand savings, gross annual fossil fuel energy savings, other resource savings, incremental costs, and measure life. https://neep.org/sites/default/files/media-files/trmv10.pdf

PJM Manual 18B: Energy Efficiency Measurement & Verification, Revision: 04, Effective Date: August 22, 2019, PJM Forward Market Operations. The PJM Manual for Energy Efficiency Measurement & Verification is one of the PJM procedure manuals under the Reserve Manuals category. https://pjm.com/~/media/documents/manuals/m18b.ashx

State & Local Energy Efficiency Action (SEE Action) Evaluation, Measurement, and Verification Resource Portal. EM&V Resource Portal is an EM&V resource for energy efficiency program administrators and project managers. https://www4.eere.energy.gov/seeaction/evaluation-measurement-and-verification-resource-portal#guidance

Dominion Energy Virginia and North Carolina Technical Reference Manual (DE TRM). The residential and non-residential Standard Tracking and Engineering Protocols (STEP) Manual (renamed to the Dominion Energy Technical Reference Manual) filed with the 2021 EM&V Report as "Appendix F1 and F2 – Residential and Non-Residential Standard Tracking and Engineering Protocols (STEP) Manual (version 10) (see DSM 8 case: PUR-2019-00201 at https://scc.virginia.gov/DocketSearch#caseDocs/140330).

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Jun 15 2022

E3. RESIDENTIAL APPLIANCE RECYCLING PROGRAM EM&V PLAN

E3.1. Program Summary

This program would provide incentives to residential customers to recycle freezers and refrigerators that are of a specific age and size. Appliance pick-up and proper recycling services are included.

E3.2. Measures

Removal of and recycling of operating refrigerators and freezers

E3.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[5] The EM&V method estimates gross and net program energy savings, including net-to-gross savings (NTG) and free-ridership estimates.

The basis for DNV's savings evaluation approach is:

1. Baseline Consumption: The baseline wattage of all installed measures will be computed using baseline conditions tracked in the program participation data using protocols developed in the DE TRM and North Carolina Technical Reference Manual (TRM). Therein, the deemed savings approach for each measure is predominantly derived from the most recent version of the Mid-Atlantic TRM and, as appropriate, from other technical Reference manuals.
2. Deemed Savings: Deemed savings (or gross savings) values will be estimated using calculation approaches in the TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs.
3. Evaluated savings (or net savings) will be determined using a combination of on-site and telephone/website survey data. The wattage and hours-of-use data for the removed appliance will be collected and metered through an on-site study of the appliances—just prior to their removal—from a representative sample of participants.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[6]

E3.4. Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, deemed savings approach or protocol for the Residential Appliance Recycling Program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the Company's TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings

[5] 20 VAC 5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

[6] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

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Jun 15 2022

protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E3.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[7]

According to Chapter 7: Refrigerator Recycling Evaluation Protocol[8] of The Uniform Methods Project[9] (UMP), the key parameters necessary for determining gross savings and peak demand reductions include measure verification, annual energy consumption data, and the proportion of the year that the appliance was in operation.

At a high level, the ratio of the measured and verified savings to the deemed savings for the sample, also called a realization rate,[10] is then applied to the population of participants to estimate overall program savings. This approach will capture Company-specific customer usage data, and then apply those to the actual measures installed to quantify energy and peak demand savings.

E3.5.1. Sample Design Considerations

The sample frame will be comprised of the earlier of either approximately 2,000 participants or all participants in the first three years of program activity (whichever milestone is reached first). Planned sample size and design are determined by considering the participant population and may change from the estimated sample size. Using standard sampling approaches and tools, the following characteristics will be considered:

- Confidence interval: 85 to 90%
- Relative precision: 10 to 15%
- Measure-level error ratio: to be updated prior to sample selection
- Budget, schedule, and geographical distribution

E3.5.2. Measurement and Verification

Measurement and verification of the installation and operation of a sample of premise-level participants will be performed using one or more of the following levels of rigor:

- Telephone-survey or online-survey verification, only
- On-site verification, short-term measurements, and long-term metering of approximately two to three weeks during a period of typical operations

[7] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[8] Keeling, J.; Bruchs, D. (2017). Chapter 7: Refrigerator Recycling Evaluation Protocol. The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68563. http://www.nrel.gov/docs/fy17osti/68563.pdf

[9] Li, M.; Haeri, H.; Reynolds, A. (2018). The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-70472. http://www.nrel.gov/docs/fy18osti/70472.pdf

[10] The "realization rate" is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or a given sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and the extent to which these were affected by exogenous changes.

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The above efforts will be used to determine the verified annual energy savings and peak coincident demand reductions using gathered data, as appropriate, for each sampled project at the premises.

In a limited set of cases, other kinds of verification strategies, such as whole-house simulation modeling incorporating various types of data can be used to estimate changes in energy use associated with customer participation in the program. Similarly, DNV may opt to use a billing analysis approach if billing data can be obtained and other conditions necessary for the application of this family of methods are met.

According to the UMP, the appropriate approach to use is defined by the International Performance Measurement and Verification Protocol[11] (IPMVP) Option B, Retrofit Isolation. Using Option B, savings are determined by field measurement of the energy use of the refrigerators or freezers to be recycled (separate from the energy use of the rest of the home). This approach can be used to determine the change in energy and demand due to the removal of the appliance from the home at a representative sample of participants. These efforts will be considered to determine the verified annual energy savings and peak demand reductions using gathered data, as appropriate, for each sampled project at the premises.

E3.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, location, type of usage, and timing of removal had the program not been available.

E3.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the measured data based off the on-site studies.
2. Apply the measured data to the actual participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation data.
3. Develop cumulative monthly energy savings based on measured and verified data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E3.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.

[11] Efficiency Value Organization. 2022. Core Concepts, International Performance Measurement and Verification Protocol. www.evo-world.org.

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- If appropriate, support lost revenue recovery activities.

E3.8. Residential Appliance Recycling Program – Revision History

Table 3-1. Revision History for Residential Appliance Recycling Program EM&V Plan

Version	Date	Notes
Version 1	2019	▪ Initial release
Version 2	3/22/2021	▪ Added date to revision history and removed "Document" from "Document Revision History." Removed decimal place from version number. Slight word changes to measure description.
Version 3	4/22/2021	▪ Updated the title of "STEP Manual" to the "Dominion Energy Virginia and North Carolina Technical Reference Manual" (DE TRM) ▪ Replaced "DNV EM&V approach" to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Updated IPMVP reference from 2012 to 2022. ▪ Removed version number from title ▪ Changed reference from verified savings to evaluated savings

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E4. RESIDENTIAL EFFICIENT PRODUCTS MARKETPLACE PROGRAM EM&V PLAN

E4.1. Program Summary

The program would provide residential customers an incentive to purchase specific energy efficient appliances with a rebate through an online marketplace and through stores.

E4.2. Measures

The following measures are included in the Residential Efficient Products Marketplace Program:

Table 4-1. Residential Efficient Products Marketplace Program Measures

End-use	Measure
Lighting	▪ A-Lines ▪ Reflectors ▪ Decorative ▪ Globes ▪ Retrofit Kit and Fixture
Refrigeration	▪ Freezer ▪ Refrigeration
Appliances	▪ Dehumidifier ▪ ENERGY STAR® Air Purifier ▪ Clothes Dryer
Domestic Hot Water	▪ Dishwasher ▪ Clothes Washer

E4.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[12]

The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach is:

1. Baseline Consumption: Baseline consumption will be calculated from AMI participant and AMI non-participant consumption data.
2. Deemed Savings: Deemed savings (or gross savings) values will be estimated from the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs.
3. Evaluated Savings: Evaluated savings (or net savings) will be determined by the methods described in Section E4.5. The evaluated savings will use program tracking data, customer energy consumption data, other customer data, and equipment data to estimate program savings.

[12] 20 VAC 5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

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The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[13]

E4.4. Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, deemed savings approach or protocol for the Residential Efficient Products Marketplace Program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E4.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[14]

According to Chapter 12: Survey Design and Implementation for Estimating Gross Savings Cross-Cutting Protocol of The Uniform Methods Project (UMP), the evaluation uses a survey approach to estimate gross and net program energy savings, and free-ridership. Sample design will follow the protocols set forth in Chapter 11: Sample Design Cross-Cutting Protocol of the UMP.[15]

The EM&V method estimates gross and net program energy savings, including net-to-gross savings and free-ridership. The following data will be used to determine evaluated program savings:

- Lighting supplier interviews: The benefit of these interviews is to collect information for net-to gross calculations.
- Survey of appliance rebate participants: Participants will be asked whether the program influenced the energy efficiency of the appliance and timing of their purchase.
- Survey of upstream lighting participants: If lighting participants are surveyed, alternate recruitment methods will be employed since retail lighting channels do not collect end-user information. As of 2020 participant level data for the retail lighting channel is not available.
- Program tracking data: Review of lighting shipment invoices

Table 4-2 describes EM&V activities, survey modes, and the data that estimates net savings.

[13] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

[14] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[15] Baumgartner, Robert. (2017). Chapter 12: Survey Design and Implementation for Estimating Gross Savings Cross-Cutting Protocol The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory, NREL/SR-7A40-68568, https://www.nrel.gov/docs/fy17osti/68568.pdf; Khawaja, Sami M. Rushton, Josh. Keeling, Josh. (2017). Chapter 11: Sample Design Cross-Cutting Protocol: The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68567, https://www.nrel.gov/docs/fy17osti/68567.pdf.

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E4.5.1. Sample Design Considerations

DNV will attempt to interview the population of participating lighting suppliers. A random sampling strategy, stratified by appliance type, will be used for the appliance participants. The following characteristics will be considered:

- Confidence interval: 85 to 90% (at the appliance level)
- Relative precision: 10 to 15% (at the appliance level)
- Upstream measures
- Rebate measures
- Budget, schedule, and geographical distribution

If applicable, for the lighting participants, a pre-survey sample design is not possible, since the types of customers responding to a web survey is unknown. However, post-stratification of the sample to develop weights based on lighting type and retail channel can be performed. Table 4-2 describes the EM&V activities, data collection modes, and the data that estimates net and gross savings.

Table 4-2. EM&V Activities, Data Collection Modes, and the Data that Estimates Net and Gross Savings

Activity	Data Collection Mode	Net Savings Data
Lighting supplier interviews	In-depth phone interview	Confirmation of shipment quantities Retrospective and prospective net-to-gross ratios
Survey of appliance participants	Web survey	Confirm the appliance is installed and operating correctly
Pending available data: Surveys of lighting participants[16]	Web survey	▪ Confirm gross savings estimation inputs (e.g. lighting quantity, installation rate, etc.) ▪ Retrospective and prospective net-to-gross ratios

E4.5.2. Net-to-Gross Assessment

If applicable, free ridership may be estimated using the approaches described below:

Free-ridership Estimates from the Lighting Supplier Interviews

In-depth interviews with participating lighting suppliers are one source of net savings estimates. For prospective net-to-gross ratios, suppliers are asked to project what share of their future lighting sales in the Virginia/North Carolina market will be LEDs.

To reliably estimate the program impact on sales, the volume of program sales must be significant enough for the suppliers to report the fluctuation in sales between program and non-program periods, or between participating and non-participating stores. The volume of appliance sales through the program, especially when appliances are sourced from multiple suppliers, is not large enough to estimate program effects. Therefore, appliance suppliers will not be interviewed.

Free-ridership Estimates from the Participating End Users

Surveys of appliance and lighting participants are used obtain net-to-gross estimates. An end-user self-report net-to-gross method uses three attribution factors: timing, efficiency, and quantity, to calculate net savings.

Participant Spill-over

[16] Not available as of December 31, 2020.

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Spill-over energy savings are awarded under the following criteria:

- The original tracked purchase is at least partially attributable to the program
- The subsequent purchase is at least partially attributable to the participant's experience with their earlier tracked purchase

E4.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the evaluation.[17]
2. Apply the evaluated savings to the participant data to arrive at program level energy savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation.
3. Develop cumulative monthly energy savings based on measured and evaluated data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E4.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 1 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

E4.8. Residential Efficient Products Marketplace Program – Revision History

Table 4-3. Revision History for Residential Efficient Products Marketplace Program EM&V Plan

Version	Date	Notes
Version 1	2019	Initial release
Version 2	3/22/2021	▪ Removed CATI survey mode ▪ Removed footnote that cited A-line availability for 2019, and that participant level data is not available for the retail lighting channel. ▪ Added date to revision history and removed "Document" from "Document Revision History." Removed decimal place from version number. Formatted measure table.
Version 3	4/22/2022	▪ Updated the title of "STEP Manual" to the "Dominion Energy Virginia and North Carolina Technical Reference Manual" (DE TRM)

[17] The realization rate is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

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Jun 15 2022

Version	Date	Notes
		▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Updated IPMVP reference from 2012 to 2022. ▪ Removed version number from title

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E5. RESIDENTIAL HOME ENERGY ASSESSMENT PROGRAM EM&V PLAN

E5.1. Program Summary

The Residential Home Energy Assessment Program provide residential customers an incentive to install a variety of energy saving measures following completion of a walk-through home energy assessment. Recommendations from the program may lead to participation in other Dominion Energy programs.

E5.2. Measures

A home energy assessment is required for a customer to be eligible for the direct-install and incentivized measures.

Table 5-1. Residential Home Energy Assessment Program Measures

End-use	Measure
HVAC	▪ HVAC ductless heat pump upgrades ▪ High-efficiency fan motors ▪ Heat pump tune-up / upgrade / duct sealing ▪ AC and heat pump duct insulation
Lighting	▪ LED A-lines
Domestic Hot Water	▪ Water heater thermostat set point adjustment ▪ Water heater replacement with a heat pump water heater ▪ Low-flow showerheads and aerators ▪ Water heater pipe insulation

E5.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[18] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach is:

1. Baseline Consumption: Baseline consumption will be calculated from monthly or AMI participant and non-participant consumption data.
2. Deemed Savings: Deemed savings (or gross savings) values will be estimated from the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs.
3. Evaluated Savings: Evaluated savings (or net savings) will be determined by the methods described in Section E5.5. The evaluated savings will use program tracking data, customer energy consumption data, and other customer data to estimate program savings.

[18] 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

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The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[19]

E5.4. Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, deemed savings approach or protocol for the Residential Home Energy Assessment Program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E5.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[20]

According to Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol of The Uniform Methods Project (UMP), the evaluation approach will include a billing analysis with a comparison group. The analysis will use a site-level or panel-model billing analysis approach (see section E5.5.1.).[21]

E5.5.1. Billing Analysis

The billing analysis for the Residential Home Energy Assessment Program will require a comparison group of non-participating customers. The matched comparison group customers will be selected based on their similarity to program participant consumption characteristics.

The billing analysis will use one of two approaches cited in the UMP, Chapter 8. Results will consider actual weather conditions and weather-normalized results for both approaches.

1. The site-level approach will estimate site-level models for each customer in the participant and comparison group. The site-level models control for heating and cooling using a method that facilitates weather normalization at the site-level. The weather-normalized annual consumption (NAC) estimates are then combined in a second stage regression to provide either average customer savings or average measure-level savings.
2. The panel model approach estimates a single model for all participant and comparison group customers. The model accounts for heating and cooling, differences between the participant and comparison groups, and the participant pre-post consumption difference.

[19] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

[20] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[21] Agnew, K., Goldberg, M. (2017). Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory; NREL/SR-7A40-68564. http://www.nrel.gov/docs/fy17osti/68564.pdf

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3. The evaluation will determine which approach to use based on the size and customer composition of program at the time of evaluation.

E5.5.2. Sample Design Considerations

Billing analysis is conducted on the program population, or census, over the analysis period. Sampling may be applied for a free-ridership survey, if applicable. The following characteristics will be considered:

- Confidence interval: 85 to 90%
- Relative precision: In the billing analysis context, precision is a function of the number of participants and the magnitude of savings.
- Installed measures
- Budget, schedule, and geographical distribution

E5.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

E5.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the billing analysis.22
2. Apply the evaluated savings to the participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation.
3. Develop cumulative monthly energy savings based on measured and evaluated data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E5.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.

[22] The realization rate is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

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- If appropriate, support lost revenue recovery activities.

E5.8. Residential Home Energy Assessment Program – Revision History

Table 5-2. Revision History for Residential Home Energy Assessment Program EM&V Plan

Version	Date	Notes
Version 1	2019	▪ Initial release
Version 2	3/22/2021	▪ Added date to revision history and removed "Document" from "Document Revision History." Removed decimal place from version number. Format measure table. Option for site-level or panel model approach to billing analysis. Precision is modified to be a function of the number of participants and the magnitude of savings.
Version 3	4/22/2022	▪ Updated the title of "STEP Manual" to the "Dominion Energy Virginia and North Carolina Technical Reference Manual" (DE TRM) ▪ Replaced "DNV EM&V approach" to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Removed version number from title ▪ Removed reference to IPMVP Option C (whole facility) because Option C is designed for site level analysis. ▪ Changed section title from Savings Estimation to Billing Analysis

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E6. RESIDENTIAL CUSTOMER ENGAGEMENT PROGRAM EM&V PLAN

E6.1. Program Summary

This Program would provide educational insights into the customer's energy consumption via a home energy report (on-line and/or paper version). The home energy report is intended to provide periodic suggestions on how to save on energy based upon analysis of the customer's energy usage. Customers can opt-out of participating in the program at any time.

E6.2. Measures

The measures included in the kit offered by the Residential Customer Engagement Program (CEP) are listed inTable 6-1.

Table 6-1. Measures Offered by Residential Customer Engagement Program

End-use	Measure
Whole house	▪ Electronic home energy report ▪ Paper home energy report

E6.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[23] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach is:

1. Baseline Consumption: Baseline consumption will be calculated from monthly or AMI participant and non-participant consumption data from the treatment and control groups.
2. Deemed Savings: In the first year of the program, deemed savings values will be estimated from the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs.
3. Evaluated Savings: Evaluated savings will be determined by the methods described in Section E6.5. The evaluated savings will use program tracking data and customer energy consumption data from the treatment and control groups.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[24]

E6.4. Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, deemed savings approach or protocol for the Residential CEP will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV will use either proxy variables

[23] 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

[24] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

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or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E6.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[25]

The CEP will be evaluated using billing analysis as recommended by Chapter 17, Residential Behavior Evaluation Protocol of the Uniform Methods Project (UMP).[26]

E6.5.1. Savings Estimation

Behavior programs take multiple years to reach their full potential. Typically, savings are estimated on an ongoing basis due to challenges of assigning a deemed savings estimate to a behavioral measure.

The evaluation assumes that the CEP will be implemented in a randomized controlled treatment (RCT) experimental design. The evaluation will validate the experimental design and use it to develop unbiased estimates of behavior-motivated savings. The evaluation will use a lagged dependent variable approach to estimate savings. This approach uses pre- and post-program monthly consumption data from both the treatment and control group in a specification designed to maximize the precision of estimates. Each evaluation will produce monthly estimates of average per-participant savings. Combining average savings with the number of active participants remaining in the program for each month produces accurate annual estimates of raw program savings.

Incentive Program Uplift Estimation

The evaluation will develop an incentive program uplift adjustment that also makes use of the CEP program RCT. Uplift estimates adjust savings estimates to account for behavior-inspired activity in rebate programs (e.g., Residential Smart Thermostat Program). All incentive program activity by CEP treatment and control group participants during the post-HER report period will be aggregated and compared on an average per customer basis. If the average cumulative incentive program-related savings stream of treatment group customers is greater than control group customers incentive program-related savings, then that estimate is used to adjust overall CEP savings estimates.

Upstream Program Uplift Estimation

Upstream uplift will be estimated using data from customer surveys that are conducted with both treatment and control groups. Survey data will indicate whether lighting products and appliances supported by Dominion Energy's upstream program (e.g. Residential Energy Efficient Product Program) have been purchased. As with incentive programs, all upstream program activity by CEP program treatment and control group participants during the post-HER report period is aggregated and compared on a per customer basis. If the average cumulative upstream program-related savings stream of treatment group customer is greater than control group customers upstream program-related savings, then that estimate is used to adjust overall CEP savings estimates.

[25] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[26] Steward, James. Todd, Anika. (2017). Chapter 17: Residential Behavior Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68573. https://www.nrel.gov/docs/fy17osti/68573.pdf.

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E6.5.2. Sample Design Considerations

DNV will coordinate with the program implementation vendor and Dominion Energy to put in place the RCT experimental design for the program in advance of the implementation of each wave of the program. After the target population is identified, a subset of that population will be randomly allocated to a control group that does not receive the reports. The RCT will be developed within strata defined by geography and energy consumption bins. The size of the control group will be determined by the:

- Desired precision of savings estimates
- Expected duration of program
- Targeted populations
- Program design over time

The precision of behavioral savings estimates is a function of the number of participants and the magnitude of the load reduction. In a large program, the sample will support 90/10 precision once the program reaches its full potential. Budget, schedule, and geographical distribution will also be considered in the sample design.

E6.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the billing analysis.[27]
2. Apply the evaluated savings to the participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation.
3. Develop cumulative monthly energy savings based on measured and evaluated data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E6.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 1 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

[27] The realization rate is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

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E6.8. Residential Customer Engagement Program – Revision History

Table 6-2. Revision History for Customer Engagement Program EM&V Plan

Version	Date	Notes
Version 1	11/26/2019	▪ Initial Release
Version 2	3/22/2021	▪ Added date to revision history and removed "Document" from "Document Revision History." Removed decimal place from version number. Deleted redundant paragraph on program uplift Section L.5.1.
Version 3	4/22/2022	▪ Updated the title of "STEP Manual" to the "Dominion Energy Virginia and North Carolina Technical Reference Manual" (DE TRM) ▪ Replaced "DNV EM&V approach" to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Removed version number from title ▪ Removed reference to IPMVP Option C (whole facility) because Option C is designed for site level analysis

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E7. RESIDENTIAL ELECTRIC VEHICLE PROGRAM (EE) EM&V PLAN

E7.1. Program Summary

This Program would provide an incentive to customers to purchase a qualifying level 2 charger for their electric vehicle (EV) and who agree to enroll in the Residential Electric Vehicle Rewards (demand response) Program.

E7.2. Measures

The measure offered by the Residential Electric Vehicle Program (EE) are as shown in Table 7-1.

Table 7-1. Measures Offered by Residential Electric Vehicle (EE) Program

End-use	Measure
Plug Load	▪ Qualifying Level 2 EV chargers with connected functionality

E7.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[28] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach for the energy efficiency portion of the program are:

1. Baseline Consumption: Baseline consumption will be calculated from AMI participant consumption data if available, and vendor supplied charging data.
2. Deemed Savings: Deemed savings values will be estimated from the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs, related research, or evaluation studies.
3. Evaluated Savings: Evaluated savings will be determined by the methods described in Section E7.5. The evaluated savings will use program tracking data, customer energy consumption data, EV charger data, and other customer data to estimate program savings.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[29]

E7.4. Deemed Savings Approach

For the energy efficiency portion of the program, upon program approval by the Virginia State Corporation Commission, deemed savings approach or protocol for the Residential Electric Vehicle (EE) Program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies, as appropriate. Given that EV utility programs are relatively new, deemed savings estimates are more uncertain compared to more mature measures. The deemed savings protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is

[28] 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

[29] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

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impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E7.5. Evaluated Savings Approach for Energy Efficiency

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[30]

There are two approaches to compare consumption (hourly and overall) of a given group of EV customers who receive Level 2 chargers: whole building hourly load analysis and end-use vehicle metering analysis. Both approaches have their respective strengths and weaknesses, because EVs and charging behavior are continuing to evolve, and interval consumption data may not be available. Both approaches may be considered. Table 7-2 presents sample research questions to be addressed by an EV program energy impacts analysis.

Table 7-2. Research Questions and Associated Analyses for EV Program Energy Impact Analysis

Sample Research Questions	Overview of Approaches
What is the incremental load (kWh and kW) associated with adoption of an EV?	▪ End use metering analysis ▪ Compare charging load shapes from whole building hourly load analysis and end use metering approaches to determine incremental EV load
What is the change in energy consumption due to the combined effects of: ▪ The net consumption changes from Level 2 chargers versus a Level 1 charger. ▪ Added load due to program-attributable EV adoption	▪ Compare charging load shapes from whole building hourly load analysis and end use metering approaches to determine incremental EV load ▪ Develop pre/post load shapes
▪ What is the difference in charging load shape with a Level 2 charger versus a Level 1 charger? ▪ How do changes in load shape align with Dominion Energy's targeted load shifting?	▪ End use metering analysis ▪ Compare charging load shapes from whole building hourly load analysis and end use metering approaches to determine incremental EV load ▪ Develop pre/post load shapes

[30] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

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Table 7-3 lists potential sources of data useful for an impact analysis.

Table 7-3. List of Potential Data Sources for EV Program M&V

Dataset	Data source	Purpose
Vehicle Registrations	▪ Virginia Automobile Dealers Association, Statistical Reports ▪ Atlas EV HUB,[31] State EV registration data, ▪ Other third-party data providers	▪ Survey stratification ▪ Develop comparison groups
Program tracking data	Dominion Energy BI data, program participants, implementation vendor	▪ Identify participants ▪ Link participants to third party data ▪ Analysis
Consumption data	Dominion Energy	▪ Analysis ▪ Develop comparison groups
AMI data or high frequency interval data	Dominion Energy	▪ Analysis ▪ Develop comparison groups
Vehicle charging data	Implementers	▪ Customer specific charging information ▪ Analysis
End use metering data	Primary data collection	▪ Analysis
Consumer survey	Primary data collection	▪ Collect additional attribute data about customers ▪ Segmentation analysis of consumption behavior
Third party data	U.S. Census, American Community Survey, customer tax assessor, other providers	▪ Identifies EV owners and attributes not otherwise publicly available

E7.5.1. Sample Design Considerations

The size of the sample will be determined using the PJM sample size approach for participating customers. If AMI data is used in the evaluation, the evaluation will be performed on a census of AMI-enabled participants. Depending on the relative proportion of AMI-enabled and non-AMI participants, it may be necessary to develop a representative sample and install AMR meters at customer households designated for the sample.

The following characteristics will be considered:

- Confidence interval: 85%
- Relative precision: 10–15%
- Budget, schedule, vehicle type, charging conditions, and geographical distribution

E7.5.2. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

[31] EV HUB. https://www.atlasevhub.com/.

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E7.5.3. Sample Design Considerations

There are several sampling options based on the size of the program and the number of AMI-enabled participants.

The evaluation will be performed on the census of AMI-enabled customers. The AMI accounts are assigned weights based on connected loads and the service divisions of all participants to ensure that the AMI analysis is representative of the program population.

E7.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the billing analysis.[32]
2. Apply the evaluated savings to the participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation.
3. Develop cumulative monthly energy savings based on measured and evaluated data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E7.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 1 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

E7.8. Residential Electric Vehicle (EE) Program – Revision History

Table 7-4. Revision History for Residential Electric Vehicle (EE) Program EM&V Plan

Version	Date	Notes
Version 1	11/26/20	Initial release
Version 2	3/22/2021	▪ Minor word changes to data type ▪ Removed reference to monthly consumption data and UMP Chapter 8 ▪ Added reference that vehicle charging data is available from the implementer in section N.3 and Table N-3. ▪ Changed reference from AMI to AMR meter is section N.5.1 and N.6.1

[32] The realization rate is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

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Version	Date	Notes
		▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number.
Version 3	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Updated IPMVP reference from 2012 to 2022. ▪ Removed version number from title ▪ Removed demand response savings estimation methods (see instead the EM&V plan for the Residential Electric Vehicle Rewards Program (DR).

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E8. RESIDENTIAL HOME RETROFIT PROGRAM EM&V PLAN

E8.1. Program Summary

This Program would target high end-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 diagnostic-driven audit will typically take between 2½ and 4 hours depending on home size, and will include: visual inspection of all areas of the home including attic and crawl spaces; blower door testing of envelope leakage; duct blaster equivalent testing of ducting system if present; line logger testing of major appliances; thermal imaging where required; physical measurements of key spaces and insulation levels; and efficiency determinations of major equipment. The contractor will be required to use the program approved energy analysis software to collect required data to perform energy modeling and savings calculations.

The software will generate a detailed report showing projected energy and potential cost savings specific to the customer's site conditions and current energy usage patterns. The auditor will provide the customer with the complete report and review the findings and recommended priorities. The report will show the collective costs and impacts of various scenarios of combined measures giving the homeowner a clear picture of the best options available to them. The program will provide rebate incentives for the installation of specific measures recommended as cost effective by the modeling software. The contractor will work with the homeowner to find the mix of measures that provides the cost-effective energy savings that best meets their specific needs. Along with the homeowner energy analysis report, the contractor will be required to provide consumer education and site-specific energy conservation information to the customer related to the installed measures and behaviors recommended by the assessment report for follow up by the customer.

E8.2. Measures

The measures offered by the Residential Home Retrofit Program are listed in Table 8-1.

Table 8-1. Measures Offered by Residential Home Retrofit Program

End-use	Measure
Building Envelope	▪ Air sealing ▪ AC and heat pump duct insulation ▪ Attic insulation ▪ Wall insulation ▪ Basement wall insulation ▪ Crawl space insulation
Domestic Hot Water	▪ Low-flow showerheads and aerators ▪ Water heat pipe insulation ▪ Water heater thermostat set point adjustment ▪ Water heater replacement with a heat pump water heater
HVAC	▪ Heat pump tune-up/upgrade/duct sealing ▪ Ground source heat pump ▪ High-efficiency fan motors ▪ HVAC ductless unit upgrades ▪ Smart thermostat installation

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E8.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[33] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach is:

1. Baseline Consumption: Baseline consumption will be calculated from monthly or AMI participant and non-participant consumption data.
2. Deemed Savings: Deemed savings values will be estimated from the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs.
3. Evaluated Savings: Evaluated savings will be determined by the methods described in Section E8.5. The evaluated savings will use program tracking data, customer energy consumption data, and other customer data to estimate program savings.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[34]

E8.4. Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, deemed savings approach or protocol for the Residential Home Retrofit Program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E8.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[35]

According to Chapter 8: Whole- Building Retrofit with Consumption Data Analysis Evaluation Protocol of The Uniform Methods Project (UMP), the evaluation approach will include a billing analysis with a comparison group. The analysis will use a site-level or panel-model billing analysis approach (see Section E8.5.1.)[36]

[33] 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

[34] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

[35] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[36] Agnew, K., Goldberg, M. (2017). Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory; NREL/SR-7A40-68564. http://www.nrel.gov/docs/fy17osti/68564.pdf.

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E8.5.1. Billing Analysis

The billing analysis for the Residential Home Retrofit Program will require a comparison group of non-participating customers. The matched comparison group customers will be selected based on their similarity to program participant consumption characteristics.

The billing analysis will use one of two approaches cited in the UMP, Chapter 8. Results will consider actual weather conditions and weather-normalized results for both approaches.

1. The site-level approach will estimate site-level models for each customer in the participant and comparison group. The site-level models control for heating and cooling using a method that facilitates weather normalization at the site-level. The weather-normalized annual consumption (NAC) estimates are then combined in a second stage regression to provide either average customer savings or average measure-level savings.
2. The panel model approach estimates a single model for all participant and comparison group customers. The model accounts for heating and cooling, differences between the participant and comparison groups, and the participant pre-post consumption difference.
3. The evaluation will determine which approach to use based on the size and customer composition of program at the time of evaluation.

E8.5.2. Sample Design Considerations

Billing analysis is conducted on the program population, or census, over the analysis period. Sampling may be applied for a free-ridership survey, if applicable.

The following characteristics will be considered:

- Confidence interval: 85–90%
- Relative precision: In the billing analysis context, precision is a function of the number of participants and the magnitude of savings.
- Installed measures
- Budget, schedule, and geographical distribution

E8.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

E8.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the billing analysis.[37]
2. Apply the evaluated savings to the participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation.

[37] The realization rate is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

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3. Develop cumulative monthly energy savings based on measured and evaluated data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E8.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 1 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

E8.8. Residential Home Retrofit Program – Revision History

Table 8-2. Revision History for Residential Home Retrofit Program EM&V Plan

Version	Date	Notes
Version 1	11/26/2019	▪ Initial release
Version 2	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number. Option for site-level or panel model approach to billing analysis. Precision is modified to be a function of the number of participants and the magnitude of savings.
Version 3	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Removed version number from title ▪ Changed sub-section title from “Savings Estimation” to “Billing Analysis”

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E9. RESIDENTIAL ENERGY EFFICIENCY KITS PROGRAM EM&V PLAN

E9.1. Program Summary

This Program would provide residential customers with new customer accounts the opportunity to receive Welcome Kits consisting of energy efficiency measures. The Welcome Kits will be sent to new residential customers only, any new customer who contacts the Company to start their service for a new residence will receive the free Welcome kit. The Welcome kit will include a Tier 1 advanced power strip and an educational insert informing customers about opportunities to manage their energy use and how to opt into receiving additional free measures by going online to the program website or calling the program hotline. To receive the additional measures, customers will have to confirm their address and account status and answer a few questions to confirm the measures will be of value in producing electric energy savings in the home such as custom LED Lighting; showerhead, bath and kitchen aerators and pipe insulation; window weather-stripping; door sweep, ten outlet gaskets, a can of insulating foam and a tube of caulk. Additionally, each customer will receive educational materials along with the program measures educating them on proper use of each measure, wise energy use in general and the EE savings available through the Company's other energy efficiency programs. Minimal program marketing will be needed as the initial kits would be sent to each new residential customer as they initiate new service

E9.2. Measures

The measures included in the kit offered by the Residential Energy Efficient Kits Program are listed in Table 9-1.

Table 9-1. Measures Offered by Residential Energy Efficient Kits Program

End-use	Measure
Building Envelope	▪ Door weather stripping ▪ Window and door weather stripping ▪ Door sweep ▪ Outlet/switch gaskets ▪ Caulking
Domestic Hot Water	▪ Low-flow showerheads ▪ Kitchen and bathroom aerators ▪ Water heater pipe insulation
Lighting	▪ LED lamps
Plug Load	▪ Tier 1 smart strip

E9.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[38] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

[38] 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

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The basis for DNV's savings evaluation approach is:

1. Baseline Consumption: Baseline consumption will be calculated from monthly or AMI participant and non-participant consumption data.
2. Deemed Savings: Deemed savings values will be estimated from the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs.
3. Evaluated Savings: Evaluated savings will be determined by the methods described in Section E9.5. The evaluated savings will use program tracking data, customer energy consumption data, and other customer data to estimate program savings.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[39]

E9.4. Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, deemed savings approach or protocol for the Residential Energy Efficient Kits Program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E9.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[40]

According to Chapter 12: Survey Design and Implementation for Estimating Gross Savings Cross-Cutting Protocol of The Uniform Methods Project (UMP), the evaluation uses a survey approach to energy savings, free-ridership, and spillover. Sample design will follow the protocols set forth in Chapter 11: Sample Design Cross-Cutting Protocol of the UMP.[41]

E9.5.1. Savings Estimation

A survey of the Residential Energy Efficient Kits Program participants will be used to estimate program energy savings, free-ridership, and spillover. Sample topics include:

- Measure installation rates
- Measure removal rates

[39] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

[40] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[41] Baumgartner, Robert. (2017). Chapter 12: Survey Design and Implementation for Estimating Gross Savings Cross-Cutting Protocol; Khawaja, Sami M. Rushton, Josh. Keeling, Josh. (2017). Chapter 11: Sample Design Cross-Cutting Protocol; Violette, Daniel M.; Rathbun, Pamela. (2017). Chapter 21: Estimating Net Savings – Common Practices. From Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68578.

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- Effectiveness of education and enrollment in other energy efficiency programs
- Optional areas of research include:
- Motivation for participation
- Barriers to participation
- Strategies for increasing participation and installation rates

E9.5.2. Sample Design Considerations

Billing analysis is conducted on the program population, or census, over the analysis period. Sampling may be applied for a free-ridership survey, if applicable. The following characteristics will be considered:

- Confidence interval: 85–90%
- Relative precision: 10–15%
- Budget, schedule, and geographical distribution

E9.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

E9.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the analysis.[42]
2. Apply the evaluated savings to the participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation.
3. Develop cumulative monthly energy savings based on measured and evaluated data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E9.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 1 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.

[42] The realization rate is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

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- If appropriate, support lost revenue recovery activities.

E9.8. Residential Energy Efficient Kits Program – Revision History

Table 9-2. Revision History for Residential Energy Efficient Kits Program EM&V Plan

Version	Date	Notes
Version 1	11/26/2019	▪ Initial release
Version 2	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number.
Version 3	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Updated IPMVP reference from 2012 to 2022. ▪ Removed version number from title

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E10. RESIDENTIAL MANUFACTURED HOUSING PROGRAM EM&V PLAN

E10.1. Program Summary

This Program would provide residential customers in manufactured housing within the Company's Virginia service territory with educational assistance and an incentive to install energy efficiency measures. The auditor will perform a walk-through audit covering the envelope and all energy systems in the home paying particular attention to the condition of DHW and HVAC systems, levels of insulation, and the condition of belly board. The contractor will be required to use the program approved energy analysis software to collect required data to perform energy calculations and generate a detailed report showing projected energy and potential cost savings specific to each customer's home. The audit software calculates and captures measure-level savings values which produces a consumer-friendly report that outlines additional energy savings recommendations. The auditor will review the findings and recommendations of the complete report with the homeowner. As part of the audit, the auditor will install all low-cost measures that meet the installation protocols, similar to the approach in the DSM Phase VII Residential Home Energy Assessment Program, but specific to the construction needs of manufactured housing.

Along with the homeowner energy analysis report, the contractor will provide consumer education and site-specific energy conservation information to the customer tailored specifically to manufactured home issues. A key part of the auditor's responsibility at the audit is to encourage and motivate participants to move forward with the selection and completion of the installation of the most comprehensive set of energy efficiency measures. The auditor will review the various options and program incentives with the customer in detail helping them understand the costs and benefits of each option and answer questions to drive the customer to a decision to move forward. The auditor will show customers how they can find and select a quality installation contractor and walk them through the available program incentives.

The Program will be delivered through an expanded network of local trade allies as well as the program implementation vendor's current network of participating contractors.

E10.2. Measures

The measures offered by the Residential Manufactured Housing Program as listed in Table 10-1.

Table 10-1. Measures Offered by Residential Manufactured Housing Program

End-use	Measure
Building Envelope	▪ Door weather-stripping ▪ Door sweep ▪ Caulking ▪ Foaming ▪ Poly tape for windows ▪ Air Sealing ▪ Attic/wall insulation ▪ Mobile home belly insulation ▪ ENERGY STAR® cool roofs
Domestic Hot Water	▪ Water heater replacement with a heat pump water heater ▪ Low-flow showerheads and aerators ▪ Water heater pipe insulation ▪ Water heater thermostat set point adjustment

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End-use	Measure
HVAC	▪ ENERGY STAR® room/wall AC units ▪ Heat pump tune-up/upgrade/duct sealing ▪ Central AC filter replacement ▪ Heat pump filter replacement ▪ Smart thermostat installation ▪ Digital switch plate wall thermometer ▪ AC cover for wall/window units(s)
Lighting	▪ LED lighting
Plug Load	▪ ENERGY STAR® refrigerator/freezer ▪ High-efficiency fan motors ▪ Refrigerator/freezer

E10.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[43] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach is:

1. Baseline Consumption: Baseline consumption will be calculated from monthly or AMI participant and non-participant consumption data.
2. Deemed Savings: Deemed savings values will be estimated from the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs.
3. Evaluated Savings: Evaluated savings will be determined by the methods described in Section E10.5. The evaluated savings will use program tracking data, customer energy consumption data, and other customer data to estimate program savings.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[44]

E10.4. Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, deemed savings approach or protocol for the Residential Manufactured Housing Program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols,

[43] 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

[44] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

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inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E10.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[45]

According to Chapter 8: Whole- Building Retrofit with Consumption Data Analysis Evaluation Protocol of The Uniform Methods Project (UMP), the evaluation approach will include a billing analysis with a comparison group. The analysis will use a site-level or panel-model billing analysis approach (see Section E10.5.1.). [46]

E10.5.1. Billing Analysis

The billing analysis for the Residential Manufactured Housing Program will require a comparison group of non-participating customers. The matched comparison group customers will be selected based on their similarity to program participant consumption characteristics.

The billing analysis will use one of two approaches cited in the UMP, Chapter 8. Results will consider actual weather conditions and weather-normalized results for both approaches.

1. The site-level approach will estimate site-level models for each customer in the participant and comparison group. The site-level models control for heating and cooling using a method that facilitates weather normalization at the site-level. The weather-normalized annual consumption (NAC) estimates are then combined in a second stage regression to provide either average customer savings or average measure-level savings.
2. The panel model approach estimates a single model for all participant and comparison group customers. The model accounts for heating and cooling, differences between the participant and comparison groups, and the participant pre-post consumption difference.

The evaluation will determine which approach to use based on the size and customer composition of program at the time of evaluation.

E10.5.2. Sample Design Considerations

Billing analysis is conducted on the program population, or census, over the analysis period. Sampling may be applied for a free-ridership survey, if applicable. The following characteristics will be considered:

- Confidence interval: 85–90%
- Relative precision: In the billing analysis context, precision is a function of the number of participants and the magnitude of savings.
- Installed measures
- Budget, schedule, and geographical distribution

[45] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[46] Agnew, K., Goldberg, M. (2017). Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory; NREL/SR-7A40-68564. http://www.nrel.gov/docs/fy17osti/68564.pdf.

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E10.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

E10.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the billing analysis.[47]
2. Apply the evaluated savings to the participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation.
3. Develop cumulative monthly energy savings based on measured and evaluated data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E10.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 1 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

E10.8. Residential Manufactured Housing Program – Revision History

Table 10-2. Revision History for Manufactured Housing Program EM&V Plan

Version	Date	Notes
Version 1	11/26/2019	▪ Initial release
Version 2	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number. Option for site-level or panel model approach to billing analysis. Precision is modified to be a function of the number of participants and the magnitude of savings.
Version 3	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM)

[47] The realization rate is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

Version	Date	Notes
		▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] Removed version number from title ▪ Removed reference to IPMVP Option C (whole facility) because Option C is designed for site level analysis. ▪ Changed sub-section title from “Savings Estimation” to “Billing Analysis”

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E11. RESIDENTIAL/NON-RESIDENTIAL MULTIFAMILY PROGRAM EM&V PLAN

E11.1. Program Summary

The Program is designed to encourage investment in both residential and commercial service aspects of multifamily properties. The program is designed using 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 meters) and encourage property owners to address the measures as a bundle. This approach provides a one stop shop programming for multifamily property owners with solutions to include direct install-in-unit measures, incentives for prescriptive efficiency improvements and access to project improvements for both in-unit and commercial common area measures. Furthermore, 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 program 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 program 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 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 program implementation vendor intends to complete site assessments at the time of the enlistment visit or within two weeks to identify all eligible electric 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 walk-through audit covering the envelope and all energy systems in the buildings, paying 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.

E11.2. Measures

The measures offered by the Residential/Non-Residential Multifamily Program are listed in Table 11-1.

Table 11-1. Measures Offered by Residential/Non-Residential Multifamily Program

End-use	Measure
Building Envelope	▪ Air sealing ▪ Attic insulation ▪ Wall insulation (residential only)
Domestic Hot Water	▪ Low-flow showerhead ▪ Faucet aerator ▪ Water heater thermostat set point adjustment ▪ Water heater pipe insulation

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End-use	Measure
HVAC	▪ Heat pumps ▪ Heat pump tune-ups ▪ Smart thermostat ▪ Duct sealing
Lighting	▪ LED lighting ▪ Occupancy sensors
Plug Load	▪ ENERGY STAR® refrigerator (residential only) ▪ Clothes washer/dryer ▪ Pool pumps (commercial only)
Refrigeration	▪ Refrigerator coil brush (residential only) ▪ Refrigerator thermostat (residential only)

E11.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[48] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach is:

1. Baseline Consumption: Baseline consumption will be calculated from monthly or AMI participant and non-participant consumption data, if available.
2. Deemed Savings: Deemed savings values will be estimated from the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs.
3. Evaluated Savings: Evaluated savings will be determined by the methods described in Section E11.5. The evaluated savings will use program tracking data, customer energy consumption data, and other customer data to estimate program savings.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[49]

E11.4. Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, deemed savings approach or protocol for the Residential/Non-Residential Multifamily Program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings

[48] 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

[49] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

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protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E11.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[50]

There is no Uniform Methods EM&V protocol that comprehensively addresses multifamily programs hence the proposed approach is based on a combination of methods, listed below, modified for a multifamily program to accommodate the variety of residential and non-residential customers that may participate in this program.

According to Chapter 8: Whole- Building Retrofit with Consumption Data Analysis Evaluation Protocol of The Uniform Methods Project (UMP), the evaluation approach will include a billing analysis, with a comparison group where feasible. The analysis will use a site-level or panel-model billing analysis approach (see Section E11.5.1.).[51]

According to Chapter 15: Commercial New Construction Evaluation Protocol of The Uniform Methods Project (UMP) and modified for a residential and non-residential multifamily program, the evaluation approach will include calibrated building simulation as recommended in Chapter 15.[52] The analysis will also follow the general approach of The IPMVP, Option D, Calibrated Simulation.[53]

E11.5.1. Savings Estimation

Multifamily program evaluations may require a combination of consumption data analysis and/or engineering approaches to evaluate the variety of potential multifamily participants (e.g. individually metered units, master metered buildings with multiple units, common areas). An objective of the evaluation for this program is to evaluate savings separately for the residential and non-residential customers. The program participation mix, and data availability will dictate the most appropriate approach or combination of approaches:

A regression analysis of billing data is the most cost-effective and comprehensive if the savings are measurable in a statistically significant way and the majority of the program impacts may be isolated. The billing analysis for the Residential/Non-Residential Multifamily Program will have a comparison group of non-participating customers. The matched comparison group customers will be selected based on their similarity to program participant consumption characteristics.

The billing analysis will use an approach cited in the UMP, Chapter 8, assuming comparison groups are available. Results will consider actual weather conditions and weather-normalized results for both approaches.

1. The site-level approach will estimate site-level models for each customer in the participant and comparison group. The site-level models control for heating and cooling using a method that facilitates weather normalization at the site-level. The weather-normalized annual consumption (NAC) estimates are then combined in a second stage regression to provide either average customer savings or average measure-level savings.

[50] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[51] Agnew, K., Goldberg, M. (2017). Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory; NREL/SR-7A40-68564. http://www.nrel.gov/docs/fy17osti/68564.pdf;

[52] Keates, Steven. (2017). Chapter 15: Commercial New Construction Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/ SR-7A40-68571. www.nrel.gov/docs/fy17osti/68571.pdf.

[53] Efficiency Value Organization. 2022. Core Concepts, International Performance Measurement and Verification Protocol.

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2. The panel model approach estimates a single model for all participant and comparison group customers. The model accounts for heating and cooling, differences between the participant and comparison groups, and the participant pre-post consumption difference.

In some cases where specific measures are only installed by customers in either the residential or non-residential rate schedules, and those measures have high installation rates and high relative impacts, the regression models can be examined to see if measure-level savings are statistically significant and can be evaluated with a reasonable level of accuracy from the models.[54]

If measure-level savings are not found to be statistically significant for all participants through billing analysis, a comparison group is not feasible, or the program impacts cannot be confidently isolated, a whole building simulation analysis may be appropriate for all or a subset of participants. The whole building simulation analysis will require a sample of program participants to represent the population of participants. DNV will use the program simulation models and occupied electric and gas billing information for each building in the sample. The sample will be stratified based on modeled site-level savings. The simulation models for the sampled participants will be reviewed for accuracy and calibrated using energy consumption from occupied buildings. The savings impacts will then be computed by starting with the calibrated occupied building model and using building code standards or existing conditions for the baseline measure inputs. The site level realization rates (the ratio of verified site savings to deemed site savings) will be combined using a sample-weighted average to represent the overall program level realization rate.

The deemed savings for each individual measure can be evaluated through parametric analysis of the building models where the measures are implemented in the model one at a time and incremental savings calculated with each change. This is not recommended until the program has been running for multiple years to accumulate measure level data that can provide meaningful results.

In a limited set of cases, other verification strategies can be used to estimate changes in energy use. For example, savings may be based on the DE TRM deemed values with adjustments to key inputs that can be verified while on-site. The key parameters for those measures will be identified to determine gross savings and peak demand reduction. Adoption of a whole facility approach under Option C will require an understanding of facility energy consumption and its relationship to operational parameters to construct a valid facility energy consumption model. This requires identification and as necessary adjustment for non-routine events that would affect pre-post usage analysis and are unrelated to the measure being assessed.

All of these efforts will be considered to determine the verified annual energy savings and peak demand reductions using gathered data, as appropriate, for each sampled project at the premises.

E11.5.2. Sample Design Considerations

Billing analysis is conducted on the program population, or census, over the analysis period. Sampling may be applied for a free-ridership survey, if applicable. The following characteristics will be considered:

- Confidence interval: 85–90%
- Relative precision: In the billing analysis context, precision is a function of the number of participants and the magnitude of savings.
- Installed measures, multifamily type
- Budget, schedule, and geographical distribution

[54] This generally requires large numbers of installations (thousands) to yield meaningful results.

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E11.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

E11.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the billing analysis.[55]
2. Apply the evaluated savings to the participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation.
3. Develop cumulative monthly energy savings based on measured and evaluated data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E11.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 1 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

E11.8. Residential/Non-Residential Multifamily Program – Revision History

Table 11-2. Revision History for Residential/Non-Residential Multifamily Program EM&V Plan

Version	Date	Notes
Version 1	11/26/2019	▪ Initial release
Version 2	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number, formatting. Option for site-level or panel model approach to billing analysis. Precision is modified to be a function of the number of participants and the magnitude of savings.
Version 3	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM)

[55] The realization rate is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

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Version	Date	Notes
		▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] Updated IPMVP reference from 2012 to 2022. ▪ Removed version number from title ▪ Provided clarification of Option C and non-routine events to “Savings Estimation” ▪ Removed feasibility assessment of the comparison group from Section E11.5.1

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E12. RESIDENTIAL NEW CONSTRUCTION PROGRAM EM&V PLAN

E12.1. Program Summary

The 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 (HERS) Raters to build and inspect ENERGY STAR® Certified New Homes. ENERGY STAR certification requires that homes be efficient at the system level instead of a menu-based offering. ENERGY STAR certification of new homes involves a whole-house set of standards that ensure homes are at least 15% more efficient than a home built to state-level minimum 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 of their home 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.

E12.2. Measures

The measures included in the Residential New Construction Program are listed in Table 12-1

Table 12-1. Measures Offered by Residential New Construction Program

End-use	Measure
Whole house	▪ Attached single-family home ▪ Detached single-family home

E12.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[56] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach is:

1. Baseline Consumption: Baseline consumption will be estimated based on a home built to meet building code energy efficiency requirements.
2. Deemed Savings: Deemed savings values will be estimated from the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs.
3. Evaluated Savings: Evaluated savings will be determined by the methods described in SectionE12.5. The evaluated savings approach will use program tracking data, customer energy consumption data, and other customer data to estimate program savings.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[57].

[56] 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

[57] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

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E12.4. Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, deemed savings approach or protocol for the Residential New Construction Program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E12.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[58]

There is no Uniform Methods EM&V protocol for residential new construction hence the proposed methods are based on Chapter 15: Commercial New Construction Evaluation Protocol of The Uniform Methods Project (UMP) and modified for a residential new construction program. The evaluation approach will include calibrated building simulation as recommended in Chapter 15.[59] The analysis will also follow the general approach of The International Performance Measurement and Verification Protocol (IPMVP), Option D, Calibrated Simulation.[60]

E12.5.1. Savings Estimation

The whole building simulation analysis for the Residential New Construction Program will require a sample of program participants to represent the population of program participants. We will require program collected Ekotrope or REM/Rate models and occupied electric and gas billing information for every home in the sample. Since the program-reported deemed savings are the same for each participating home, the sample will be stratified, and sample weights will be developed, based on site level post-occupancy kWh consumption. The sample will be further stratified by heating fuel. The REM/Rate simulation models for the sampled participants will be reviewed for accuracy and calibrated using energy consumption from inhabited homes. The site level realization rates (the ratio of verified site savings to deemed site savings) will be combined using a sampling-weighted average to represent the overall program level realization rate. We will evaluate savings for attached and detached single family homes separately.

E12.5.2. Sample Design Considerations

Sampling will be used for the impact evaluation and may be applied for a free-ridership survey, if applicable. The following characteristics will be considered:

- Confidence interval: 85–90%
- Relative precision: 10–15%

[58] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[59] Keates, Steven. (2017). Chapter 15: Commercial New Construction Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/ SR-7A40-68571. www.nrel.gov/docs/fy17osti/68571.pdf.

[60] Efficiency Value Organization. 2022. Core Concepts, International Performance Measurement and Verification Protocol.

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- Installed measures
- Budget, schedule, and geographical distribution

E12.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

E12.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the calibrated energy simulations.[61]
2. Apply the evaluated savings to the participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation.
3. Develop cumulative monthly energy savings based on measured and evaluated data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E12.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 1 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

E12.8. Residential New Construction Program – Revision History

Table 12-2. Revision History for Residential New Construction Program EM&V Plan

Version	Date	Notes
Version 1	11/26/2019	▪ Initial release
Version 2	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number.
Version 3	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM)

[61] The realization rate is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

Version	Date	Notes
		▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Updated IPMVP reference from 2012 to 2022. ▪ Removed version number from title

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E13. RESIDENTIAL SMART THERMOSTAT PURCHASE AND WEATHERSMART℠ PROGRAM EM&V PLAN

E13.1. Program Summary

This Program would provide an incentive to either purchase a qualifying smart thermostat and/or enroll in an energy efficiency program, which would help customers manage their daily heating and cooling energy usage by allowing remote optimization of their thermostat operation and would provide specific recommendations by e-mail or letter that customers can act on to realize additional energy savings. The Program would be open to several thermostat manufacturers, makes, and models that meet or exceed the ENERGY STAR® requirements and have communicating technology. Rebates for the purchase of a smart thermostat would be provided on a one-time basis; incentives for participation in remote thermostat management would be provided on an annual basis. For those customers who enroll in thermostat management, additional energy-saving suggestions, based on operational data specific to the customer's heating and cooling system, would be provided to the customer at least quarterly.

Residential Smart Thermostat Purchase and WeatherSmart provides an incentive to participate in smart thermostat optimization. The program will help customers manage their daily heating and cooling energy consumption by allowing remote optimization of their thermostat operation. In addition, the customer will receive recommendations and educational materials by mail or e-mail that describe strategies for realizing additional energy savings.

The Program would be open to several thermostat manufacturers, makes, and models that meet or exceed the ENERGY STAR® requirements and have communicating technology.

E13.2. Measures

The measures offered by the Residential Smart Thermostat Purchase and WeatherSmart Program is shown in Table 13-1.

Table 13-1. Measures Offered by Residential Smart Thermostat Purchase and WeatherSmart Program

End-use	Measure
HVAC	▪ Smart thermostat ▪ Heat pump system optimization and behavioral messaging ▪ Air conditioning system optimization and behavioral messaging

E13.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[62] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach is:

1. Baseline Consumption: Baseline consumption will be calculated from monthly or AMI participant and non-participant consumption data and thermostat telemetry data if available and strengthens the analysis.
2. Deemed Savings: Deemed savings values will be estimated from the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs.

[62] 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

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site-level. The weather-normalized annual consumption (NAC) estimates are then combined in a second stage regression to provide either average customer savings or average measure-level savings.

2. The panel model approach estimates a single model for all participant and comparison group customers. The model accounts for heating and cooling, differences between the participant and comparison groups, and the participant pre-post consumption difference.
3. The evaluation will determine which approach to use based on the size and customer composition of program at the time of evaluation.

E13.5.2. Sample Design Considerations

The census of Smart Thermostat Purchase and WeatherSmart Program participants will be evaluated. Precision will be a function of the number of participants and the magnitude of savings.

E13.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

E13.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the billing analysis.[66]
2. Apply the evaluated savings to the participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation.
3. Develop cumulative monthly energy savings based on measured and evaluated data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E13.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 1 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

[66] The realization rate is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

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E13.8. Residential Smart Thermostat Purchase and WeatherSmart Program (EE) – Revision History

Table 13-2. Revision History for Residential Smart Thermostat Purchase and WeatherSmart Program EM&V Plan

Version	Date	Notes
Version 1	11/26/2019	Initial release
Version 2	3/22/2021	▪ Added reference to thermostat telemetry data in M.3 Combined measure list for purchase and optimization component and removed duplicate text. ▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number. Option for site-level or panel model approach to billing analysis. Precision is modified to be a function of the number of participants and the magnitude of savings.
Version 3	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Removed version number from title ▪ Removed reference to IPMVP Option C (whole facility) because Option C is designed for site level analysis ▪ Changed sub-section title from “Savings Estimation” to “Billing Analysis”

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E14. RESIDENTIAL SMART HOME PROGRAM EM&V PLAN

E14.1. Program Summary

The Residential Smart Homes Program would provide the Company's residential customers a suite of smart home products that provide seamless integration into the home. The program will deliver the energy-efficient measures bundled in two versions of a Smart Home Kit so that customers can benefit from a fully-integrated set of compatible smart products. The Smart Home Kit will include general instructions for installing the specific energy-efficient measure within their home. Customers will be encouraged to utilize their smart phone or tablet to access the connected functionality of the Smart Home Kit through individual manufacturer smart thermostat, smart home hub, and smart home energy monitor applications (apps). Smart phone and tablet apps and individual manufacturer websites will include links to videos and installation "how-to" guidance documents, especially for do-it-yourself products such as smart plugs, LEDs, and motion sensors. Customers will be guided to enroll separately in the Dominion Smart Thermostat DR and HVAC optimization programs based on individual program eligibility requirements.

E14.2. Measures

The measures offered by the Residential Smart Home Program are as shown in Table 14-1.

Table 14-1. Measures Offered by Smart Home Program

End-Use	Measure
Plug Load	▪ Smart Plug ▪ Smart home hub with entry and motion sensor
HVAC	▪ Smart thermostat with voice control and temperature/humidity sensor
Lighting	▪ Connected 9.5W Energy Star® LED
Multiple	▪ Smart home energy monitor (with solar option)

E14.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[67] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach for the energy efficiency portion of the program is:

1. Baseline Consumption: Baseline consumption will be calculated from monthly or AMI participant consumption data.
2. Deemed Savings: Deemed savings values will be estimated from the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs, related research, or evaluation studies.

67 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

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3. Evaluated Savings: Evaluated savings will be determined by the methods described in Section E14.5. The evaluated savings will use program tracking data, customer energy consumption data, and other customer data to estimate program savings.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[68]

E14.4. Deemed Savings Approach

For the energy efficiency portion of the program, upon program approval by the Virginia State Corporation Commission, deemed savings calculation approach or protocol for the Smart Home Program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies or protocols, as appropriate. Given that Smart Home utility programs are relatively new, deemed savings calculation estimates are more uncertain compared to more mature measures. The deemed savings calculation protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data are impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E14.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[69]

According to Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol of The Uniform Methods Project (UMP), the evaluation approach will include a billing analysis with a comparison group. The analysis will use a site-level and panel-model billing analysis approach.[70]

E14.5.1. Billing Analysis

The billing analysis for the Smart Homes Program requires a comparison group. The evaluation will apply a matching algorithm to a range of customer characteristics (e.g. pre-period monthly energy consumption data, geography, program enrollment, heating and/or cooling type) to identify comparison group customers who are like participants with respect to consumption characteristics.

The billing analysis will use two approaches cited in the UMP, Chapter 8. Results will consider actual weather conditions and weather-normalized results for both approaches.

1. The site-level approach will estimate site-level models for each customer in the participant and comparison group. The site-level models control for heating and cooling using a method that facilitates weather normalization at the

[68] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

[69] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[70] Agnew, K., Goldberg, M. (2017). Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory; NREL/SR-7A40-68564. http://www.nrel.gov/docs/fy17osti/68564.pdf;

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site-level. The weather-normalized annual consumption (NAC) estimates are then combined in a second-stage regression to provide either average customer savings or average measure-level savings.

2. The panel model approach estimates a single model for all participant and comparison group customers. The model accounts for heating and cooling, differences between the participant and comparison groups, and the participant pre-post consumption difference.

E14.5.2. Sample Design Considerations

Billing analysis is conducted on the program population, or census, over the analysis period. Sampling may be applied for a free-ridership survey, if applicable. The following characteristics will be considered:

- Confidence interval: 85–90%
- Relative precision: For billing analysis, relative precision is a function of the magnitude of savings, the natural variability of consumption and savings and the size of the population. A relative precision of 50% or better is considered strong for a billing analysis.
- Installed Measures
- Budget and schedule

E14.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

E14.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the impact evaluation.[71]
2. Apply the evaluated savings to the participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation.
3. Develop cumulative monthly energy savings based on measured and evaluated data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E14.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced sources.

[71] The realization rate is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

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- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.

E14.8. Residential Smart Home Program – Revision History

Table 14-2. Revision History for Smart Home Program EM&V Plan

Version	Date	Notes
Version 1	Nov. 2020	Initial release
Version 2	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number.
Version 3	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Removed version number from title ▪ Changed reference from tracked savings to deemed savings in EM&V Overview ▪ Removed reference to IPMVP Option C (whole facility) because Option C is designed for site level analysis ▪ Changed sub-section title from “Savings Estimation” to “Billing Analysis”

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E15. RESIDENTIAL VIRTUAL AUDIT PROGRAM EM&V PLAN

E15.1. Program Summary

The Residential Virtual Audit Program would offer customers a self-directed home energy assessment using energy-audit software, completed by the customer, with no trade ally entering the home. Customers would be directed to a website or toll-free number where they would answer a set of questions to describe the conditions and systems in their home with prompts to help them answer accurately. From this information, the software would generate a report of recommended measures and actions available to the customer to improve the efficiency of their home. The audit will typically take between 15 and 30 minutes to complete, depending on home complexity and will include: taking an inventory of energy-consuming systems and appliances as well as attic and crawl spaces; approximating leakage and insulation levels; and determining efficiencies of major equipment using customer descriptions. The report would also identify the Company's other active energy-efficiency programs that fit each customer's needs.

The software will generate a report showing projected energy and potential cost savings specific to the customer's site conditions. The customer can access the report and review the findings and recommended priorities at any time at their convenience. The Program will then provide participating customers with access to lists of participating contractors and tips on how they can find and select a quality installation contractor.

Customers who complete an energy self-assessment would then be given the opportunity to receive a kit of low-cost measures at no cost to them. The measures would be based on questions in the assessment determining which measures would address specific energy savings opportunities in each home. The kit will consist of some combination of LED specialty bulbs, energy-efficient showerheads and faucet aerators, and weatherization products along with instructions on the installation and proper use of the kit measures.

E15.2. Measures

The measure offered by the Residential Virtual Audit Program are as shown in Table 15-1.

Table 15-1. Measures Offered by Residential Virtual Audit Program

End-Use	Measure
Domestic Hot Water	▪ Showerhead ▪ Faucet aerator ▪ Pipe insulation
Lighting	▪ LED lighting
Plug Load	▪ Tier 1 smart strip
Weatherization	▪ Weatherstripping ▪ Door sweep ▪ Outlet / switch gasket ▪ Caulking

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E15.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[72] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach for the energy efficiency portion of the program is:

1. Baseline Consumption: Baseline consumption will be calculated from monthly or AMI participant consumption data.
2. Deemed Savings: Deemed savings values will be estimated from the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs, related research, or evaluation studies.
3. Evaluated Savings: Evaluated savings will be determined by the methods described in Section E15.5. The evaluated savings will use program tracking data, customer energy consumption data and other customer data to estimate program savings.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[73]

E15.4. Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, deemed savings calculation approach or protocol for the Residential Energy Efficient Kits Program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies or protocols, as appropriate. The deemed savings calculation protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data are impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E15.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[74]

According to Chapter 12: Survey Design and Implementation for Estimating Gross Savings Cross-Cutting Protocol of The Uniform Methods Project (UMP), the evaluation uses a survey approach to energy savings, free-ridership, and spillover. Sample design will follow the protocols set forth in Chapter 11: Sample Design Cross-Cutting Protocol of the UMP.[75]

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72 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

73 Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

74 Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

75 Robert Baumgartner. (2017). Chapter 12: Survey Design and Implementation for Estimating Gross Savings Cross-Cutting Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/ SR-7A40-68568. http://www.nrel.gov/docs/fy17osti/68568.pdf;

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Jun 15 2022

During program implementation, Dominion Energy will determine, in consultation with DNV, the appropriateness of conducting evaluations to estimate program net savings in net kilowatt and net kilowatt-hours.

E15.5.1. Savings Estimation

A survey of the Residential Virtual Audit Program participants will be used to estimate program energy savings, free-ridership, and spillover. Sample topics include:

- Measure installation rates
- Measure removal rates
- Effectiveness of education and enrollment in other energy efficiency programs
- Optional areas of research include:
  - Motivation for participation
  - Barriers to participation
  - Strategies for increasing participation and installation rates

E15.5.2. Sample Design Considerations

Sample design will follow the protocols set forth in Chapter 11: Sample Design Cross-Cutting Protocol of the Uniform Methods Project.[76] Energy consumption, building type, location, and other customer characteristics may be considered in the sample design. The following characteristics will be considered:

- Confidence interval: 85–90%
- Relative precision: 10–15%
- Installed measures
- Budget and schedule

E15.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

E15.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the impact evaluation.[77]
2. Apply the evaluated savings to the participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation.
3. Develop cumulative monthly energy savings based on measured and evaluated data to represent the lost sales (kWh) associated with the program.

[76] Chapter 11: Sample Design Cross-Cutting Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/ SR-7A40- 68567. http://www.nrel.gov/docs/fy17osti/68567.pdf

[77] The realization rate is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

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4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E15.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.

E15.8. Residential Virtual Audit Program – Revision History

Table 15-2. Revision History for Residential Virtual Audit Program EM&V Plan

Version	Date	Notes
Version 1	Nov 2020	Initial release
Version 2	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number.
Version 3	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Removed version number from title ▪ Changed reference from Tracked Savings Deemed Savings in EM^V Overview

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E16. RESIDENTIAL WATER SAVINGS (EE) PROGRAM EM&V PLAN

E16.1. Program Summary

The Residential Water Savings (EE) Program is designed to give the Company's residential customers control over their water-related energy use. The proposed Program leverages the installation of smart communicating water heating and pool pump technologies to facilitate more efficient operation while reducing overall electricity usage and peak demand response. Customers have the option to purchase a qualified program product online, in-store, equipment distributor, or through qualified local trade allies.

E16.2. Measures

The measures offered by the Residential Water Savings (EE) are as shown in Table 16-1.

Table 16-1. Measures Offered by Residential Water Savings (EE) Program

End-Use	Measure
Domestic Hot Water	▪ Heat pump water heater
Recreation	▪ Variable-speed pool pump

E16.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[78] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach for the energy efficiency portion of the program is:

1. Baseline Consumption: Baseline consumption will be calculated from monthly or AMI participant consumption data.
2. Deemed Savings: Deemed savings values will be estimated from the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs, related research, or evaluation studies.
3. Evaluated Savings: Evaluated savings will be determined by the methods described in Section E16.5. The evaluated savings will use program tracking data, customer energy consumption data and other customer data to estimate program savings.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[79]

E16.4. Deemed Savings Approach

For the energy efficiency portion of the program, upon program approval by the Virginia State Corporation Commission, deemed savings calculation approach or protocol for the Residential Water Savings Program (EE) Program will be

[78] 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

[79] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

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developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs, relevant studies or protocols, as appropriate. The deemed savings calculation protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data are impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E16.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[80]

The analysis will likely follow the general approach of IPMVP, Option A, Partially Measured Retrofit Isolation.[81] This approach uses engineering calculations, spot measurements, post-retrofit metering data, and stipulations. With this approach, key parameters are determined either from spot measurements in different operating states or short-term metering.

For heat pump water heaters, applying Option A would likely mean setting controls to electric resistance mode to simulate a baseline. In this state, power would be monitored to determine baseline energy and water usage patterns. The efficient case would be established by monitoring the power while in heat pump mode. Other supporting parameters may be metered as well, such as air temperature, inlet water temperature, and outlet water temperature.

For variable-speed pool pumps, applying Option A may require post-retrofit short-term metering of power or current, along with spot power measurements in various operating stages. Baseline power and schedule may need to be approximated with TRM values informed by implementer data.

Customer AMI data can be used to identify equipment cycling and load. Table 16-2 summarizes the approaches used for this program.

Table 16-2. Approaches for Determining Energy Savings from Residential Water Savings (EE)

Approach	Protocol	Description
End-Use Metering	Option A: Partially Measured Retrofit Isolation	▪ Key parameters are metered and applied to engineering calculation. ▪ May require changing controls settings to simulate baseline conditions. ▪ In other cases, baseline conditions can be approximated using implementer data and TRM based assumptions ▪ Metering period may be a couple of weeks or longer to get representative data set.
Consumption Data Analysis	Uniform Methods Project	▪ Billing analysis

[80] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[81] Efficiency Value Organization. 2022. Core Concepts, International Performance Measurement and Verification Protocol.

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E16.5.1. Sample Design Considerations

The evaluation will be performed on the census of participants. If a census is not possible the sample frame will be comprised of a representative sample of projects following guidance for the PJM sample size approach.[82] Project size, measure mix, facility type, vendor, location, and other project characteristics may be considered in the sample design. The following characteristics will be considered:

- Confidence interval: 85%
- Relative precision: 10–15%
- Installed measures
- Budget and schedule

E16.5.2. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

E16.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the impact evaluation.[83]
2. Apply the evaluated savings to the participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation.
3. Develop cumulative monthly energy savings based on measured and evaluated data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E16.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.

[82] PJM Manual 18B: Energy Efficiency Measurement & Verification, Revision: 04, Effective Date: August 22, 2019, PJM Forward Market Operations.

[83] The realization rate is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

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E16.8. Residential Water Savings (EE) Program – Revision History

Table 16-3. Revision History for Residential Water Savings (EE) EM&V Plan

Version	Date	Notes
Version 1	Nov. 2020	▪ Initial release
Version 2	4/22/2022	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number, formatting. Option for site-level or panel model approach to billing analysis. Precision is modified to be a function of the number of participants and the magnitude of savings.
Version 3	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Removed version number from title ▪ Changed reference from Tracked Savings Deemed Savings in EM&V Overview ▪ Replaced IPMVP Option C with billing analysis from the Inform methods project

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E17. RESIDENTIAL HVAC HEALTH AND SAFETY PROGRAM EM&V PLAN

E17.1. Program Summary

This Program, the first of two programs consistent with the directives contained in Virginia House Bill 2789 (2019 Session), would offer incentives for the installation of measures that reduce residential heating and cooling costs, and 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. The Program's eligibility is limited based on income, age, and disability status.

E17.2. Measures

An extensive list of heating, ventilation, and air conditioning (HVAC) and weatherization energy efficiency measures is proposed for this program, but as directed by HB 2789 it also includes health and safety measures. Some of the measures are available to residential customers only, while others are available to both residential and non-residential customers who are eligible for this program. The measures and measure classifications are listed in Table 17-1.

Table 17-1. Measures Offered by Residential HVAC Health and Safety Program

End-use	Measure
Building Envelope	▪ Insulation repair/upgrade wall ▪ Insulation repair/upgrade floor ▪ Comprehensive air sealing, envelope improvements, insulation ▪ Roof repair (residential only)
HVAC	▪ Heat pump replacement ▪ Duct sealing/insulation/repair/replacement ▪ Electric baseboard heat upgrade ▪ Upgrades to mini-split/ductless heat pumps ▪ Thermostat replacement ▪ HVAC tune-up ▪ HVAC/home-ventilation improvements
Health & Safety	▪ Mold/mildew removal (residential only) ▪ Re-wiring (residential only) ▪ Air quality control (residential only) ▪ Carbon monoxide detectors and sources (residential only) ▪ Assessments of indoor air quality (residential only) ▪ Combustion appliance safety checks/enhancements (residential only) ▪ Fire and fall safety checks/enhancements (residential only) ▪ Dehumidifiers (residential only)

As an alternative to the direct installation of specific measures at participant residences, the Company may provide, on a case-by-case basis, portions of the incentive budget to organizations that assist low income, elderly, and disabled individuals.

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E17.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[84] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach is:

1. Baseline Consumption: Baseline consumption will be calculated from monthly or AMI participant and non-participant consumption data.
2. Deemed Savings: Deemed savings values will be estimated from the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs.
3. Evaluated Savings: Evaluated savings will be determined by the methods described in Section E17.5. The evaluated savings will use program tracking data, customer energy consumption data, and other customer data to estimate program savings.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[85]

E17.4. Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, deemed savings approach or protocol for the HB 2789 Heating and Cooling System Component Program energy efficiency and weatherization measures will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E17.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[86]

There is no Uniform Methods EM&V protocol that comprehensively addresses multifamily programs hence the proposed approach is based on a combination of methods, listed below, modified for a multifamily program to accommodate the variety of residential and non-residential customers that may participate in this program.

[84] 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

[85] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

[86] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

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According to Chapter 8: Whole- Building Retrofit with Consumption Data Analysis Evaluation Protocol of The Uniform Methods Project (UMP), the evaluation approach will include a billing analysis, with a comparison group where feasible.[87] The analysis will use a site-level or panel-model billing analysis approach (see Section E17.5.1.).

According to Chapter 15: Commercial New Construction Evaluation Protocol of The Uniform Methods Project (UMP) and modified for a multifamily program, the evaluation approach will include calibrated building simulation as recommended in Chapter 15.[88] (see Section E17.5.1.). The analysis will also follow the general approach of IPMVP, Option D, Calibrated Simulation.[89]

E17.5.1. Savings Estimation

Evaluations that include multifamily building types may require a combination of consumption data analysis and/or engineering approaches to evaluate the variety of potential multifamily participants (e.g. individually metered units, master metered buildings with multiple units, common spaces). An objective of the evaluation for this program is to evaluate savings separately for the residential and non-residential customers. The program participation mix, and data availability will dictate the most appropriate approach or combination of approaches:

A regression analysis of billing data is the most cost-effective and comprehensive if the savings are measurable in a statistically significant way and the majority of the program impacts may be isolated. The billing analysis for the HB 2789 Heating & Cooling–Health & Safety Program will have a comparison group of non-participating customers. The matched comparison group customers will be selected based on their similarity to program participant consumption characteristics.

The billing analysis will use one of two approaches cited in the UMP, Chapter 8, depending on whether comparison groups are available. Results will consider actual weather conditions and weather-normalized results for both approaches.

1. The site-level approach will estimate site-level models for each customer in the participant and comparison group, if a comparison group is available. The site-level models control for heating and cooling using a method that facilitates weather normalization at the site-level. The weather-normalized annual consumption (NAC) estimates are then combined in a second stage regression to provide either average customer savings or average measure-level savings.
2. The panel model approach estimates a single model for all participant and comparison group customers, if a comparison group is available. The model accounts for heating and cooling, differences between the participant and comparison groups (if a comparison group is available), and the participant pre-post consumption difference.

The evaluation will determine which approach to use based on the size and customer composition of program at the time of evaluation. In some cases where specific measures are only installed by customers in either the residential or non-residential rate schedules, and those measures have high installation rates and high relative impacts, the regression models can be examined to see if measure-level savings are statistically significant and can be evaluated with a reasonable level of accuracy from the models.[90]

[87] Agnew, K., Goldberg, M. (2017). Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory; NREL/SR-7A40-68564. http://www.nrel.gov/docs/fy17osti/68564.pdf;

[88] Keates, Steven. (2017). Chapter 15: Commercial New Construction Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/ SR-7A40-68571. www.nrel.gov/docs/fy17osti/68571.pdf.

[89] Efficiency Value Organization. 2022. Core Concepts, International Performance Measurement and Verification Protocol. www.evo-world.org.

[90] This generally requires large numbers of installs (thousands) to yield meaningful results.

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If measure-level savings are not found to be statistically significant for all participants through billing analysis, a comparison group is not feasible, or the program impacts cannot be confidently isolated, a whole building simulation analysis may be appropriate for all or a subset of participants. The whole building simulation analysis will require a sample of program participants to represent the population of participants. DNV will use the program simulation models and occupied electric and gas billing information for each building in the sample. The sample will be stratified based on modeled site-level savings. The simulation models for the sampled participants will be reviewed for accuracy and calibrated using energy consumption from occupied buildings. The savings impacts will then be computed by starting with the calibrated occupied building model and using building code standards or existing conditions for the baseline measure inputs. The site level realization rates (the ratio of verified site savings to deemed site savings) will be combined using a sample-weighted average to represent the overall program level realization rate.

The deemed savings for each individual measure can be evaluated through parametric analysis of the building models where the measures are implemented in the model one at a time and incremental savings calculated with each change. This is not recommended until the program has been running for multiple years to accumulate measure level data that can provide meaningful results.

In a limited set of cases, other verification strategies can be used to estimate changes in energy use. For example, savings may be based on the DE TRM deemed values with adjustments to key inputs that can be verified while on-site. The key parameters for those measures will be identified to determine gross savings and peak demand reduction. Adoption of a whole facility approach under Option C will require an understanding of facility energy consumption and its relationship to operational parameters to construct a valid facility energy consumption model. This requires identification and as necessary adjustment for non-routine events that would affect pre-post usage analysis and are unrelated to the measure being assessed.

All of these efforts will be considered to determine the verified annual energy savings and peak demand reductions using gathered data, as appropriate, for each sampled project at the premises.

E17.5.2. Sample Design Considerations

Billing analysis is conducted on the program population, or census, over the analysis period. Sampling may be applied for a free-ridership survey, if applicable. The following characteristics will be considered:

- Confidence interval: 85–90%
- Relative precision: In the billing analysis context, precision is a function of the number of participants and the magnitude of savings.
- Installed measures
- Budget, schedule, and geographical distribution

E17.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

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E17.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the billing analysis.[91]
2. Apply the evaluated savings to the participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation.
3. Develop cumulative monthly energy savings based on measured and evaluated data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E17.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 1 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

E17.8. Residential HVAC Health and Safety Program – Revision History

Table 17-2. Revision History for Residential HVAC Health and Safety Program EM&V Plan

Version	Date	Notes
Version 1	11/26/2019	▪ Initial release
Version 2	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number, formatting. Option for site-level or panel model approach to billing analysis. Precision is modified to be a function of the number of participants and the magnitude of savings.
Version 3	4/22/2022	▪ Updated program name from “HB2789 Heating and Cooling Health and Safety” to “Residential HVAC Health and Safety” ▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Updated IPMVP reference from 2012 to 2022. ▪ Removed version number from title

[91] The realization rate is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

Version	Date	Notes
		▪ Provided clarification of Option C and non-routine events to “Savings Estimation” ▪ Removed feasibility assessment of the comparison group from Section E17.5.1

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E18. RESIDENTIAL INCOME AND AGE QUALIFYING HOME IMPROVEMENT

E18.1. Program Summary

The Residential Income and Age Qualifying Program would provide in-home energy assessments and installation of select energy-saving products at no cost to eligible participants. As with the Company's other low-income programs, the Company will partner with weatherization service providers to perform community outreach and install program measures at the homes of eligible customers.

E18.2. Measures

The measure offered by the Residential Income and Age Qualifying Program are as shown in Table 18-1

Table 18-1. Measures Offered by Residential Income and Age Qualifying Program

End-Use	Measure
Lighting	▪ LED lighting
Domestic Hot Water	▪ Showerhead ▪ Faucet aerator ▪ Pipe insulation ▪ Insulating tank wrap
Building Envelope	▪ Attic insulation ▪ Floor insulation ▪ Air sealing
HVAC	▪ Heat pump tune-up ▪ AC tune-up ▪ Duct sealing
Refrigeration	▪ Refrigerator replacement

E18.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[92] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach is:

1. Baseline Consumption: Baseline consumption will be calculated from monthly or AMI participant and non-participant consumption data.
2. Deemed Savings: Deemed savings (or gross savings) values will be estimated from the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs.

[92] 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

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3. Evaluated Savings: Evaluated savings (or net savings) will be determined by the methods described in Section E5.5. The evaluated savings will use program tracking data, customer energy consumption data, and other customer data to estimate program savings.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[93]

E18.4. Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, deemed savings approach or protocol for the Residential Income and Age Qualifying Program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E18.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[94]

According to Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol of The Uniform Methods Project (UMP), the evaluation approach will include a billing analysis, with a comparison group where feasible.95 The analysis will use a site-level and panel-model billing analysis approach.

E18.5.1. Billing Analysis

The billing analysis for the Residential Income and Age Qualifying Program will require a comparison group of non-participating customers. The matched comparison group customers will be selected based on their similarity to program participant consumption characteristics.

The billing analysis will use one of two approaches cited in the UMP, Chapter 8. Results will consider actual weather conditions and weather-normalized results for both approaches.

1. The site-level approach will estimate site-level models for each customer in the participant and comparison group. The site-level models control for heating and cooling using a method that facilitates weather normalization at the site-level. The weather-normalized annual consumption (NAC) estimates are then combined in a second stage regression to provide either average customer savings or average measure-level savings.

[93] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

[94] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[95] Agnew, K., Goldberg, M. (2017). Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory; NREL/SR-7A40-68564. http://www.nrel.gov/docs/fy17osti/68564.pdf.

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2. The panel model approach estimates a single model for all participant and comparison group customers. The model accounts for heating and cooling, differences between the participant and comparison groups, and the participant pre-post consumption difference.

The evaluation will determine which approach to use based on the size and customer composition of program at the time of evaluation.

E18.5.2. Sample Design Considerations

Billing analysis is conducted on the program population, or census, over the analysis period. Sampling may be applied for a free-ridership survey, if applicable. The following characteristics will be considered:

- Confidence interval: 85–90%
- Relative precision: For billing analysis, relative precision is a function of the magnitude of savings, the natural variability of consumption and savings and the size of the population. A relative precision of 50% or better is considered strong for a billing analysis.
- Installed measures
- Budget and schedule

E18.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV GL standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

E18.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the impact evaluation.[96]
2. Apply the evaluated savings to the participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation.
3. Develop cumulative monthly energy savings based on measured and evaluated data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E18.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15 of each year following program launch).
- Update DE TRM annually for updates that occurred to its referenced sources.

[96] The realization rate is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

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- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.

E18.8. Residential Income and Age Qualifying Home Improvement – Revision History

Table 18-2. Residential Income and Age Qualifying Program EM&V Plan

Version	Date	Notes
Version 1	Nov 2020	▪ Initial release
Version 2	3/22/2021	▪ Added date to revision history and removed "Document" from "Document Revision History." Removed decimal place from version number, formatting. Option for site-level or panel model approach to billing analysis. Precision is modified to be a function of the number of participants and the magnitude of savings.
Version 3	4/22/2022	▪ Updated the title of "STEP Manual" to the "Dominion Energy Virginia and North Carolina Technical Reference Manual" (DE TRM) ▪ Replaced "DNV EM&V approach" to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Removed version number from title ▪ Removed reference to IPMVP Option C (whole facility) because Option C is designed for site level analysis ▪ Changed sub-section title from "Savings Estimation" to "Billing Analysis"

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E19. HB 2789 (SOLAR COMPONENT) PROGRAM EM&V PLAN

E19.1. Program Summary

This program would provide a mechanism for customers who meet certain income, age, or disability eligibility requirements as well as previous program-participation requirements regarding weatherization to receive, at no cost to the customer, photovoltaic solar panels installed at their residence.

Program Characteristics

- Solar installations must be installed behind the participant's meter and net energy metered.
- Solar panels and associated inverters and connecting equipment would be owned by the program participant.
- Solar installations would be standardized across participants. Residential participants would receive an installation with a maximum value to be established in consultation with stakeholders in the range of 3-5 kW_{ac}; individually metered multifamily residences or facilities providing residences would receive an installation no larger than a 10 kW_{ac}.
- Funding for battery energy storage systems not included in program.
- Limited funding would be provided for necessary roof repair/reinforcement.

The program would be managed by a demand-side management program implementation firm. The solar installations would be managed by Weatherization Service Providers who are participating in the Company's DSM Phase IX Income and Age Qualifying Program.

The program implementation firm would provide a minimum of the following services:

- Confirm customer/project eligibility
- Confirm site suitability screening
- Review and approve project scopes of work
- Perform on-site visits to ensure quality control
- Review project submittals to ensure all documentation is captured
- Approve projects and administer funds
- Facilitate solar training for the provider network and implementer staff
- Identify certified solar installers to participate in areas not covered by the Weatherization Service Provider (WSP) network
- Track/Evaluate program spending

The Weatherization Service Providers would provide a minimum of the following services:

- Identify eligible customers and eligible worksites for projects
- Perform initial site suitability assessment
- Educate eligible customers on the process and systems to ensure the perfect match
- Submit project scopes of work to program implementer for review
- Contract with certified solar installers to perform all work and on-going maintenance
- Oversee projects through completion and ensure projects meet quality standards
- Submit completed projects to program implementer for reimbursement
- Provide primary telephone contacts for interested and participating customers

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- Participating solar providers will be expected to hire diverse firms for the solar component work and participate in Targeted Solar Education Program

Training/Workforce Development

The program would provide the following:

- Training for program implementation staff and 1-2 staff members at each WSP aimed at enabling the WSP to oversee a solar project from start to finish, ensuring certain levels of installation quality and competence. The program implementer will help facilitate a training program that meets industry standards, such as those recognized by DOE, that apply towards the industry standard certification through the North American Board of Certified Energy Practitioners (NABCEP).
- Targeted solar education funding aimed at funding solar technician NABCEP-certified training targeting small, diverse-owned firms

E19.2. Measures

The measure offered by the HB 2789 (Solar Component) are shown in Table 19-1.

Table 19-1. Measures Offered by HB 2789 (Solar Component) Program

End-Use	Measure
Generation	▪ Installation of roof- or pole-mounted solar photovoltaic panels on the customer's property

E19.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[97] The basis for DNV's approach for estimating generation is:

1. Modeled Generation: PV generation will be estimated from the DE TRM (see Section E19.4.) using standard engineering methods. Methods will reference other State TRMs, protocols, related research, and applicable evaluation studies.
2. Evaluated Generation: Evaluated generation will be determined by the methods described in Section E19.5. .

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[98]

E19.4. Deemed Generation Approach

Upon program approval by the Virginia State Corporation Commission, the tracking protocols for the HB2789 (Solar Component) will be developed according to industry standards and best practices.[99]

97 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

98 Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

99 For example, S. Pless, M. Deru, P. Torcellini, and S. Hayter. October 2005. Procedure for Measuring and Reporting the Performance of Photovoltaic Systems in Buildings, National Renewable Energy Laboratory, NREL/TP-550-38603.

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Photovoltaic solar production is based on system design (azimuth, tilt, shading, and component performance characteristics) and local conditions, including weather. Generation models may be developed with assumed design characteristics and customer-specific site studies and site-specific data such as shade analysis and production estimates for each project. Both the deemed calculation and evaluated methods will require site-specific engineering analyses, documentation from the installing contractor and program implementer, production records, utility billing and AMI data, and other customer data. DNV will work with program implementers and Dominion Energy to identify the data to collect from installation contractors and program participants to estimate generation in kilowatt and kilowatt-hours. Where such data are impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research.

All models and protocols will be documented in the DE TRM and calculated using utility-reported program participant data. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all analysis protocols, model inputs and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E19.5. Evaluated PV Generation Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[100]

Table 19-2 lists several IPMVP based approaches for determining PV generation.[101] The selection of a given approach will be influenced by the data availability and the level of rigor desired. The program evaluation will make use of site-specific engineering analyses, documentation from the installing contractor and program implementer, production records, utility billing and AMI data, and other customer data.

Table 19-2. Approaches for Evaluating PV Generation

Approach	IPMVP Description	Description
Production Data Analysis	▪ Option B, Retrofit Isolation	▪ Using monthly or shorter interval production data ▪ Annualizing and weather normalizing production estimates.
Verified Solar Contractor Models	▪ Option D, Calibrated Simulation	▪ In the absence of monthly or shorter interval site-level production data, perform desk reviews of contractor models. ▪ Site-specific verification can be used to inform the models. ▪ If longer interval production data are available, the model can be calibrated.
Solar Models	▪ Option D: Calibrated Simulation	▪ This approach uses solar models for a given site or a prototype system ▪ The model can be calibrated using site-level production if available. ▪ If prototype models are used, verified site-specific characteristics can be the basis for determining which prototype model or combination of models apply to a project.
Consumption Data Analysis	▪ Option C: Whole Facility	▪ This approach can be used if only net meter data are available ▪ Takes advantage of utility billing data and post net metering data

[100] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[101] Efficiency Value Organization. 2022. Core Concepts, International Performance Measurement and Verification Protocol (IPMVP).

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Adoption of a whole facility approach under Option C will require an understanding of facility energy consumption and its relationship to operational parameters to construct a valid facility energy consumption model. This requires identification and as necessary adjustment for non-routine events that would affect pre-post usage analysis and are unrelated to the measure being assessed.

E19.5.1. Sample Design Considerations

The sample frame will be a representative sample of projects. Project size, solar installer, build type and other project characteristics may be considered in the sample design. Additionally, the evaluation approach and data availability may impact the sample design. The following characteristics will be considered:

- Confidence interval: 85–90%
- Relative precision: 10–15%
- Installed measures
- Budget and schedule

E19.6. Lost Revenue Methodology

Lost revenue will not be calculated for this program.

E19.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced sources.
- Develop baseline use and measure generation load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.

E19.8. HB 2789 (Solar Component) Program – Revision History

Table 19-3. Revision History for HB2789 (Solar Component) EM&V Plan

Version	Date	Notes
Version 1	Nov. 2020	▪ Initial release
Version 2	4/22/2022	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number, formatting.
Version 3	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Updated IPMVP reference from 2012 to 2022. ▪ Removed version number from title ▪ Provided clarification of Option C and non-routine events to “Savings Estimation”

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E20. SMALL BUSINESS IMPROVEMENT ENHANCED PROGRAM EM&V PLAN

The Program is an enhancement to the existing DSM Phase V Small Business Improvement Program. The program would provide small businesses an energy use assessment and tune-up or re-commissioning of electric heating and cooling systems, along with financial incentives for the installation of specific energy efficiency measures. Participating small businesses would be required to meet certain size and connected load requirements.

E20.1. Measures

The following measures are included in the Small Business Improvement Enhanced Program.

Table 20-1: Measures Offered by Small Business Improvement Enhanced Program

End-use	Measure
Building Envelope	▪ Window Film
HVAC	▪ Efficient air conditioning upgrades ▪ Efficient heat pump upgrades ▪ Variable Frequency Drives ▪ Window film ▪ Prescriptive re-commissioning
Lighting	▪ Direct install lighting ▪ Dimmers and controls
Refrigeration	▪ Refrigeration measures

E20.2. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[102] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach is:

1. Baseline Consumption: Baseline consumption will be calculated per the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs.
2. Deemed Savings: Deemed savings values will be estimated per the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic Technical TRM, and as appropriate, other TRMs.
3. Evaluated Savings: Evaluated savings will be determined by the methods described in Section E20.5. The evaluated savings will use program tracking data, customer energy consumption data, and other customer data to estimate program savings.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").

[102] 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

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E20.3. Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, deemed savings approach or protocol for the Small Business Improvement Enhanced Program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatts and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E20.4. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[103]

For the window film measure, the evaluation will select a sample for on-site verification. Savings will be based on the DE TRM deemed values with adjustments to key inputs that can be verified while on-site. Although the Uniform Methods Project[104] (UMP) does not specifically address window film, the key parameter for determining gross savings and peak demand reductions include surface area of treated windows and the Solar Heat Gain Coefficient (SHGC).

According to Chapter 4—Small Commercial and Residential Unitary and Split System HVAC Heating and Cooling Equipment, the key measured parameters for HVAC measures include the unit size, unit rated efficiency (energy efficient and baseline), annual operating hours, and—for peak demand reductions—coincidence factor. The first two parameters can be verified by either a desk review or on-site audit.[105]

According to Chapter 2: Commercial and Industrial Lighting Evaluation Protocol of the UMP,[106] the key measured parameters for lighting retrofits include the hours of use and the fixture wattages (energy efficient and baseline). According to Chapter 3: Commercial and Industrial Lighting Controls Evaluation Protocol,[107] the key measured parameters for occupancy sensor retrofits include the hours of use (energy efficient and baseline) and the controlled fixture wattages.

For the refrigeration measures, savings will be based on the DE TRM deemed values with adjustments to key inputs that can be verified while on-site. Although the UMP does not specifically address refrigeration measures, the key parameter for

[103] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[104] Li, M.; Haeri, H.; Reynolds, A. (2018). The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-70472. http://www.nrel.gov/docs/fy18osti/70472.pdf

[105] Jacobson, D. and Metoyer, J. (2017). Chapter 4: Small Commercial and Residential Unitary and Split System HVAC Heating and Cooling Equipment-Efficiency Upgrade Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68560. http://www.nrel.gov/docs/fy17osti/68560.pdf

[106] Gowans, D.; Telarico, C. (2017). Chapter 2: Commercial and Industrial Lighting Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68558. http://www.nrel.gov/docs/fy17osti/68558.pdf

[107] Carlson, Stephen. (2017). Chapter 3: Commercial and Industrial Lighting Controls Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/ SR-7A40-68559. http://www.nrel.gov/docs/fy17osti/68559.pdf

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determining gross savings and peak demand reductions include hours of operation, whether located in a conditioned space, and equipment type.

At a high level, the ratio of the measured and verified savings to the deemed savings for the sample, also called a realization rate,[108] is then applied to the population of participants to estimate overall program savings. This approach will capture Company-specific customer usage data, and then apply those to the actual measures installed to quantify energy and peak demand savings.

E20.4.1. Savings Estimation

Measurement and verification of the installation and operation of a sample of participants at the premises-level will be performed using one or more of the following levels of rigor:

- Desk-review verification
- Phone survey verification
- On-site verification, only
- On-site verification and short-term measurements
- On-site verification, short-term measurements, and long-term metering of approximately six to eight weeks during a period of typical operations

If metering is used, it will be conducted according to the International Performance Measurement and Verification Protocol (IPMVP) as shown in Table 20-2.[109]

Table 20-2. Preferred IPMVP Options for Small Business Improvement Enhanced Program Measures

Measure	IPMVP Option	Key Parameter(s)
Window Film	Option A: Retrofit Isolation: Key Parameter Measurement Approach	▪ Area of window film ▪ HVAC and lighting annual hours of operation
Duct Testing & Sealing and HVAC Tune-ups	Option A: Retrofit Isolation: Key Parameter Measurement Approach	▪ Cooling loads ▪ Heating loads (if applicable) ▪ Annual hours of operation
PTACs, Unitary AC/HP Systems, Mini-split Systems	Option A: Retrofit Isolation: Key Parameter Measurement Approach	▪ Cooling loads ▪ Heating loads (if applicable) ▪ Annual hours of operation
VFDs	Option B: Retrofit Isolation: All Parameter Measurement	▪ Annual hours of operation at part-load conditions
Economizers	Option A: Retrofit Isolation: Key Parameter Measurement Approach, or Option D. Calibrated Simulation	▪ Verify proper operation ▪ Annual hours of operation

[108] The "realization rate" is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or a given sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

[109] Efficiency Value Organization. 2022. Core Concepts, International Performance Measurement and Verification Protocol. www.evo-world.org.

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Measure	IPMVP Option	Key Parameter(s)
Programmable Thermostats	Option A: Retrofit Isolation: Key Parameter Measurement Approach	▪ Operating setpoints ▪ Annual hours of operation ▪ Equipment type
Lighting & Lighting Controls	Option A: Retrofit Isolation: Key Parameter Measurement Approach	▪ Fixture quantity (baseline and efficient) ▪ Wattage (baseline and efficient) ▪ Annual hours of operation
Refrigeration Equipment	Option A: Retrofit Isolation: Key Parameter Measurement Approach	▪ Space-conditioning category ▪ Annual hours of operation

According to UMP, IPMVP Option A: A Retrofit Isolation, Key Parameter Measurement Approach is most appropriate for window film, most HVAC-system types, typical economizers, and typical refrigeration equipment. IPMVP Option A is a partially-measured, retrofit-isolation study that meters the actual energy and demand reduction of an installed efficiency measure from a representative sample of participants, and adjusts the savings estimates derived from engineering algorithms applied to the Company's reported program participation data.

According to UMP, IPMVP Option B, Retrofit Isolation is most appropriate for VFD retrofits. Using Option B, savings are determined by field measurement of the energy use of the HVAC system components. By performing a bin analysis of the pre- and post-installation energy data and local weather data, it is possible to determine the energy savings and demand reduction.

According to UMP, IPMVP Option D—Calibrated Simulation may be most appropriate for installed or replaced economizer measures at complex installations. IPMVP Option D uses computer simulation software (e.g., DOE-2.2 software) to predict the change in energy and demand of efficiency measures from a representative sample of participants, and adjusts the savings estimates derived from engineering algorithms applied to Dominion Energy's reported program participation data. The computer simulation is developed using economizer system inputs collected on-site or through interviews with installation and service contractors. On-site hourly meter data is collected from the cooling systems and is used to calibrate the simulation for accuracy.

In a limited set of cases, other kinds of verification strategies, such as building simulation modelling incorporating various types of data can be used to estimate changes in energy use associated with customer participation in the program. Similarly, DNV may opt to use a billing analysis approach if billing data can be obtained and other conditions necessary for the application of this family of methods are met.

All of these efforts will be considered to determine the verified annual energy savings and peak demand reductions using gathered data, as appropriate, for each sampled project at the premises.

E20.4.2. Sample Design Considerations

The sample frame will be comprised of the earlier of either approximately 2,000 participants or all participants in the first three years of program activity (whichever milestone is reached first). Planned sample size and design are determined by considering the participant population and may change from the estimated sample size.

Using standard sampling approaches and tools, the following characteristics will be considered:

- Confidence interval: 85–90%

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- Relative precision: 10–15%
- Installed measures
- Budget, schedule, and geographical distribution

E20.4.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

E20.5. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the gross impact evaluation methods as appropriate.[110]
2. Apply the evaluated savings to the participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation.
3. Develop cumulative monthly energy savings based on measured and evaluated data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E20.6. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 1 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

E20.7. Small Business Improvement Enhanced Program – Revision History

Table 20-3. Revision History for Small Business Improvement Enhanced Program EM&V Plan

Version	Date	Notes
Version 1	11/26/2019	▪ Initial release

[110] The realization rate is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

Version	Date	Notes
Version 2	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number. Minor word changes in measure introduction.
Version 3	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Updated IPMVP reference from 2012 to 2022. ▪ Removed version number from title

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E21. NON-RESIDENTIAL PRESCRIPTIVE PROGRAM EM&V PLAN

E21.1. Program Summary

In the Non-Residential Prescriptive program, qualifying customers are eligible to pursue one or more of the qualified energy efficiency measures through a local, participating contractor in Dominion's contractor network. To qualify for this program, the customer must be responsible for the electric bill and must be the owner of the facility or reasonably able to secure permission to complete the measures.

This program is part of demand side management (DSM) Phase VI in Virginia and North Carolina.

E21.2. Measures

The following measures are included in the Non-Residential Prescriptive Program.

Table 21-1: Measures Offered by Non-Residential Prescriptive Program

End-use	Measure
Cooking	▪ Commercial Convection Oven
	▪ Commercial Electric Combination Oven
	▪ Commercial Electric Fryer
	▪ Commercial Griddle
	▪ Commercial Hot Food Holding Cabinet
	▪ Commercial Steam Cooker
HVAC	▪ Duct Testing & Sealing
	▪ Unitary/Split AC & HP Tune-up
	▪ Variable Speed Drives on Kitchen Fan
Plug Load	▪ Smart Strip
Refrigeration	▪ Door Closer
	▪ Door Gasket
	▪ Evaporator Fan Control
	▪ Floating Head Pressure Control
	▪ Refrigeration Night Cover
	▪ Refrigeration Coil Cleaning
	▪ Suction Pipe Insulation
	▪ Strip Curtain
	▪ Vending Machine Miser
	▪ Commercial Freezers and Refrigerators – Solid Door
	▪ Ice Maker
	▪ Low/No-Sweat Door Film

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Jun 15 2022

E21.3. Evaluation, Measurement & Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[111] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach is:

1. Baseline Estimation Approach: The baseline load shape will be computed based on pre-retrofit capacity data from the rebate application data, applying Equivalent Full Load Hours (EFLH) as metered from an on-site study of installed rebated measures from a representative sample of participants.
2. Deemed Savings Approach: Deemed savings values will be developed and incorporated into the DE TRM for planning purposes.
3. Evaluated Savings Approach: The wattage and hours of use data for each measure will be collected and metered through an on-site study of installed efficiency measures from a representative sample of participants.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[112]

E21.4. Deemed Savings Approach

Refer to the Non-Residential Prescriptive Program section of the DE TRM Manual for the standard deemed savings approaches for the measures in this program.

E21.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[113]

The Evaluation approach will follow International Performance Measurement and Verification Protocol (IPMVP) Option A: For physically accessible equipment measures, an EM&V method like IPMVP Option A is applied. IPMVP Option A is a partially-measured retrofit isolation study that measures the selected parameters leading to the change in energy and demand of an installed efficiency measure from a representative sample of participants, and adjusts the savings estimates derived from engineering algorithms applied to the Company's program participation data. IPMVP Option A shall be applied to a sample of all implemented measures.[114]

For all measures, the evaluation will select a sample for on-site verification. Savings will be based on the DE TRM deemed values with adjustments to key inputs that can be verified while on-site. The ratio of the weighted, measured, and verified savings to the weighted deemed savings, also called a realization rate, is then applied to the population of participants to estimate program savings. This approach will capture Company-specific customer usage data, which will be applied to the actual measures installed to quantify energy and peak demand savings.

[111] 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

[112] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

[113] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[114] Efficiency Value Organization. 2022. Core Concepts, International Performance Measurement and Verification Protocol. www.evo-world.org.

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E21.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the measured data based off the on-site studies.
2. Apply the measured data to the actual participant data to arrive at program level energy and demand savings, reflected on a monthly basis. Program savings are annualized in the EM&V tracking reports based on monthly participation data.
3. Develop cumulative monthly energy savings based on measured and verified data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges and exclude Fuel Charge Rider A and all other applicable riders) for the rate period to arrive at lost revenues.

E21.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 1 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

E21.8. Non-Residential Prescriptive Program – Revision History

Table 21-2. Revision History for Non-Residential Prescriptive Program EM&V Plan

Version	Date	Notes
Version 8		▪ Initial release
Version 9		▪ Formatting updates ▪ Updated from DNV Energy to DNV Energy Insights
Version 10	2020	▪ Formatting updates
Version 11	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number. Minor word changes in measure introduction.
Version 12	4/20/2022	▪ Corrected a typo by adding activities to the timeline to align with EM&V plan structure. Moved evaluated savings approach from “EM&V Overview” to “Evaluated Savings Approach” ▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Updated IPMVP reference from 2012 to 2022. Removed version and phase number from title

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E22. NON-RESIDENTIAL HEATING AND COOLING EFFICIENCY PROGRAM EM&V PLAN

E22.1. Program Summary

This program would provide qualifying non-residential customers with incentives to implement new and upgrade existing high efficiency heating and cooling system equipment to more efficient HVAC technologies that can produce verifiable savings.

E22.2. Measures

The following high-efficiency HVAC measures are included in the program:

Table 22-1: Measures Offered by Non-Residential Heating and cooling Efficiency Program

End-use	Measure
HVAC	▪ Air conditioner upgrade ▪ HP upgrade ▪ Geothermal HP ▪ Mini split HP ▪ Water source HP ▪ Chiller upgrade ▪ Economizers ▪ Variable frequency drives ▪ Variable refrigerant flow ▪ Unitary AC

E22.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[115] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach is:

1. Baseline Usage Estimate: The baseline load shape will be computed based on pre-retrofit capacity data from the rebate application data, applying Equivalent Full Load Hours (EFLH) as metered in on-site studies of installed rebated measures from a representative sample of participants.
2. Deemed Savings: Deemed savings (or gross savings) values will be estimated from the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs.
3. Verified Savings: Verified savings (or net savings) will be determined using on-site data. The wattage and hours of use data for the installed efficiency measure will be collected and metered through an on-site study of installed rebated measures from a representative sample of participants.

[115] 20 VAC 5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

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The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[116]

E22.4. Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, the deemed savings approach or protocol for the Non-Residential Heating and Cooling Efficiency Program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate demand and energy savings in kW and kWh, respectively. Where such data is impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the data source priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E22.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[117]

Our approach relies heavily on the DOE's Uniform Methods Project protocols (UMP):[118] According to Chapter 4—Small Commercial and Residential Unitary and Split System HVAC Heating and Cooling Equipment,[119] the key measured parameters for HVAC measures include the unit size, unit rated efficiency (energy efficient and baseline), annual operating hours, and—for peak demand reductions—coincidence factor. The first two parameters can be verified by either a desk review or on-site audit. According to Chapter 18—VFD,[120] the key measured parameters at VFD installations include: hours of operation at each VFD speed, fan/pump motor horsepower, rotational speed, motor enclosure type, motor efficiency, and VFD efficiency.

According to Chapter 19—HVAC Controls,[121] the key measured parameters at dual-enthalpy economizer installations include: pre- and post-installation energy consumption of HVAC system components. These are normalized to TMY3 weather data.

[116] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

[117] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[118] Li, M.; Haeri, H.; Reynolds, A. (2018). The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-70472. http://www.nrel.gov/docs/fy18osti/70472.pdf

[119] Jacobson, D. and Metoyer, J. (2017). Chapter 4: Small Commercial and Residential Unitary and Split System HVAC Heating and Cooling Equipment-Efficiency Upgrade Evaluation Protocol. The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68560. http://www.nrel.gov/docs/fy17osti/68560.pdf

[120] Romberger, Jeff. (2017). Chapter 18: Variable Frequency Drive Evaluation Protocol. The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/ SR-7A40-68574. http://www.nrel.gov/docs/fy17osti/68574.pdf

[121] Romberger, Jeff. (2017). Chapter 19: HVAC Controls (DDC/EMS/BAS) Evaluation Protocol. The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/ SR-7A40-68575. http://www.nrel.gov/docs/fy17osti/68575.pdf

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For all measures in this program, the annual operating hours vary by climate, building type, occupancy type, etc. A high-rigor evaluation would require metering for a sample of the participants that represented all of these categories. However, because this approach can be expensive, a lower-rigor approach using metering for only a sample of the predominant building types may be considered.

At a high level, the ratio of the measured and verified savings to the deemed savings for the sample, also called a realization rate,[122] is then applied to the population of participants to estimate overall program savings. This approach will capture Company-specific customer usage data, and then apply those to the actual measures installed to quantify energy and peak demand savings.

E22.5.1. Sample Design Considerations

The sample frame will be comprised of the earlier of either approximately 2,000 participants or all participants in the first three years of program activity (whichever milestone is reached first). Planned sample size and design are determined by considering the participant population and may change from the estimated sample size. Using standard sampling approaches and tools, the following characteristics will be considered:

- Confidence interval: 85 to 90%
- Relative precision: 10 to 15%
- Measure-level error ratio: to be updated prior to sample selection
- Budget, schedule, and geographical distribution

E22.5.2. Measurement and Verification

Measurement and verification of the installation and operation of a sample of participants at the premises-level will be performed using one or more of the following levels of rigor:

- Desk-review verification
- On-site verification, only
- On-site verification and short-term measurements
- On-site verification, short-term measurements, and long-term metering of approximately six to eight weeks during a period of typical operations

If metering is used, it will be conducted according to the International Performance Measurement and Verification Protocol[123] (IPMVP) as shown in Table 22-2.

[122] The “realization rate” is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or a given sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

[123] Efficiency Value Organization. 2022. Core Concepts, International Performance Measurement and Verification Protocol. www.evo-world.org.

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Table 22-2. Preferred IPMVP Options for Non-Residential Heating and Cooling Efficiency Program Measures

Measure	IPMVP Option	Key Parameter(s)
Package Terminal Air Conditioners and Package Terminal Heat Pumps	Option A. Retrofit Isolation: Key Parameter Measurement Approach	• Cooling loads • Heating loads (if applicable) • Annual hours of operation
Unitary and Split Air-conditioning Systems and Air-source Heat Pumps	Option A. Retrofit Isolation: Key Parameter Measurement Approach	• Cooling loads • Heating loads (if applicable) • Annual hours of operation
Variable Frequency Drives	Option B. Retrofit Isolation: All Parameter Measurement	• Annual hours of operation at part-load conditions
Economizers	Option D. Calibrated Simulation	• Verify proper operation • Annual hours of operation
Water- and Air-cooled Chillers	Option A. Retrofit Isolation: Key Parameter Measurement Approach or Option C. Whole Facility, if energy management system data are available and project-level savings are large compared to other energy variations at facility	• Cooling loads • Outside air temperatures • Manufacturer part-load efficiency data • Annual hours of operation
Geothermal Heat Pumps	Option A. Retrofit Isolation: Key Parameter Measurement Approach	• Cooling loads • Heating loads (if applicable) • Annual hours of operation
Variable-refrigerant-flow systems and mini-split heat pumps	Option A. Retrofit Isolation: Key Parameter Measurement Approach	• Cooling loads • Heating loads (if applicable) • Annual hours of operation

According to UMP, IPMVP Option A: A Retrofit Isolation, Key Parameter Measurement Approach is most appropriate for HVAC system replacement measures. IPMVP Option A is a partially-measured, retrofit-isolation study that meters the actual energy and demand reduction of an installed efficiency measure from a representative sample of participants, and adjusts the savings estimates derived from engineering algorithms applied to Dominion Energy's reported program participation data.

According to UMP, IPMVP Option B, Retrofit Isolation is most appropriate for economizer retrofits. Using Option B, savings are determined by field measurement of the energy use of the HVAC system components. By performing a bin analysis of the pre- and post-installation energy data, and local weather data, it is possible for determine the energy savings and demand reductions.

According to UMP, IPMVP Option D—Calibrated Simulation is most appropriate for installed or replaced economizer measures. IPMVP Option D uses computer simulation software (e.g., DOE-2.2 software) to predict the change in energy and demand of efficiency measures from a representative sample of participants, and adjusts the savings estimates derived from engineering algorithms applied to Dominion Energy's reported program participation data. The computer simulation is developed using economizer system inputs collected on-site or through interviews with installation and service contractors. On-site hourly meter data is collected from the cooling systems and is used to calibrate the simulation for accuracy.

In a limited set of cases, other kinds of verification strategies, such as building or campus simulation modelling incorporating various types of data can be used to estimate changes in energy use associated with customer participation in the program. Similarly, DNV may opt to use a billing analysis approach if billing data can be obtained and other conditions necessary for the application of this family of methods are met.

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All of these efforts will be considered to determine the verified annual energy savings and peak demand reductions using gathered data, as appropriate, for each sampled project at the premises.

E22.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

E22.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the measured consumption and demand data based off the on-site studies.
2. Apply the measured data to the actual participant data to arrive at program level energy and demand impacts, reflected on a monthly basis. Program savings are annualized in the EM&V tracking reports based on monthly participation data.
3. Develop cumulative monthly energy savings based on measured and verified data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E22.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

E22.8. Non-Residential Heating and Cooling Efficiency Program – Revision History

Table 22-3. Revision History for Non-Residential Heating and Cooling Efficiency Program EM&V Plan

Version	Date	Notes
Version 1		▪ Initial release
Version 2	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number.
Version 3	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM)

Version	Date	Notes
		▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Updated IPMVP reference from 2012 to 2022. ▪ Removed version number from title

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E23. NON-RESIDENTIAL LIGHTING SYSTEMS & CONTROLS PROGRAM EM&V PLAN

E23.1. Program Summary

This program would provide qualifying non-residential customers with an incentive to implement more efficient lighting technologies that can produce verifiable savings. The program promotes the installation of lighting technologies, including, but not limited to, LED-based bulbs and lighting control systems.

E23.2. Measures

The following high efficiency lighting measures are included in the program:

Table 23-1: Measures Offered by Non-Residential Lighting Systems & Controls Program

End-use	Measure
Lighting	▪ High-efficiency T8/T5 lamps ▪ LED lamps ▪ Occupancy sensor(s) and lighting controls

E23.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[124] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach is:

1. Baseline Consumption: The baseline wattage will be computed using the prescriptive replacement combinations presented in the DE TRM. The replaced lighting fixtures from the rebate application data will be used, applying hours of use as metered in on-site studies of installed rebated measures from a representative sample of participants in Virginia.
2. Deemed Savings: Deemed savings (or gross savings) values will be estimated from the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs.
3. Verified Savings: Verified savings (or net savings) will be determined using on-site data. The wattage and hours of use data for the installed efficiency measure will be collected and metered through an on-site study of installed rebated measures from a representative sample of participants.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[125]

E23.4. Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, deemed savings approach or protocol for the Non-Residential Lighting Systems & Controls Program will be developed through research primarily in the most recent version of

[124] 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

[125] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

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the Mid-Atlantic TRM, and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E23.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[126]

According to Chapter 2: Commercial and Industrial Lighting Evaluation Protocol[127] of The Uniform Methods Project[128] (UMP), the key measured parameters for lighting retrofits include the hours of use and the fixture wattages (energy efficient and baseline). According to Chapter 3: Commercial and Industrial Lighting Controls Evaluation Protocol,[129] the key measured parameters for occupancy sensor retrofits include the hours of use (energy efficient and baseline) and the controlled fixture wattages.

At a high level, the ratio of the measured and verified savings to the deemed savings for the sample, also called a realization rate,[130] is then applied to the population of participants to estimate overall program savings. This approach will capture Company-specific customer usage data, and then apply those to the actual measures installed to quantify energy and peak demand savings.

E23.5.1. Sample Design Considerations

The sample frame will be comprised of the earlier of either approximately 2,000 participants or all participants in the first three years of program activity (whichever milestone is reached first). Planned sample size and design are determined by considering the participant population and may change from the estimated sample size. Using standard sampling approaches and tools, the following characteristics will be considered:

- Confidence interval: 85 to 90%
- Relative precision: 10 to 15%
- Measure-level error ratio: to be updated prior to sample selection

[126] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[127] Gowans, D.; Telarico, C. (2017). Chapter 2: Commercial and Industrial Lighting Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68558. http://www.nrel.gov/docs/fy17osti/68558.pdf

[128] Li, M.; Haeri, H.; Reynolds, A. (2018). The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-70472. http://www.nrel.gov/docs/fy18osti/70472.pdf

[129] Carlson, Stephen. (2017). Chapter 3: Commercial and Industrial Lighting Controls Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/ SR-7A40-68559. http://www.nrel.gov/docs/fy17osti/68559.pdf

[130] The “realization rate” is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or a given sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and the extent to which these were affected by exogenous changes.

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- Budget, schedule, and geographical distribution

E23.5.2. Measurement and Verification

Measurement and verification of the installation and operation of a sample of premise-level participants will be performed using one or more of the following levels of rigor:

- On-site verification, only
- On-site verification and short-term measurements
- On-site verification, short-term measurements, and long-term metering of approximately six to eight weeks during a period of typical operations

According to UMP, International Performance Measurement and Verification Protocol (IPMVP) Option A—Retrofit Isolation, Key Parameter Measurement Approach) is the appropriate method for lighting fixture retrofits and most occupancy sensor retrofits.[131] IPMVP Option A is a partially measured retrofit isolation study that determines the actual energy and demand of an installed efficiency measure from a representative sample of participants, and adjusts the savings estimates derived from engineering algorithms applied to Dominion Energy's reported program participation data. The adjustment factor, also called a realization rate,[132] is then applied to the population of participants to estimate program savings.

DNV will verify the hours of use, quantity of fixtures, and the type and wattage of fixtures for a representative sample of the energy efficient retrofits. To verify the hours of use, electronic metering equipment is typically installed temporarily throughout the duration of the measurement period. For facilities with constant schedules, the measurement period must last for a minimum of four weeks; for facilities with variable schedules, additional metering time may be required to be representative of the average operation over the full range of variable schedules. In facilities with energy management systems (EMS) that monitor lighting circuits, hours of use may be verified by gathering EMS data.

To verify the baseline conditions, a facility representative will be interviewed. If no lighting controls measures were implemented at a given lighting circuit in the sample, the baseline hours of use equal the efficient; otherwise, they will usually be greater. Next, the heating and cooling status and associated fuel type will also be verified to account for interactive effects using stipulated values. DNV will either confirm or correct all reported values described in this section.

In a limited set of cases, other kinds of verification strategies, such as building or campus simulation modelling incorporating various types of data can be used to estimate changes in energy use associated with customer participation in the program. Similarly, DNV may opt to use a billing analysis approach if billing data can be obtained and other conditions necessary for the application of this family of methods are met.

All of these efforts will be considered to determine the verified annual energy savings and peak demand reductions using gathered data, as appropriate, for each sampled project at the premises.

E23.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

[131] Efficiency Value Organization. 2022. Core Concepts, International Performance Measurement and Verification Protocol. www.evo-world.org.

[132] The "realization rate" is the proportion of deemed or reported energy savings and peak demand reductions that have been verified for all customers or projects in a sample. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

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E23.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the measured data based off the on-site studies.
2. Apply the measured data to the actual participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation data.
3. Develop cumulative monthly energy savings based on measured and verified data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E23.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies upon sufficient program participation.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

E23.8. Non-Residential Lighting Systems & Controls Program – Revision History

Table 23-2. Revision History for Non-Residential Lighting Systems & Controls Program EM&V Plan

Version	Date	Notes
Version 1	2022	▪ Initial release
Version 2	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number. Formatted measure table.
Version 3	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Updated IPMVP reference from 2012 to 2022. ▪ Removed version number from title

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E24. NON-RESIDENTIAL OFFICE PROGRAM EM&V PLAN

E24.1. Program Summary

This program would provide qualifying customers incentives for the installation of energy efficiency improvements, consisting of recommissioning measures at smaller office facilities.

E24.2. Measures

The following measures are included in the Non-Residential Office Program.

Table 24-1: Measures Offered by Non-Residential Office Program

End-use	Measure
HVAC	▪ Schedule HVAC ▪ Temperature setback ▪ Condenser water reset ▪ Discharge air temp reset ▪ Static pressure reset ▪ Enthalpy economizer ▪ Variable air volume box minimum
Lighting	▪ Schedule lighting

E24.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[133] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach is:

1. Baseline Usage Estimate: The baseline load shape will be computed based on pre-retrofit capacity data from the rebate application data, applying Equivalent Full Load Hours (EFLH) as metered from an on-site study of installed rebated measures from a representative sample of participants.
2. Deemed Savings: Deemed savings (or gross savings) values will be developed and incorporated into the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs.
3. Verified Savings: Verified savings (or net savings) will be determined using on-site data. The wattage and hours of use data for each measure will be collected and metered through an on-site study of installed efficiency measures from a representative sample of participants.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[134]

[133] 20 VAC 5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

[134] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

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E24.4. Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, the deemed savings approach or protocol for the Non-Residential Office Program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the data source priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E24.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[135]

For all measures, the evaluation will select a sample for on-site verification. Savings will be based on the DE TRM deemed values with adjustments to key inputs that can be verified while on-site. In keeping with accepted practices defined by Chapter 16: Retrocommissioning Evaluation Protocol[136] of The Uniform Methods Project[137] (UMP), the key parameters for determining gross savings and peak demand reductions include: equivalent full-load operating hours, building energy management data, and estimated savings.

At a high level, the ratio of the measured and verified savings to the deemed savings for the sample, also called a realization rate,[138] is then applied to the population of participants to estimate overall program savings. This approach will capture Company-specific customer usage data, and then apply those to the actual measures installed to quantify energy and peak demand savings.

E24.5.1. Sample Design Considerations

The sample frame will be comprised of the earlier of either approximately 2,000 participants or all participants in the first three years of program activity (whichever milestone is reached first). Planned sample size and design are determined by considering the participant population and may change from the estimated sample size. Using standard sampling approaches and tools, the following characteristics will be considered:

- Confidence interval: 85 to 90%
- Relative precision: 10 to 15%

[135] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[136] Tiessen, A. (2017). Chapter 16: Retrocommissioning Evaluation Protocol. The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68572. http://www.nrel.gov/docs/fy17osti/68572.pdf

[137] Li, M.; Haeri, H.; Reynolds, A. (2018). The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-70472. http://www.nrel.gov/docs/fy18osti/70472.pdf

[138] The "realization rate" is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or a given sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and the extent to which these were affected by exogenous changes.

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- Measure-level error ratio: to be updated prior to sample selection
- Budget, schedule, and geographical distribution

E24.5.2. Measurement and Verification

Measurement and verification of the installation and operation of a sample of participants at the premises-level will be performed using one or more of the following levels of rigor:

- On-site verification, only
- On-site verification and short-term measurements
- On-site verification, short-term measurements, and long-term metering of approximately six to eight weeks during a period of typical operations

If metering is used, it will be conducted according to the International Performance Measurement and Verification Protocol[139] (IMPVP). IPMVP Option A. Retrofit Isolation, Key Parameter Measurement: For physically accessible equipment measures, an EM&V method like IPMVP Option A is applied. IPMVP Option A is a partially-measured retrofit isolation study that measures the selected parameters leading to the change in energy and demand of an installed retrocommissioning measure from a representative sample of participants, and adjusts the savings estimates derived from engineering algorithms applied to Dominion Energy's program participation data. IPMVP Option A shall be applied to a sample of HVAC Retrocommissioning measures for which annual savings are <75,000 kWh.

IPMVP Option C. Whole Facility: Where multiple retrocommissioning measures are implemented at a given premises, a whole-facility study that makes use of Building Energy Management System data may be more cost-effective. This requires access to at least one year, each, of pre- and post-retrocommissioning data, including electric energy consumption data, for analysis. Adoption of a whole facility approach under Option C will require an understanding of facility energy consumption and its relationship to operational parameters to construct a valid facility energy consumption model. This requires identification and as necessary adjustment for non-routine events that would affect pre-post usage analysis and are unrelated to the measure being assessed.

At facilities for which neither Option A nor Option C is feasible and cost-effective, deemed savings may be appropriate upon verifying the implementation of the retrocommissioning measures. For all measures, the evaluation will select a sample for on-site verification. Savings will be based on the DE TRM deemed values with adjustments to key inputs that can be verified while on-site.

The ratio of the weighted, measured, and verified savings to the weighted deemed savings, also called a realization rate,[140] is then applied to the population of participants to estimate program savings. This approach will capture Company-specific customer usage data, which will be applied to the actual measures installed to quantify energy and peak demand savings.

E24.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

[139] Efficiency Value Organization. 2022. Core Concepts, International Performance Measurement and Verification Protocol. www.evo-world.org

[140] The "realization rate" is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

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E24.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the measured data based off the on-site studies.
2. Apply the measured data to the actual participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation data.
3. Develop cumulative monthly energy savings based on measured and verified data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E24.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced source.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

E24.8. Non-Residential Office Program – Revision History

Table 24-2. Revision History for Non-Residential Office Program EM&V Plan

Version	Date	Notes
Version 1	2020	▪ Initial release
Version 2	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number. Formatted measure table.
Version 3	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Updated IPMVP reference from 2012 to 2022. ▪ Removed version number from title ▪ Provided clarification of Option C and non-routine events to “Savings Estimation”

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E25. NON-RESIDENTIAL SMALL MANUFACTURING PROGRAM EM&V PLAN

E25.1. Program Summary

This program would provide qualifying customers incentives for the installation of energy efficiency improvements, consisting of primarily compressed air systems measures for small manufacturing facilities.

E25.2. Measures

The following measures are included in the Non-Residential Small Manufacturing Program.

Table 25-1: Measures Offered by Non-Residential Small Manufacturing Program

End-use	Measure
Compressed Air	▪ Compressed air nozzles ▪ Leaks ▪ No loss drains ▪ Additional compressed air storage ▪ Heat of compression dryer ▪ Low Pressure Drop filter ▪ Variable speed drive air compressor ▪ Cycling refrigerant dryer ▪ Dewpoint controls ▪ Pressure reduction ▪ Downsized variable frequency drive compressor

E25.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[141] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach is:

1. Baseline Usage Estimate: The baseline load shape will be computed based on pre-retrofit capacity data from the rebate application data, applying Equivalent Full Load Hours (EFLH) as metered from an on-site study of installed rebated measures from a representative sample of participants.
2. Deemed Savings: Deemed savings (or gross savings) values will be developed and incorporated into the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs.
3. Verified Savings: Verified savings (or net savings) will be determined using on-site data. The wattage and hours of use data for each measure will be collected and metered through an on-site study of installed efficiency measures from a representative sample of participants.

[141] 20 VAC 5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

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The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[142]

E25.4. Deemed Savings Approach

Deemed savings approach or protocol for the Non-Residential Small Manufacturing Program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the data source priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E25.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[143]

For all measures, the evaluation will select a sample for on-site verification. Savings will be based on the DE TRM deemed values with adjustments to key inputs that can be verified while on-site. In keeping with accepted practices defined by Chapter 22: Compressed Air Evaluation Protocol[144] of The Uniform Methods Project[145] (UMP), the key parameters for determining gross savings and peak demand reductions include: airflow rate, line pressure, compressor power, production rates, and operating hours.

At a high level, the ratio of the measured and verified savings to the deemed savings for the sample, also called a realization rate,[146] is then applied to the population of participants to estimate overall program savings. This approach will capture Company-specific customer usage data, and then apply those to the actual measures installed to quantify energy and peak demand savings.

E25.5.1. Sample Design Considerations

The sample frame will be comprised of the earlier of either approximately 2,000 participants or all participants in the first three years of program activity (whichever milestone is reached first). Planned sample size and design are determined by

[142] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

[143] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[144] Benton, N.; Burns, P. (2017). Chapter 22: Compressed Air Evaluation Protocol. The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68577. http://www.nrel.gov/docs/fy18osti/68577.pdf

[145] Li, M.; Haeri, H.; Reynolds, A. (2018). The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-70472. http://www.nrel.gov/docs/fy18osti/70472.pdf

[146] The "realization rate" is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

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considering the participant population and may change from the estimated sample size. Using standard sampling approaches and tools, the following characteristics will be considered:

- Confidence interval: 85 to 90%
- Relative precision: 10 to 15%
- Measure-level error ratio: to be updated prior to sample selection
- Budget, schedule, and geographical distribution

E25.5.2. Measurement and Verification

Measurement and verification of the installation and operation of a sample of premise-level participants will be performed using one or more of the following levels of rigor:

- On-site verification, only
- On-site verification and short-term measurements
- On-site verification, short-term measurements, and long-term metering of approximately six to eight weeks during a period of typical operations

If metering is used, it will be conducted according to the International Performance Measurement and Verification Protocol (IPMVP).[147]

IPMVP Option A. Retrofit Isolation, Key Parameter Measurement: It is a partially-measured retrofit isolation study that measures the selected parameters leading to the change in energy and demand of an installed efficiency measure from a representative sample of participants, and adjusts the savings estimates derived from engineering algorithms applied to Dominion Energy's program participation data. IPMVP Option A shall be applied to a sample of air-compressor system retrofit and re-commissioning measures by performing spot measurements of compressor load current or root-mean-square power. These are supplemented by on-site observations of airflow and line pressure, site-contact reported hours of use and historical production data, and manufacturer specifications and standard data sheets.

In a limited set of cases, other kinds of verification strategies, such as building or campus simulation modelling incorporating various types of data can be used to estimate changes in energy use associated with customer participation in the program. Similarly, DNV may opt to use a billing analysis approach if billing data can be obtained and other conditions necessary for the application of this family of methods are met.

The above efforts will be used to determine the verified annual energy savings and peak demand reductions using gathered data, as appropriate, for each sampled project at the premises.

E25.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

E25.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the measured data based off the on-site studies.

[147] Efficiency Value Organization. 2022. Core Concepts, International Performance Measurement and Verification Protocol. www.evo-world.org.

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2. Apply the measured data to the actual participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation data.
3. Develop cumulative monthly energy savings based on measured and verified data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E25.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

E25.8. Non-Residential Small Manufacturing Program – Revision History

Table 25-2. Revision History for Non-Residential Small Manufacturing Program EM&V Plan

Version	Date	Notes
Version 1	2020	▪ Initial release
Version 2	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number. Formatted measure table.
Version 3	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Updated IPMVP reference from 2012 to 2022. ▪ Removed version number from title

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E26. NON-RESIDENTIAL WINDOW FILM PROGRAM EM&V PLAN

E26.1. Program Summary

This program would provide qualifying non-residential customers with an incentive install solar reduction window film to lower their cooling bills and improve occupant comfort.

E26.2. Measures

Solar window film installation(s) are eligible for rebate through the program under specified conditions.

E26.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[148] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership.

The basis for DNV's savings evaluation approach is:

1. Baseline Usage Estimate: The baseline load shape will be computed based on pre-retrofit capacity data from the rebate application data, applying Equivalent Full Load Hours (EFLH) as metered in on-site studies of installed rebated measures from a representative sample of participants.
2. Deemed Savings: Deemed savings (or gross savings) values will be estimated from the DE TRM. The source of the deemed savings values will be models of 21 prototypical building types using Database for Energy Efficiency References (DEER) average values for building parameters (building sq. ft., EFLH, etc.).[149] Variations in deemed savings values are provided in the DE TRM for some important parameters reported on customer rebate applications, including weather zone, window orientation, and heating system type.
3. Verified Savings: Verified savings (or net savings) will be determined using on-site data. Solar emittance spot measurement data and operation schedules will be collected through an on-site study of installed rebated measures from a representative sample of participants. Load data from applicable non-residential HVAC measures across all other Dominion programs will be used in the simulation model as the basis of the measured savings load shape.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[150]

E26.4. Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, deemed savings approach or protocol for the Non-Residential Window Film Program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV will use

[148] 20 VAC 5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

[149] California Electronic Technical Reference Manual, DEER Database, https://cedars.sound-data.com/deer-resources/deer-database/.

[150] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

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either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E26.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[151]

For the window film measure, the evaluation will select a sample for on-site verification. Savings will be based on the DE TRM deemed values with adjustments to key inputs that can be verified while on-site. Although the Uniform Methods Project[152] (UMP) does not specifically address this measure, the key parameter for determining gross savings and peak demand reductions include surface area of treated windows and the SHGC.

At a high level, the ratio of the measured and verified savings to the deemed savings for the sample, also called a realization rate,[153] is then applied to the population of participants to estimate overall program savings. This approach will capture Company-specific customer usage data, and then apply those to the actual measures installed to quantify energy and peak demand savings.

E26.5.1. Sample Design Considerations

The sample frame will be comprised of the earlier of either approximately 2,000 participants or all participants in the first three years of program activity (whichever milestone is reached first). Planned sample size and design are determined by considering the participant population and may change from the estimated sample size. Using standard sampling approaches and tools, the following characteristics will be considered:

- Confidence interval: 85 to 90%
- Relative precision: 10 to 15%
- Measure-level error ratio: to be updated prior to sample selection
- Budget, schedule, and geographical distribution

E26.5.2. Measurement and Verification

Measurement and verification of the installation and operation of a sample of premise-level participants will be performed using one or more of the following levels of rigor:

- On-site verification, only
- On-site verification and short-term measurements
- On-site verification, short-term measurements, and long-term metering of approximately six to eight weeks during a period of typical operations

[151] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[152] Li, M.; Haeri, H.; Reynolds, A. (2018). The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-70472. http://www.nrel.gov/docs/fy18osti/70472.pdf

[153] The “realization rate” is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or a given sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and the extent to which these were affected by exogenous changes.

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As recommended in UMP, the International Performance Measurement and Verification Protocol (IPMVP) Option D. Calibrated Simulation,[154] is a calibrated simulation study that uses computer simulation software (e.g. DOE 2 eQUEST or Energy Plus software packages), will be used to predict the change in energy and demand of efficiency measures from a representative sample of participants, and adjusts the savings estimates derived from engineering algorithms applied to Dominion Energy's program participation data. The computer simulation is developed using building and window film parameters collected on-site or through interviews with installation and service contractors.

In a limited set of cases, other kinds of verification strategies, such as building or campus simulation modelling incorporating various types of data can be used to estimate changes in energy use associated with customer participation in the program. Similarly, DNV may opt to use a billing analysis approach if billing data can be obtained and other conditions necessary for the application of this family of methods are met.

The above efforts will be used to determine the verified annual energy savings and peak demand reductions using gathered data, as appropriate, for each sampled project at the premises.

E26.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

E26.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the measured data based off the on-site studies.
2. Apply the measured data to the actual participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation data.
3. Develop cumulative monthly energy savings based on measured and verified data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E26.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.

Efficiency Value Organization. 2022. Core Concepts, International Performance Measurement and Verification Protocol. www.evo-world.org.

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- If appropriate, support lost revenue recovery activities.

E26.8. Non-Residential Window Film Program – Revision History

Table 26-1. Revision History for Non-Residential Window Film Program EM&V Plan

Version	Date	Notes
Version 1		▪ Initial release
Version 2	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number. Added reference to DEER database.
Version 3	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Updated IPMVP reference from 2012 to 2022. ▪ Removed version number from title

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E27. NON-RESIDENTIAL MIDSTREAM EFFICIENCY PRODUCTS PROGRAM EM&V PLAN

E27.1. Program Summary

Unlike the Company's other EE Program portfolio offerings, the proposed Midstream program does not enroll end-use customers. Instead, the program enrolls equipment distributors into the program through an agreement to provide point-of-sales data in an agreed upon format each month. The distributor will discount the rebate-eligible items sold to end-use customers. This program aims to increase the availability and uptake of efficient equipment for the Company's non-residential customers. The monthly sales data will contain the data necessary to perform measurement and verification for the program in the Company's service territory.

E27.2. Measures

The measures to be offered through the Non-Residential Midstream Efficient Products Program are provided in Table 27-1.

Table 27-1: Measures Offered by the Non-Residential Midstream Efficiency Products Program

End-use	Measure
Cooking	▪ Commercial kitchen equipment
HVAC	▪ Efficient heat pumps ▪ Efficient air conditioning units ▪ Air- and water-cooled Chillers
Refrigeration	▪ Commercial freezers and coolers

E27.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[155] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach is:

1. Baseline Consumption: Baseline consumption will be calculated per the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs.
2. Deemed Savings: Deemed savings values will be estimated from the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs.
3. Evaluated Savings: Evaluated savings will be determined by the methods described in Section E27.5. The evaluated savings will use program tracking data, customer energy consumption data, and other customer data to estimate program savings.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[156]

[155] 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

[156] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

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Jun 15 2022

E27.4. Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, deemed savings approach or protocol for the Non-Residential Midstream Efficient Products Program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatts and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E27.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[157]

For the cooking measures, savings will be based on the DE TRM deemed values with adjustments to key inputs that can be verified while on-site. Although the Uniform Methods Project[158] (UMP) does not specifically address cooking measures, the key parameter for determining gross savings and peak demand reductions include hours of operation, cooking load, and equipment type.

According to Chapter 4—Small Commercial and Residential Unitary and Split System HVAC Heating and Cooling Equipment,[159] savings will be based on the DE TRM deemed values with adjustments to key inputs that can be verified while on-site. The key measured parameters for HVAC measures include the unit size, unit rated efficiency (energy efficient and baseline), annual operating hours, and—for peak demand reductions—coincidence factor. The first two parameters can be verified by either a desk review or on-site audit.

According to Chapter 14—Chiller Equipment,[160] savings will be based on the DE TRM deemed values with adjustments to key inputs that can be verified while on-site. The key measured parameters include operating schedule and pre- and post-installation energy consumption of chiller measure(s). For chillers that provide space cooling, these are normalized to TMY3 weather data.

For the refrigeration measures, savings will be based on the DE TRM deemed values with adjustments to key inputs that can be verified while on-site. Although the UMP does not specifically address refrigeration measures, the key parameters for determining gross savings and peak demand reductions include hours of operation, whether equipment is in a conditioned space, and equipment type.

[157] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[158] Li, M.; Haeri, H.; Reynolds, A. (2018). The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-70472. http://www.nrel.gov/docs/fy18osti/70472.pdf

[159] Jacobson, D. and Metoyer, J. (2017). Chapter 4: Small Commercial and Residential Unitary and Split System HVAC Heating and Cooling Equipment-Efficiency Upgrade Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68560. http://www.nrel.gov/docs/fy17osti/68560.pdf

[160] Tiessen, A. (2017). Chapter 14: Chiller Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68570. http://www.nrel.gov/docs/fy17osti/68570.pdf

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Jun 15 2022

For most measures in this program, the annual operating hours vary by climate, building type, occupancy type, etc. A high-rigor evaluation would require metering for a sample of the participants that represented all listed categories. However, because this approach can be expensive, a lower-rigor approach using metering for only a sample of the predominant building types may be considered.

At a high level, the ratio of the measured and verified savings to the deemed savings for the sample, also called a realization rate,[161] is then applied to the population of participants to estimate overall program savings. This approach will capture Company-specific customer usage data, and then apply those to the actual measures installed to quantify energy and peak demand savings.

E27.5.1. Savings Estimation

Measurement and verification of the installation and operation of a sample of participants at the premises-level will be performed using one or more of the following levels of rigor:

- Desk-review verification
- Phone verification
- On-site verification, only
- On-site verification and short-term measurements
- On-site verification, short-term measurements, and long-term metering of approximately six to eight weeks during a period of typical operations

If metering is used, it will be conducted according to the International Performance Measurement and Verification Protocol (IPMVP) as shown in . [162]

Table 27-2. Preferred IPMVP Options for Non-Residential Midstream Efficiency Products Program Measures

Measure	IPMVP Option	Key Parameter(s)
Cooking Equipment	Option A. Retrofit Isolation: Key Parameter Measurement Approach	▪ Cooking loads ▪ Annual hours of operation
PTACs, Unitary and Split Air-conditioning Systems and Air-source Heat Pumps, and Mini-split Systems	Option A. Retrofit Isolation: Key Parameter Measurement Approach	▪ Cooling loads ▪ Heating loads (if applicable) ▪ Annual hours of operation
Air- and Water-cooled Chillers	Option A. Retrofit Isolation: Key Parameter Measurement Approach or, Option C. Whole Facility, if energy management system data are available and project-level savings are large compared to other energy variations at facility	▪ Cooling loads ▪ Outside air temperatures ▪ Manufacturer part-load efficiency data ▪ Annual hours of operation
Refrigeration Equipment	Option A. Retrofit Isolation: Key Parameter Measurement Approach	▪ Space-conditioning category ▪ Annual hours of operation

[161] The “realization rate” is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or a given sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

[162] Efficiency Value Organization. 2022. Core Concepts, International Performance Measurement and Verification Protocol. www.evo-world.org.

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According to UMP, IPMVP Option A: A Retrofit Isolation, Key Parameter Measurement Approach is most appropriate for replacements of cooking equipment, most HVAC-system types, and refrigeration equipment. IPMVP Option A is a partially-measured, retrofit-isolation study that meters the actual energy and demand reduction of an installed efficiency measure from a representative sample of participants, and adjusts the savings estimates derived from engineering algorithms applied to the Company's reported program participation data.

According to UMP, IPMVP Option C: Whole Facility Approach is most appropriate for chiller equipment at facilities with building management systems. Gross savings are determined by taking the difference between the measured energy use at the whole facility, before and after the measure implementation, from a representative sample of participants, and adjusts the savings estimates derived from engineering algorithms applied to the Company's reported program participation data. Adoption of a whole facility approach under Option C will require an understanding of facility energy consumption and its relationship to operational parameters to construct a valid facility energy consumption model. This requires identification and as necessary adjustment for non-routine events that would affect pre-post usage analysis and are unrelated to the measure being assessed.

In a limited set of cases, other kinds of verification strategies, such as building or campus simulation modelling incorporating various types of data can be used to estimate changes in energy use associated with customer participation in the program. Similarly, DNV may opt to use a billing analysis approach if billing data can be obtained and other conditions necessary for the application of this family of methods are met.

All of these efforts will be considered to determine the verified annual energy savings and peak demand reductions using gathered data, as appropriate, for each sampled project at the premises.

E27.5.2. Sample Design Considerations

The sample frame will be comprised of the earlier of either approximately 15,000 participants (or units) or all participants in the first three years of program activity (whichever milestone is reached first). Planned sample size and design are determined by considering the participant population and may change from the estimated sample size. Using standard sampling approaches and tools, the following characteristics will be considered:

- Confidence interval: 85–90%
- Relative precision: 10–15%
- Installed measures
- Budget, schedule, and geographical distribution

E27.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

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E27.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the gross impact evaluation method as appropriate.[163]
2. Apply the evaluated savings to the participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation.
3. Develop cumulative monthly energy savings based on measured and evaluated data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E27.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 1 of each year following program launch).
- Update the DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

E27.8. Non-Residential Midstream Efficiency Products Program – Revision History

Table 27-3. Revision History for Non-Residential Midstream Energy Efficiency Products Program EM&V Plan

Version	Date	Notes
Version 1	11/26/2019	▪ Initial Release
Version 2	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number. Minor word edits to measure section.
Version 3	4/22/2022	▪ Updated program name from “Non-Residential Midstream Energy Efficient Products Program” to “Non-Residential Midstream Energy Efficiency Products Program” ▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Updated IPMVP reference from 2012 to 2022.

[163] The realization rate is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

Version	Date	Notes
		▪ Removed version number from title ▪ Provided clarification of Option C and non-routine events to “Savings Estimation”

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E28. NON-RESIDENTIAL NEW CONSTRUCTION PROGRAM EM&V PLAN

E28.1. Program Summary

This Program would provide qualifying facility owners with incentives to install energy efficient program measures in new construction projects. The program engineers will determine what potential energy efficiency upgrades are of interest to the owner and feasible within the existing budget. These measures coupled with basic facility design data will be analyzed to determine the optimized building design. This in-depth analysis will be performed using building energy simulation models, which account for the interactive effects of measure bundles. The results of the various measures and measure bundles will be presented to the facility owner to determine which measures(s) are to be installed. Program design building types modeled include small offices, medium offices, stand-alone retail, and outpatient health care.

E28.2. Measures

The program will incentivize “above code” measures to save energy in newly constructed buildings. Example measures to be offered through the program are provided in Table 28-1.

Table 28-1: Measures Offered by the Non-Residential New Construction Program

End-use	Measure
Lighting	▪ Exterior LED lighting
HVAC	▪ High efficiency and variable speed chillers ▪ High efficiency direct expansion (DX) cooling equipment ▪ High efficiency packaged air-source heat pumps ▪ Demand controlled ventilation ▪ Variable air volume (VAV) dual-max controls ▪ Chiller controls
Plug Load	▪ Supervisory plug load management systems

E28.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[164] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV’s savings evaluation approach is:

1. Baseline Consumption: Baseline consumption will be calculated using a combination of operating schedule and setpoint and controls schedules for model inputs and will be simulated using prototype commercial computer models. Since this is a new construction program there will be no monthly or AMI participant consumption data.
2. Deemed Savings: Deemed savings values will be estimated from the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs.

[164] 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

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3. Evaluated Savings: Evaluated savings will be determined by the methods described in Section E28.5. The evaluated savings will use program tracking data, customer energy consumption data, and other customer data to estimate program savings.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[165]

E28.4. Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, deemed savings approach or protocol for the Non-Residential New Construction Program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E28.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[166]

According to Chapter 15: Commercial New Construction Evaluation Protocol of The Uniform Methods Project (UMP), the evaluation approach will include calibrated building simulation.[167] The analysis will use a site-level analysis approach (see Section E28.5.1.). The analysis will also follow the general approach of The International Performance Measurement and Verification Protocol (IPMVP), Option D, Calibrated Simulation.[168]

E28.5.1. Savings Estimation

The whole building simulation analysis for the Non-Residential New Construction Program will require a sample of program participants to represent the population of participants. DNV will use the program simulation models and occupied electric and gas billing information for each building in the sample. The sample will be stratified based on modelled site level savings. The simulation models for the sampled participants will be reviewed for accuracy and calibrated using energy consumption from occupied buildings. The savings impacts will then be computed by starting with the calibrated occupied building model and using building code standards for the baseline measure inputs. The site level realization rates (the ratio of verified site savings to deemed site savings) will be combined using a sample-weighted average to represent the overall program level realization rate.

[165] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

[166] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[167] Keates, Steven. (2017). Chapter 15: Commercial New Construction Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/ SR-7A40-68571. www.nrel.gov/docs/fy17osti/68571.pdf.

[168] Efficiency Value Organization. 2022. Core Concepts, International Performance Measurement and Verification Protocol. www.evo-world.org.

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The deemed savings for each individual measure can be evaluated through parametric analysis of the building models where the measures are implemented in the model one at a time and incremental savings calculated with each change. This is not recommended until the program has been running for multiple years to accumulate measure level data that can provide meaningful results.

E28.5.2. Sample Design Considerations

Sampling will be used for the impact evaluation and may be applied for a free-ridership survey, if applicable. The following characteristics will be considered:

- Modeled site-level savings
- Confidence interval: 85–90%
- Relative precision: 10–15%
- Installed measures
- Building type
- Budget, schedule, and geographical distribution

E28.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

E28.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the calibrated simulation analysis.[169]
2. Apply the evaluated savings to the participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation.
3. Develop cumulative monthly energy savings based on measured and evaluated data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E28.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 1 of each year following program launch).
- Update The DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.

[169] The realization rate is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

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- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

E28.8. Non-Residential New Construction Program – Revision History

Table 28-2. Revision History for Non-Residential New Construction Program EM&V Plan

Version	Date	Notes
Version 1	11/26/2019	▪ Initial release
Version 2	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number.
Version 3	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Updated IPMVP reference from 2012 to 2022. ▪ Removed version number from title

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E29. NON-RESIDENTIAL AGRICULTURAL PROGRAM EM&V PLAN

E29.1. Program Summary

This Program would provide qualifying non-residential customers with incentives to implement specific energy efficiency measures to help agribusinesses replace aging, inefficient equipment, and systems with new, energy-efficient technologies. The Program is designed to help agricultural customers make their operations more energy-efficient by providing incentives for efficient agricultural equipment and lighting technologies specific to agricultural applications.

E29.2. Measures

The measures offered by the Non-Residential Agricultural Program are as shown in Table 29-1.

Table 29-1. Measures Offered by Non-Residential Agricultural Program

End-Use	Measure
HVAC	▪ Circulation fan ▪ High volume low speed fan ▪ Ventilation fan ▪ Livestock warming equipment
Lighting	▪ Lighting ▪ Dairy lighting control ▪ Greenhouse LED lighting
Process	▪ Agricultural VFD ▪ Automatic milker takeoff ▪ Efficient grain dryer ▪ Grain storage aeration control ▪ Low pressure irrigation ▪ Heat reclaimer ▪ Dairy plate cooler
Refrigeration	▪ Refrigeration tune-up

E29.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[170] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach for the energy efficiency program is:

1. Baseline Consumption: Baseline consumption will be calculated per the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs or protocols.
2. Deemed Savings: Deemed savings values will be estimated from the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs, related research, or evaluation studies.

170 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

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3. Evaluated Savings: Evaluated savings will be determined by the methods described in Section E29.5. The evaluated savings will use program tracking data, and other customer data to estimate program savings.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[171]

E29.4. Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, deemed savings calculation approach or protocol for the Non-Residential Agricultural Program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies or protocols, as appropriate. The deemed savings calculation protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data are impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E29.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[172]

To the extent possible, DNV draws from the Uniform Methods Project[173] (UMP) to establish protocols for evaluating measures. According to Chapter 4—Small Commercial and Residential Unitary and Split System HVAC Heating and Cooling Equipment, the key measured parameters for HVAC measures include the unit size, unit rated efficiency (energy efficient and baseline), annual operating hours, and—for peak demand reductions—coincidence factor. While the measures offered through this program are not typical of those covered by Chapter 4, the methodology is still applicable. The first two parameters can be verified by either a desk review or on-site audit.[174]

According to Chapter 2: Commercial and Industrial Lighting Evaluation Protocol of the UMP, the key measured parameters for lighting retrofits include the hours of use and the fixture wattages (energy efficient and baseline). According to Chapter 3: Commercial and Industrial Lighting Controls Evaluation Protocol,[175] the key measured parameters for occupancy sensor retrofits include the hours of use (energy efficient and baseline) and the controlled fixture wattages.

For the process and refrigeration measures, savings will be based on the DE TRM deemed calculations with adjustments to key inputs that can be verified while on-site. Although the UMP does not specifically address such measures, the key

[171] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

[172] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[173] Li, M.; Haeri, H.; Reynolds, A. (2018). The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-70472. http://www.nrel.gov/docs/fy18osti/70472.pdf

[174] Jacobson, D. and Metoyer, J. (2017). Chapter 4: Small Commercial and Residential Unitary and Split System HVAC Heating and Cooling Equipment-Efficiency Upgrade Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68560. http://www.nrel.gov/docs/fy17osti/68560.pdf

[175] Carlson, Stephen. (2017). Chapter 3: Commercial and Industrial Lighting Controls Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/ SR-7A40-68559. http://www.nrel.gov/docs/fy17osti/68559.pdf

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parameter for determining gross savings and peak demand reductions include hours of operation, whether located in a conditioned space, and equipment type.

At a high level, the ratio of the measured and verified savings to the deemed savings calculation for the sample, also called a realization rate, is then applied to the population of participants to estimate overall program savings. This approach will capture Company-specific customer usage data, and then apply those to the actual measures installed to quantify energy and peak demand savings.

E29.5.1. Savings Estimation

The analysis will follow the general approach of IPMVP, Option A, Partially Measured Retrofit Isolation. This approach uses engineering calculations using spot measurements, post metering data, and stipulations.[176] The program evaluation will make use of site-specific engineering analyses, documentation from the installing contractor and program implementer, program tracking data, utility billing and AMI data, survey, and other customer data.

If metering is used, it will be conducted according to the International Performance Measurements and Verification Protocol (IPMVP) as shown in Table 29-2.

Table 29-2. Preferred IPMVP Options for Non-Residential Agricultural Program Measures

Measure	IPMVP Option	Key Parameters
HVAC	Option A: Retrofit Isolation: Key Parameter Measurement Approach	▪ Annual hours of operation ▪ Equipment efficiency
Lighting and controls	Option A: Retrofit Isolation: Key Parameter Measurement Approach	▪ Fixture quantity (baseline and efficient) ▪ Wattage (baseline and efficient) ▪ Annual hours of operation
Process equipment	Option B: Retrofit Isolation: All Parameter Measurement	▪ Annual hours of operation at part-load conditions for VFDs ▪ Full-load amperage ▪ Heat exchange rate (flow rates and temperature differences)
Refrigeration tune-up	Option A: Retrofit Isolation: Key Parameter Measurement Approach	▪ Equipment location ▪ Annual hours of operation

E29.5.2. Sample Design Considerations

The sample frame will be comprised of a representative sample of projects. Project size, measure mix, facility type, vendor, and other project characteristics may be considered in the sample design. The sample frame will also be influenced by evaluation approach and available data. The following characteristics will be considered:

- Confidence interval: 85-90%%
- Relative precision: 10–15%
- Installed measures
- Budget, schedule, and geographical distribution

[176] Efficiency Value Organization. 2022. Core Concepts, International Performance Measurement and Verification Protocol.

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E29.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

E29.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the measured data based off the on-site studies or consumption data analysis.[177]
2. Apply the measured data to the actual participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation data.
3. Develop cumulative monthly energy savings based on measured and verified data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E29.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15 of each year following program launch).
- Update The DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.

E29.8. Non-residential Agricultural Program – Revision History

Table 29-3. Revision History for Non-Residential Agricultural Program EM&V Plan

Version	Date	Notes
Version 1	11/26/2019	Initial release
Version 2	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number.
Version 3	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.]

[177] The realization rate is the proportion of deemed calculated or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

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Version	Date	Notes
		▪ Updated IPMVP reference from 2012 to 2022. ▪ Removed version number from title

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E30. NON-RESIDENTIAL BUILDING AUTOMATION PROGRAM EM&V PLAN

E30.1. Program Summary

This Program would provide qualifying non-residential customers with incentives to install new building automation systems (BAS) in facilities that do not have centralized controls or have antiquated systems that require full replacement. The Program would be marketed and promoted to controls contractors who design, install, and maintain building automation systems.

E30.2. Measures

The measure offered by the Non-Residential Building Automation Program are as shown in Table 30-1.

Table 30-1. Measures Offered by Non-Residential Building Automation Program

End-Use	Measure
HVAC	▪ Efficient building automation system programming

E30.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[178] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach for the energy efficiency portion of the program is:

1. Baseline Consumption: Baseline consumption will be calculated from data available from the BAS, temporary meters, participant monthly billing or AMI data, or using deemed calculation estimates and algorithms based on the DE TRM or other published deemed values or calculations from other TRMs or sources. Baseline consumption may also be estimated using building simulation software, provided that baseline control strategies are understood, and that the baseline energy model can be calibrated to baseline energy consumption levels within accepted levels. The source of the baseline energy consumption will be dependent on data availability, level of savings, and savings interactivity with other measures or systems.
2. Deemed Savings: Deemed savings values will be estimated from the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs, related research or protocols, or evaluation studies.
3. Evaluated Savings: Evaluated savings will be determined by the methods described in Section E30.5. .

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[179]

178 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

179 Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

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E30.4. Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, a deemed savings calculations approach or protocol for the Non-Residential Building Automation Program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, other TRMs, relevant studies or protocols, as appropriate.

Given that Non-Residential Building Automation Programs can include a variety of new control sequences that can affect many types of equipment unique to any particular building, deemed savings calculation estimates are more uncertain than for most measures. The deemed savings calculation protocol for the measures in this program are documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data are impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E30.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[180]

E30.5.1. Savings Estimation

Chapter 19 of the UMP, "HVAC Controls (DDC/EMS/BAS)," lists four approaches for determining the energy savings resulting from the HVAC controls measures.[181] Table 30-2 describes each approach. The selected method will depend on the level of savings and relative cost of the different approach options.

Table 30-2. Approaches for Determining Energy Savings from HVAC Controls

Approach	IPMVP Description	Description
Consumption Data Analysis	▪ Option C: Whole Facility	▪ Can be used if industry-accepted statistical criteria are met[182] ▪ With daily data, savings as low as 3% of a facility's entire energy usage can be detected using this methodology meeting the ASHRAE Guideline 14 criteria above.[183]
End Use Regression Model	▪ Option B: All parameter measurement	Requires pre and post metering of affected equipment
Deemed Calculation Methodology	▪ Although not in IPMVP, it can incorporate Option	▪ This approach can be used in most situations, with varying amounts of measured versus deemed values and calculations

[180] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[181] Romberger, Jeff. (2017). Chapter 19: HVAC Controls (DDC/EMS/BAS) Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/ SR-7A40-68575. http://www.nrel.gov/docs/fy17osti/68575.pdf

[182] ASHRAE Guideline 14: Measurement of Energy and Demand Savings (2002), Page 16, Table 5-2, Performance Method Approach

[183] Kelly, A and Sinnamon, C. Detecting Savings Under 10% Using IPMVP Option C. (2020). https://evo-world.org/en/news-media/m-v-focus/883-october-2020-m-v-focus-issue-7/1192-detecting-savings-under-10-using-ipmvp-option-c

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Jun 15 2022

Approach	IPMVP Description	Description
(Bin Model Calculations)	A: Key Parameter Measurement	▪ Bin model calculation can refer to either standard 5°F or 10°F bin models or annual hourly spreadsheet model, with 8,760 bins for each hour of the year
Calibrated Simulation	▪ Option D: Calibrated Simulation	▪ This approach can be used for complex facilities and can be cost effective if building simulation model already exists, but can be costly if a building simulation model does not already exist.

Adoption of a whole facility approach under Option C will require an understanding of facility energy consumption and its relationship to operational parameters to construct a valid facility energy consumption model. This requires identification and as necessary adjustment for non-routine events that would affect pre-post usage analysis and are unrelated to the measure being assessed.

We recommend that as part of the project incentive review and approval process, the implementer include a site- or project-specific M&V plan that are typically produced for internal use between the implementer and customers, outlining a proposed methodology for measuring and verifying the savings for each particular site or project. We recommend that this site- or project-specific M&V plan should include all relevant baseline data, including independent and dependent variables, in accordance with the IPMVP, and describe the measure-case data that will be collected immediately after project completion to verify measure installation. The evaluation will utilize this baseline data, and post-case data collected immediately after project completion, and post-case data collected during the evaluation monitoring period.

E30.5.2. Sample Design Considerations

The sample frame will be comprised of a representative sample of projects. Project size, measure mix, facility type, vendor, and other project characteristics may be considered in the sample design. The sample frame will also be influenced by evaluation approach and available data. Using standard sampling approaches and tools, the following characteristics will be considered:

- Confidence interval: 85%
- Relative precision: 10–15%
- Installed measures
- Budget, schedule, and project type

E30.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

E30.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from impact evaluation.[184]

[184] The realization rate is the proportion of deemed calculated or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses,

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2. Apply the measured data to the actual participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation data.
3. Develop cumulative monthly energy savings based on measured and verified data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E30.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15 of each year following program launch).
- Update The DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.

E30.8. Non-Residential Building Automation Program – Revision History

Table 30-3. Revision History for Non-Residential Building Automation Program EM&V Plan

Version	Date	Notes
Version 1	11/26/2019	Initial release
Version 2	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number.
Version 3	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Updated IPMVP reference from 2012 to 2022. ▪ Removed version number from title. Changed reference from Tracked Savings to Deemed savings in EM&V Overview ▪ Provided clarification of Option C and non-routine events to “Savings Estimation”

on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

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E31. NON-RESIDENTIAL BUILDING OPTIMIZATION PROGRAM EM&V PLAN

E31.1. Program Summary

This Program would provide qualifying non-residential customers incentives for the installation of energy-efficient recommissioning measures. The Program seeks to capture energy savings through control system audits and tune-up measures in facilities with building energy management systems.

E31.2. Measures

The measures offered by the Non-Residential Building Optimization Program are as shown in Table 31-1.

Table 31-1. Measures Offered by Non-Residential Building Optimization Program

End-Use	Measure
Lighting	▪ Schedule lighting
HVAC	▪ Schedule HVAC ▪ Temperature setback or setup ▪ Condenser water temperature reset ▪ Discharge-air temperature reset ▪ Static pressure reset ▪ Enthalpy economizer ▪ Variable air-volume (VAV) box minimum ▪ Chilled water temperature reset ▪ Outdoor air damper adjustments ▪ Coil cleaning ▪ Pump pressure reduction ▪ Schedule equipment ▪ Advanced rooftop-unit controls ▪ Custom recommissioning measure ▪ Study rebate

E31.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[185] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach for the energy efficiency portion of the program is:

1. Baseline Consumption: Baseline consumption will be calculated from data available from a facility's Building Automation System (BAS), temporary meters, monthly or participant AMI consumption data, or using deemed calculation estimates and algorithms based on the DE TRM or other published deemed calculations or algorithms from other TRMs or sources. The source of the baseline energy consumption will be dependent on data availability, level of savings, and savings interactivity with other measures or systems.

185 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

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2. Deemed Savings: Deemed savings values will be estimated from the DE TRM, which will be derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs or protocols, related research, or evaluation studies.
3. Evaluated Savings: Evaluated savings will be determined through the methods described in Section E31.5. The evaluated savings will use program tracking data, customer energy consumption data, and other customer data to estimate program savings.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[186]

E31.4. Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, a deemed savings calculation approach or protocol for the Non-Residential Building Optimization Program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, other TRMs, and relevant studies or protocols, as appropriate.

Given that Non-Residential Building Optimization Programs include numerous measures that can be different for each building or application, deemed savings calculation estimates are more uncertain than other measures. The deemed savings calculation protocol for some of the measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatts and kilowatt-hours. Where such data are impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will consider the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E31.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[187]

E31.5.1. Savings Estimation

According to Chapter 16: Retrocommissioning Evaluation Protocol of the UMP:[188]

> *Measurement is inherent with most RCx projects because RCx measures typically involve modifications made through a facility's BAS. As mentioned, RCx implementation (an iterative process) often leverages metered data to evaluate and optimize changes throughout the process. Therefore, in many cases, a retrofit isolation approach adhering to Option A or Option B of the IPMVP proves most logical. That said, scenarios exist where Option C, Option D, or even a deemed approach may be more appropriate.*

[186] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

[187] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[188] Tiessen, A. (2017). Chapter 16: Retrocommissioning Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/ SR-7A40-68572., 8.

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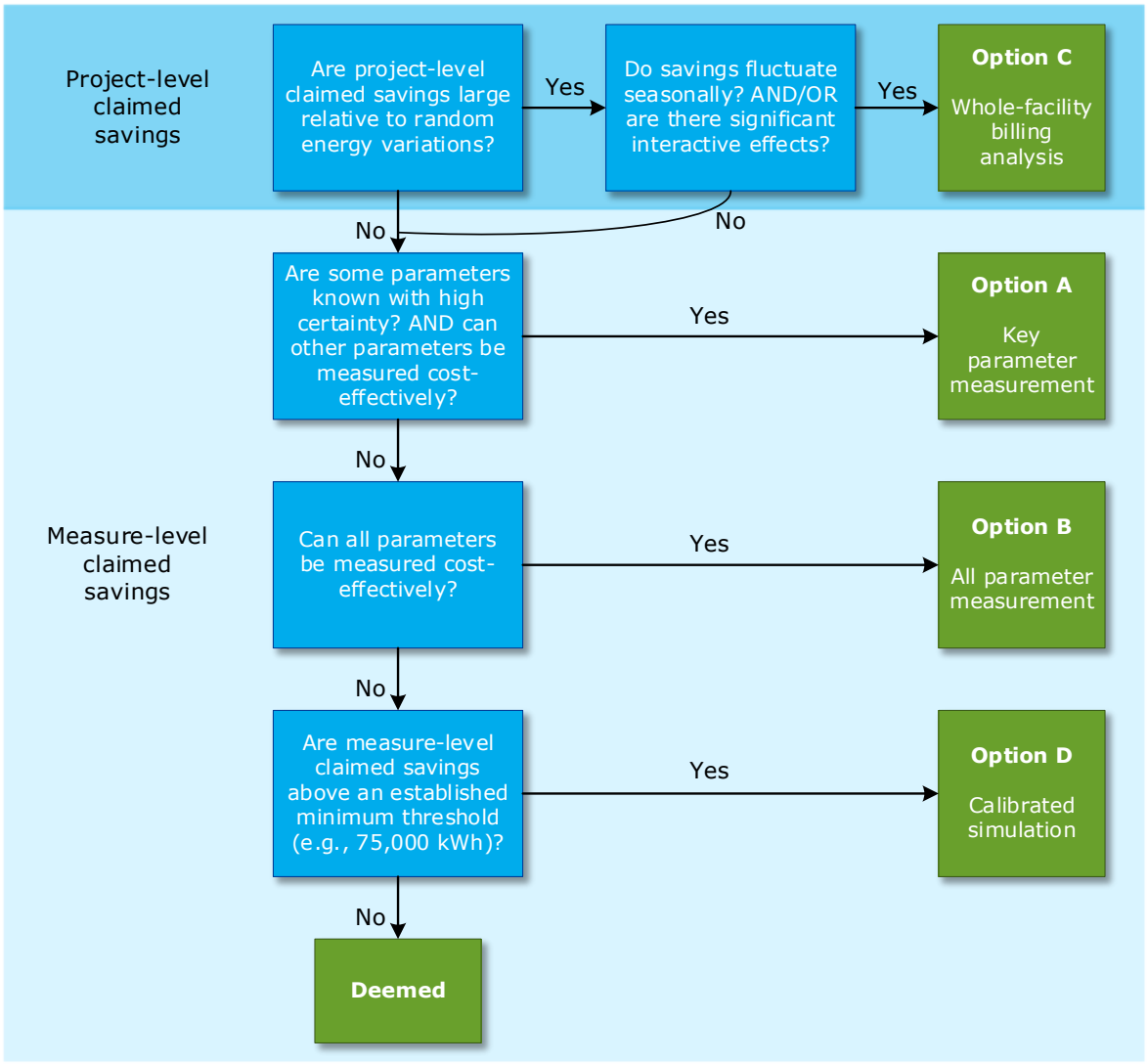
Figure 31-1 is a flow chart from Chapter 16: Retro-commissioning Evaluation Protocol of the UMP outlining a proposed decision process for determining which approach from the IPMVP to use for evaluating a specific retrocommissioning measure, or group of retrocommissioning measures.[189]

Figure 31-1. Measurement and verification approach decision flow chart for retro-commissioning measures (Uniform Methods Project, Chapter 16)



For the evaluation of specific measures completed, the evaluation will rely upon data available from the facility's BAS, temporary meters, monthly or AMI participant consumption data, or using deemed calculation estimates and algorithms based on a) the DE TRM, or other published deemed calculations, or b) algorithms from other TRMs or protocols.

DNV will review any project measurement and verification plan provided by implementers and include it as a component of program tracking data. DNV recommends that the project M&V plan include all relevant baseline data, including independent and dependent variables in accordance with the IPMVP, and describe the post-case data that will be collected immediately

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after project completion to verify measure installation. The evaluation will utilize this baseline data, post-case data collected immediately after project completion, and post-case data collected during the evaluation monitoring period (if applicable).

Table 31-2 lists key parameters for each retro-commissioning measure offered through this program that may require collection during the baseline- and measure-case periods to evaluate a measure's performance. Table 31-2 also lists the potential evaluation methodologies that can be utilized for estimating measure-level savings. The approach selected for each measure is going to depend on the level of savings and relative cost of the various approach options. For projects involving multiple measures, it may be more cost-effective and appropriate to utilize an IPMVP Option C whole-building approach, if the accepted statistical criteria for using such an approach is met.

Table 31-2. Key Parameters and Potential Evaluation Methodologies for Building Optimization Measures

Measure	Key Parameters (Baseline and Post)	Methodologies
Schedule lighting	▪ Fixture quantity, wattage, hours of operation, control type	▪ Option A
Schedule HVAC	▪ Equipment quantity, capacity, and capacity profile, efficiency, and efficiency profile ▪ Equipment hours of operation profile ▪ Variables affecting equipment efficiency	▪ Option A–B
Temperature setback or setup	▪ Space temperature and temperature setpoint ▪ Outdoor air temperature ▪ Building heat-loss characteristics ▪ HVAC equipment details	▪ Deemed calculation ▪ Option A, D
Condenser water temperature reset	▪ Condenser water temperature and setpoint temperature ▪ Cooling tower design approach temperature ▪ Cooling tower sequence of operation, fan control type, operating kW, operating hours ▪ Chiller type, efficiency points or curves as a function of condenser water temperature and chiller load ▪ Chiller operating characteristics ▪ Chiller hours of operation	▪ Deemed calculation ▪ Option A, D
Discharge-air temperature reset	▪ Discharge air temperature and temperature setpoint ▪ Mixed air temperature ▪ Airflow rate across heating or cooling coil ▪ Primary cooling/heating efficiency and/or efficiency curve ▪ Primary cooling/heating equipment hours of operation ▪ Primary air-moving equipment hours of operation	▪ Deemed calculation ▪ Option A–B, D
Static pressure reset	▪ Fan sequence of operations, static pressure, static pressure setpoint ▪ Supply airflow rate, operating kW, hours of operation	▪ Deemed calculation ▪ Option A–B
Enthalpy economizer	▪ Economizer type ▪ Outdoor and supply air temperature and humidity ▪ Mixed-air temperature and humidity ▪ Supply airflow rate ▪ Outdoor air damper position	▪ Deemed calculation ▪ Option A–B, D

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Measure	Key Parameters (Baseline and Post)	Methodologies
Variable air volume box minimum	▪ VAV box minimum open %, open % ▪ Supply and discharge air temperature ▪ Supply airflow ▪ Mixed air temperature ▪ Heating/cooling equipment, and AHU hours of operation	▪ Deemed calculation ▪ Option B
Chilled water reset	▪ Chilled water supply temperature and temperature setpoint ▪ Chiller efficiency points or curves as a function of condenser water temperature and chiller load ▪ Chiller operating characteristics and hours of operation ▪ Outdoor air temperature and humidity	▪ Deemed calculation ▪ Option A, D
Outdoor air damper adjustments	▪ Outdoor air flow ▪ Damper control sequence of operation ▪ Damper control signal values and damper position ▪ Mixed air, outdoor and return air temperature ▪ Supply air temperature ▪ Heating/cooling equipment efficiencies and hours of operation ▪ Supply fan hours of operation	▪ Deemed calculation ▪ Option A, D
Coil cleaning	▪ Pressure drop across coil ▪ Airflow rate across coil ▪ Fan hours of operation	▪ Deemed calculation ▪ Option A–B
Pump pressure reduction	▪ Pump differential pressure and operating kW ▪ Independent variable such as schedule, outdoor air temperature ▪ Pump performance curve	▪ Deemed calculation ▪ Option A–B
Scheduling non-HVAC equipment	▪ Equipment quantity, capacity, and capacity profile ▪ Equipment efficiency and efficiency profile ▪ Equipment hours of operation profile ▪ Variables affecting equipment efficiency	▪ Option A–B
Advanced rooftop controls	▪ Fan control type ▪ RTU operating kW ▪ RTU hours of operation	▪ Option A–B
Custom recommissioning measure	Varies	▪ Deemed calculation ▪ Option A–D

Adoption of a whole facility approach under Option C will require an understanding of facility energy consumption and its relationship to operational parameters to construct a valid facility energy consumption model. This requires identification and as necessary adjustment for non-routine events that would affect pre-post usage analysis and are unrelated to the measure being assessed.

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E31.5.2. Sample Design Considerations

The sample frame will be comprised of a representative sample of projects. Project size, measure mix, facility type, vendor, and other project characteristics may be considered in the sample design. The sample frame will also be influenced by evaluation approach and available data. Using standard sampling approaches and tools, the following characteristics will be considered:

- Confidence interval: 85%
- Relative precision: 10–15%
- Installed measures
- Budget, schedule, and project type

E31.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

E31.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the impact evaluation.[190]
2. Apply the measured data to the actual participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation data.
3. Develop cumulative monthly energy savings based on measured and verified data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E31.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15 of each year following program launch).
- Update The DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.

[190] The realization rate is the proportion of deemed calculated or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

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E31.8. Non-Residential Building Optimization Program – Revision History

Table 31-3. Revision History for Non-Residential Building Optimization Program EM&V Plan

Version	Date	Notes
Version 1	Nov 2020	Initial release
Version 2	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number.
Version 3	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Updated IPMVP reference from 2012 to 2022. ▪ Removed version number from title ▪ Changed reference from Tracked Savings Deemed Savings in EM^V Overview ▪ Provided clarification of Option C and non-routine events to “Savings Estimation”

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E32. NON-RESIDENTIAL CUSTOMER ENGAGEMENT PROGRAM EM&V PLAN

E32.1. Program Summary

The proposed Program would engage commercial buildings in energy management best practices to increase awareness of operational and behavioral energy-saving opportunities. The Program would educate and train businesses' facility management staff on ways to achieve energy savings through optimization of building energy performance and integrating ongoing commissioning best practices into their operations.

Through a customer engagement portal, building operators can also access educational content and technical resources as part of a series of operator challenges. By completing these challenges, participants will review and implement energy efficient operational best practices, earning them points while competing against facility teams from other participating buildings.

The non-residential engagement program's operator energy challenges were designed to include technical resources and advice to educate building operators on how they can evaluate their building system performance and take corrective action. The energy challenges include, but are not limited to the following building retuning activities:

- Review outside air damper operation
- Minimize the introduction of outside air
- Review of supply fan operation and minimum flow setpoints
- Review of airside economizer operation and performance
- Review of air-handler supply air temperature sequences and setpoints
- Review of HVAC schedules and zone temperature setbacks
- Review lighting schedules and alignment with occupancy and use
- Review lighting levels
- Review condenser water setpoint and sequencing
- Review chilled water temperature setpoint and sequencing
- Review off-peak heating loads and lockouts
- Review AHU static pressure setpoints and sequencing
- VAV box sequencing

E32.2. Measures

The measure offered by the Non-Residential Engagement are as shown in Table 32-1.

Table 32-1. Measures Offered by the Non-Residential Engagement Program

End-Use	Measure
Cross-cutting	▪ Building operator training

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E32.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[191] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach for the energy efficiency portion of the program is:

1. Baseline Consumption: Baseline consumption will be calculated from data available from a facility's BAS, temporary meters, monthly or participant AMI consumption data, or using deemed calculation estimates and algorithms based on the DE TRM or other published deemed calculation or algorithms from other TRMs or sources. The source of the baseline energy consumption will be dependent on data availability, level of savings, and savings interactivity with other measures or systems.
2. Deemed Savings: Deemed savings values will be estimated from the DE TRM, which are derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs, related research, or evaluation studies.
3. Evaluated Savings: Evaluated savings will be determined by the methods described in Section E32.5. .

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[192]

E32.4. Deemed Savings Approach

For the energy efficiency portion of the program, upon program approval by the Virginia State Corporation Commission, deemed savings calculation approach or protocol for the Non-Residential Engagement Program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs or relevant studies or protocols, as appropriate. Given that EV utility programs are relatively new, deemed savings calculation estimates are more uncertain compared to more mature measures. The deemed savings calculation protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data are impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E32.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[193]

191 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

192 Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

193 Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

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E32.5.1. Savings Estimation

Because there are no national evaluation protocols for non-residential engagement programs without enabling technologies, this EM&V plan follows guidance from Chapter 24: Strategic Energy Management (SEM) Evaluation Protocol from the UMP.[194]

The Non-Residential Engagement Program is expected to produce energy savings across multiple end-uses with a high potential for interactive energy effects between end-uses. Regression-based statistical analysis that adheres to IPMVP Whole Building Section C, and ASHRAE 14 Annex D requirements for modeling energy savings is the preferred evaluation approach.[195] Adoption of a whole facility approach will require an understanding of facility energy consumption and its relationship to operational parameters to construct a valid facility energy consumption model.

Whole facility analyses can be used to evaluate the program if energy savings are large enough to be detected with a statistical analysis of the AMI or monthly billing data. Statistical power analyses using baseline energy consumption data to estimate the probability of detecting the expected savings can be used to determine whether a regression-based statistical approach is recommended. Adoption of a whole facility approach under Option C will require an understanding of facility energy consumption and its relationship to operational parameters to construct a valid facility energy consumption model. This requires identification and as necessary adjustment for non-routine events that would affect pre-post usage analysis and are unrelated to the measure being assessed.

If savings are too small to be detected with whole-facility regressions methods, surveys of building operators may be used to estimate program energy savings. Sample topics include:

- Measure installation
- Measure removal
- Schedule changes
- Operations and maintenance practices
- Engagement with customer engagement tools and benchmarking practices,
- Effectiveness of education
- Motivation for participation
- Barriers to participation
- Strategies for increasing participation and installation rates

E32.5.2. Sample Design Considerations

The evaluation will be performed on the census of participants. If a census is not possible the sample frame will be comprised of a representative sample of projects following guidance for the PJM sample size approach.[196] Project size, measure mix, facility type, vendor, location, and other project characteristics may be considered in the sample design. The following characteristics will be considered:

- Confidence interval: 85%
- Relative precision: 50%
- Installed measures, if any
- Budget and schedule

[194] Stewart, James. 2017. Chapter 24: Strategic Energy Management (SEM) Evaluation Protocol. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68316. http://www.nrel.gov/docs/fy17osti/68316.pdf

[195] Efficiency Value Organization. 2022. Core Concepts, International Performance Measurement and Verification Protocol; ASHRAE Guideline 14-2014, Measurement of Energy, Demand, and Water Savings, Informative Annex D: Regression Techniques

[196] PJM Manual 18B: Energy Efficiency Measurement & Verification, Revision: 04, Effective Date: August 22, 2019, PJM Forward Market Operations.

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E32.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

E32.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the impact evaluation.[197]
2. Apply the evaluated savings to the participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation.
3. Develop cumulative monthly energy savings based on measured and evaluated data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E32.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15 of each year following program launch).
- Update The DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.

E32.8. Non-Residential Customer Engagement Program – Revision History

Table 32-2. Revision History for Non-Residential Engagement Program EM&V Plan

Version	Date	Notes
Version 1	Nov. 2020	Initial release
Version 2	4/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number.
Version 3	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Updated IPMVP reference from 2012 to 2022. ▪ Removed version number from title

[197] The realization rate is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

Version	Date	Notes
		▪ Changed reference from Tracked Savings Deemed Savings in EM^V Overview ▪ Provided clarification of Option C and non-routine events to “Savings Estimation” ▪ Added the use of survey methods to estimate savings

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E33. NON-RESIDENTIAL PRESCRIPTIVE PROGRAM ENHANCED EM&V PLAN

E33.1. Program Summary

The proposed Program will provide qualifying non-residential customers with incentives for the installation of refrigeration, commercial kitchen equipment, HVAC improvements, and maintenance and installation of other program-specific, energy-efficient measures.

E33.2. Measures

The measures offered by the Non-Residential Prescriptive Program are as shown in Table 33-1.

Table 33-1. Measures Offered by Non-Residential Prescriptive Program

End-Use	Measure
	▪ Commercial oven ▪ Commercial electric fryer ▪ Commercial griddle ▪ Commercial hot food holding cabinet ▪ Commercial steam cooker ▪ Commercial dishwasher ▪ Food seal wrapper ▪ Pre-rinse sprayer
HVAC	▪ AC & HP tune Up ▪ Duct testing & sealing ▪ Electrically commutated motor (ECM) ▪ Guest room energy management ▪ Parking ventilation VSD
Plug Load	▪ Advanced power strip ▪ Commercial dryer ▪ Commercial washing machine ▪ Ozone laundry ▪ Vending machine miser
Recreation	▪ Heat pump pool heater ▪ Pool pump VSD ▪ Pool spa cover

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End-Use	Measure
Refrigeration	▪ Anti-sweat door film ▪ Auto closer ▪ Coil cleaning ▪ Commercial cooler & freezer ▪ Door gasket ▪ Evaporator fan control ▪ Evaporator fan ECM ▪ Floating head pressure control ▪ Ice maker ▪ Night cover ▪ Strip curtain ▪ Suction pipe insulation

E33.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[198] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach for the energy efficiency portion of the program is:

1. Baseline Consumption: Baseline consumption will be calculated per the DE TRM, which is derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs.
2. Deemed Savings: Deemed savings values will be estimated per the DE TRM, which is derived primarily from the most recent version of the Mid-Atlantic TRM, and as appropriate, other TRMs or protocols.
3. Evaluated Savings: Evaluated savings will be determined by the methods described in Section E33.5. The evaluated savings will use program tracking data, customer energy consumption data, and other customer data to estimate program savings.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[199]

E33.4. Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, the deemed savings approach or protocols for the program will be developed through research primarily in the most recent version of the Mid-Atlantic TRM, and other TRMs, or relevant studies or protocols. The deemed savings protocol for measures in this program will be documented in the DE TRM and calculated using utility-reported program participant data. DNV will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatts and kilowatt-hours. Where such data are impractical for implementation contractors to collect, DNV will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV will take into

198 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

199 Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

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consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E33.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[200]

According to "Chapter 4—Small Commercial and Residential Unitary and Split System HVAC Heating and Cooling Equipment," the key measured parameters for HVAC measures include the unit size, unit-rated efficiencies (energy-efficient and baseline cases), annual operating hours, and—for peak demand reductions—coincidence factor. The first two parameters can be verified by either a desk review or an on-site audit.[201]

For the refrigeration and food service measures, savings will be based on the DE TRM with adjustments to key inputs that can be verified while on-site. Although the UMP does not specifically address refrigeration and cooking measures, the key parameters for determining gross savings and peak demand reductions include quantity, wattage (baseline and efficient), Cooling loads, operating setpoint, annual hours of operation.

For VSDs and ECM measures, the key measured parameter is the annual operating hours at part-load conditions, and—for peak demand reductions—coincidence factor. The first parameter can be verified by either a desk review or on-site audit.[202]

At a high level, the ratio of the measured and verified savings to the deemed savings for the sample, also called a realization rate,[203] is then applied to the population of participants to estimate overall program savings. This approach will capture Company-specific customer usage data, and then apply those to the actual measures installed to quantify energy and peak demand savings.

E33.5.1. Savings Estimation

Measurement and verification of the installation and operation of a sample of participants at the premises-level will be performed using one or more of the following levels of rigor:

- Desk-review verification
- Phone or email survey verification
- On-site verification, only
- On-site verification and short-term measurements
- On-site verification, short-term measurements, and long-term metering of approximately six to eight weeks during a period of typical operations

[200] Virginia State Corporation Commission, PUR-2020-00156, Final Order, Appendix A, EM&V Framework For Dominion's DSM Programs.

[201] Jacobson, D. and Metoyer, J. (2017). Chapter 4: Small Commercial and Residential Unitary and Split System HVAC Heating and Cooling Equipment-Efficiency Upgrade Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68560. http://www.nrel.gov/docs/fy17osti/68560.pdf

[202] Romberger, Jeff. (2017). Chapter 18: Variable Frequency Drive Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68574. https://www.nrel.gov/docs/fy17osti/68574.pdf

[203] The "realization rate" is the proportion of deemed calculated or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or a given sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

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If metering is used, it will be conducted according to the IPMVP as shown in Table 33-2 [204]

Table 33-2. Preferred IPMVP Options for Non-Residential Prescriptive Program Measures

End-Use/Measure	IPMVP Option	Key Parameter(s)
Food Service	Option A: Retrofit Isolation: Key Parameter Measurement Approach	▪ Quantity ▪ Wattage (baseline and efficient) ▪ Operating setpoints ▪ Annual hours of operation
HVAC & Retro-commissioning	Option A: Retrofit Isolation: Key Parameter Measurement Approach	▪ Cooling loads ▪ Heating loads (if applicable) ▪ Operating setpoints ▪ Annual hours of operation ▪ HVAC equipment type
HVAC: VSD & ECM	Option B: Retrofit Isolation: All Parameter Measurement	▪ Annual hours of operation at part- and full-load conditions
Plug Load	Option A: Retrofit Isolation: Key Parameter Measurement Approach	▪ Quantity ▪ Wattage (baseline and efficient) ▪ Operating setpoints ▪ Annual hours of operation
Recreation	Option A: Retrofit Isolation: Key Parameter Measurement Approach	▪ Quantity ▪ Wattage (baseline and efficient) ▪ Operating setpoints ▪ Annual hours of operation
Refrigeration	Option A: Retrofit Isolation: Key Parameter Measurement Approach	▪ Cooling loads ▪ Annual hours of operation

IPMVP Option A, the Retrofit Isolation, Key Parameter Measurement Approach is most appropriate for most of the measures in the program. IPMVP Option A is a partially-measured, retrofit-isolation study that meters the actual energy and demand reduction of an installed efficiency measure from a representative sample of participants, and adjusts the savings estimates derived from engineering algorithms applied to the Company's reported program participation data.

IPMVP Option B, Retrofit Isolation is most appropriate for VSD and ECM retrofits. Using Option B, savings are determined by field measurement of the energy use of the system components. By performing a bin analysis of the pre- and post-installation energy data, it is possible to determine the energy savings and demand reduction.

In a limited set of cases, other kinds of verification strategies, such as building simulation models can be used to estimate program related energy impacts. Similarly, DNV may opt to use whole facility approach (Option C) if appropriate. Adoption of a whole facility approach under Option C will require an understanding of facility energy consumption and its relationship to operational parameters to construct a valid facility energy consumption model. This requires identification and as necessary adjustment for non-routine events that would affect pre-post usage analysis and are unrelated to the measure being assessed.

[204] Efficiency Value Organization. 2022. Core Concepts, International Performance Measurement and Verification Protocol.

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E33.5.2. Sample Design Considerations

The sample frame will be comprised of a representative sample of projects. Project size, measure mix, facility type, vendor, and other project characteristics may be considered in the sample design. The sample frame will also be influenced by evaluation approach and available data. Using standard sampling approaches and tools, the following characteristics will be considered:

- Confidence interval: 85–90%
- Relative precision: 10–15%
- Installed measures
- Budget, schedule, and geographical distribution

E33.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

E33.6. Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the impact evaluation.[205]
2. Apply the measured data to the actual participant data to arrive at program level energy and demand savings, reflected on a monthly basis. Program savings are annualized in the EM&V tracking reports based on monthly participation data.
3. Develop cumulative monthly energy savings based on measured and evaluated data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E33.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15 of each year following program launch).
- Annually update The DE TRM, as needed, to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.

[205] The realization rate is the proportion of deemed calculated or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

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E33.8. Non-residential Prescriptive Program – Revision History

Table 33-3. Revision History for Non-Residential Prescriptive Program EM&V Plan

Version	Date	Notes
Version 1	Nov. 2020	Initial release
Version 2	4/22/2022	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number.
Version 3	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Updated IPMVP reference from 2012 to 2022. ▪ Removed version and phase number from title ▪ Provided clarification of Option C and non-routine events to “Savings Estimation”

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E34. RESIDENTIAL SMART COOLING REWARDS PROGRAM EM&V PLAN

E34.1. Program Summary

The Residential Smart Cooling Rewards Program compensates customers who allow the Company to reduce the cycle of their central air conditioning (CAC) during peak load conditions by 30–50%. When Smart Cooling Rewards events are called, a radiofrequency (RF) paging signal is broadcast throughout the Company's service area. The signal is received by load curtailment switches installed on the CACs 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 units up to 50% during an event. The Smart Cooling Rewards event season spans June 1 through September 30 on non-holiday weekdays.

E34.2. Measures

The program measure is the cycling control switch. The eligible classes of air conditioners and heat pumps in the Smart Cooling Rewards Program are:

Table 34-1: Measures Offered by the Smart Cooling Rewards Program

End-use	Measure
HVAC	▪ Control switch, central air conditioners ▪ Control switch, electric and dual fuel heat pumps

E34.3. Evaluation, Measurement & Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[206] The EM&V method empirically estimates demand reduction (kW) during Smart Cooling Rewards program events. The Smart Cooling Rewards program is evaluated annually for the life of the program.

The basis for DNV's savings evaluation approach is:

1. Baseline Consumption: Baseline consumption will be calculated from AMI participant consumption data.
2. Demand reduction will be evaluated using the methods described in Section E34.5. The evaluated approach will use program tracking data, customer energy consumption data, and customer specific control histories to estimate demand reduction.

The evaluation follows protocols established in "Measurement and Verification for Demand Response."[207] The evaluation method meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").

E34.4. Deemed Savings Approach

Deemed savings are not calculated for the Smart Cooling Rewards Program

[206] 20 VAC 5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

[207] Measurement and Verification for Demand Response Prepared for the National Forum on the National Action Plan on Demand Response.: Measurement and Verification Working Group, February 2013. https://www.ferc.gov/industries/electric/indus-act/demand-response/dr-potential.asp

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E34.5. Evaluated Savings Approach

E34.5.1. Load Reduction Estimation for Demand Response

Given the investment in this program and the planned peak shaving reductions, this EM&V plan calls for an annual impact evaluation. The evaluation reports ex post impacts by event hour and THI, event average THI's, event opt-out percentages, and ex ante estimates by event hour and THI.

E34.5.2. Data

Four sources of data are used in the impact analysis:

- Event records of controlled participants
- Half-hourly AMI customer consumption data collected from customer meters
- Regional weather data to account for customer-specific temperature and humidity for each event hour.[208]

E34.5.3. Methodology

The following steps are used to calculate the kW impact demand reduction estimates for the program:

1. AMI interval data are merged with the record of controlled customers for each event.
2. Using AMI data, event control data, and weather data, regression analysis is used to predict event-day baseline consumption for each controlled AMI-enabled account. The predicted and actual consumption for AMI-enabled accounts is weighted to the full program population and the difference between baseline predicted consumption and actual consumption is the calculated ex post impact.
3. The ex ante estimates are calculated using a regression analysis of the ex post impacts for each event-hour as the dependent variable and temperature humidity index (THI) as the independent variable. Ex ante results are the predicted impacts for each event hour and THI and are used to estimate the program impacts at the Company's peak planning conditions of 95°F at 43% relative humidity at hour-ending 17 (THI 83.4).[209]
4. AMI customer accounts are assigned weights based on state, connected loads, and the participant's location within the Company's service territory to ensure that the AMI population is representative of the program population

E34.5.4. Sample Design Considerations

For customers who already have AMI meters installed, the evaluation will be performed on a census of these sites. For customers without AMI meters, it will be necessary to develop a representative sample and install AMI meters at customer households designated for the sample.

E34.6. Lost Revenue Methodology

Not applicable.

E34.7. Timeline and Scope of Work

- Conduct a monthly review of program tracking and AMI participant consumption data

[208] National Oceanic and Atmospheric Association (NOAA), National Centers for Environmental Information, Local Climatological Data.

[209] Dominions Energy's peak planning condition is hour-ending 17 at 95°F at 43% RH, or 83.4 THI. Temperature Humidity Index = THI = Td – (0.55 – 0.55*RH) * (Td – 58) where Td is dry bulb temperature and RH is relative humidity. Source: PJM Glossary: http://www.pjm.com/Glossary.aspx

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- Prepare monthly tracking indicator tables
- Evaluate impacts of dispatch events and prepare an annual impact evaluation report
- Enter annual updates of model specifications to the DE TRM
- Provide program and regulatory support as necessary
- Update EM&V plans as needed

E34.8. Residential Smart Cooling Rewards Program – Revision History

Table 34-2. Revision History for Smart Cooling Rewards Program EM&V Plan

Version	Date	Notes
Version 1	2011	▪ Added semi-annual program tracking summary table in the "Frequency of EM&V Measurement & Timeline" section. ▪ Changed assumed error ratio from 0.5 to 0.96 (computed) with an error margin of 9.12%.
Version 2	2012	▪ Updated document formatting. ▪ Updated "KEMA" to "DNV KEMA." ▪ Modified the required sample size from 300. ▪ Changed "Program Penetration & Initial Baseline Assumptions" section title to "Program Penetration" and removed initial baseline assumptions. ▪ Updated planned penetrations and added "Source" column to the "Program Penetration" table. ▪ Changed "Revision History" section title to "Document Revision History."
Version 3	2013	▪ Updated "EM&V Summary and Sampling Strategy" section with description of experimental design analysis for 2013.
Version 4	2014	▪ Update Program Penetration Table based on 2013 IRP.
Version 5	2015	▪ Removed 2013 planned customer penetration numbers. ▪ Added sentence on PJM requirements to end of "EM&V Method." ▪ Updated deemed savings approach to utilize ex ante estimates for aggregate program impacts conditional on temperature humidity index and hour, developed from a regression analysis of historical program performance. Changes affected EM&V Method and EM&V Summary and Sampling Strategy sections.
Version 6	2016	▪ Updated DNV KEMA to DNV Energy. ▪ Updated EM&V method to IPMVP Option C to reflect impact estimation using premise level AMI data. ▪ Added description of analytical tasks to meet requirements for PJM compliance. ▪ Updated error ratio to reflect results used in 2014 sample design. ▪ Added planned annual updates to the representative load shape of the program resource. ▪ Renamed "Frequency of EM&V Measurement and Timeline" section title to "EM&V Measurement, Timeline and Scope of Work" to reflect the content more accurately in that section. ▪ Added on-going scope that was not explicitly mentioned to "EM&V Measurement, Timeline and Scope of Work" section. ▪ Deleted program penetrations section.
Version 7	2017	▪ Updated "EM&V Summary and Sampling Strategy" section with description of the 2016 study population which includes all participants with AMI meters. ▪ Changed "semi-annual" to "monthly" program tracking summary table in the "Frequency of EM&V Measurement & Timeline" section. ▪ Prior to 2016, the measured average load reduction was computed from the interval load data of a sample of participating homes with AMI. Starting in 2016

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Version	Date	Notes
		the measured average load reduction is computed from the interval load data of all participants with AMI. ▪ Removed reference to a 96% operability rate. ▪ Added scope description for ex ante and ex post demand reduction estimates in EM&V Measurement, Timeline and Scope of Work.
Version 8	2018	▪ Updated with 2017 ex ante evaluated results.
Version 9	2019	▪ Formatting and minor edits. ▪ Updated from DNV Energy to DNV Energy Insights. ▪ Removed 2018 ex ante impact estimates.
Version 10	2020	▪ Formatting updates.
Version 11	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number. Changed format of measure table. Removed reference to load shapes. Added detail to evaluated savings methodology in EE.5.
Version 12	4/22/2022	▪ Changed reference from AC Cycling to Smart Cooling Rewards ▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Removed version number from title ▪ Added sample design considerations ▪ Removed reference to IPMVP Option C (whole facility) because Option C is designed for site level analysis.

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E35. NON-RESIDENTIAL DISTRIBUTED GENERATION PROGRAM EM&V PLAN

E35.1. Program Summary

The Non-Residential Distributed Generation Program provides qualifying commercial customers with an incentive to curtail load by operating backup generation at the request of the Company, up to a limited number of hours per year. Participants must have at least 200 kW demand to be eligible for this program. The program implementer is responsible for installing remote generation equipment controls, monitoring the customer's generators, and dispatching load under the direction of the Company. The program implementer is notified of a dispatch event 30 minutes in advance of the event either by e-mail or phone. Monthly average site-level load curtailment must be at least 95% of registered/enrolled kW to receive the incentive. Average monthly site level load curtailment must be at least 50% of registered/enrolled kW for continued program participation.

E35.2. Measures

The program dispatches power from on-site generators of participating customers

E35.3. Evaluation, Measurement & Verification Overview

International Performance Measurement and Verification Protocol (IPMVP - Option B): Because impacts are calculated from metered energy consumption, IPMVP Option B is the appropriate EM&V method. Program participants are known, and the load curtailment will be metered directly.[210]

1. Baseline estimation approach: The baseline for this program is 0 kW because the power generators are not operating at the beginning of each event.
2. Demand reduction will be evaluated using the methods described in Section E33.5. The evaluated approach will use program tracking data, customer energy consumption data, and customer specific control histories to estimate demand reduction.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[211]

E35.4. Deemed Savings Approach

Deemed savings are not calculated for the Non-Residential Distributed Generation Program.

E35.5. Evaluated Savings Approach

E35.5.1. Load Reduction Estimation for Demand Response

Metered generation data is collected from the implementer using Company and implementer owned equipment. Total and average measured generation is metered on-site and is the amount of load curtailed by the participant per event-hour interval. Total and average dispatched generation is the amount of load curtailment, in kW, requested by the Company, per

[210] Efficiency Value Organization. 2022. Core Concepts, International Performance Measurement and Verification Protocol. www.evo-world.org.

[211] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

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event-hour, aggregated and reported at the daily, monthly, seasonal, and yearly level. Impacts are evaluated on the census of participants.

The realization rate is calculated by dividing the average monthly measured generation by the average monthly dispatched generation for participating sites, expressed as a percent. Measured generation prior to or following an event is not attributed to the Program.

E35.5.2. Sample design considerations

A census of participant data will be evaluated since electrical output from 100% of enrolled generators will be metered, the event times are known, and the load and run time hours will be directly metered and reported. Missing meter data will be replaced to the extent possible with redundant meter data.

E35.6. Lost Revenue Methodology

Not applicable.

E35.7. Timeline and Scope of Work

- Analysis of program tracking and metered data: Annual Report (May 15 of each year following program launch).
- Semi-annual program tracking summary table (ending July 2015). 2015 will be final year of semi-annual reporting, as North Carolina submissions will be changing next year to line up with Virginia. Semi-annual program tracking summary table (July of each year).
- Annual event season report (November of each year).
- Annual updates to the DE TRM.
- Develop baseline, measure savings, and efficient load shapes.
- Provide regulatory support as necessary.

E35.8. Non-Residential Distributed Generation Program – Revision History

Table 35-1. Revision History for Non-Residential Distributed Generation Program EM&V Plan

Version	Date	Notes
Version 1	2011	▪ Added semi-annual program tracking summary table in the “Frequency of EM&V Measurement & Timeline” section.
Version 2	2012	▪ No material changes to the content. ▪ Added semi-annual program tracking summary table in the “Frequency of EM&V Measurement & Timeline” section.
Version 3	2013	▪ No material changes to the content.
Version 4	2014	▪ Updated program requirements with more details, as shown below: ▪ Added minimum kW demand requirement of 200 kW to be eligible for this program to the “Program Summary” section. ▪ Added customer notification process of each DG event through e-mail or phone 30 minutes in advance. ▪ Added compliance requirement that participants must be within +/- 5% of committed peak shaving enrolled kW. ▪ Changed “KEMA” to “DNV KEMA.” ▪ Changed “Program Penetration & Initial Baseline Assumptions” section title to “Program Penetration” and removed initial baseline assumptions. ▪ Updated program penetrations and added “Source” column to the “Program Penetration” table.

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Jun 15 2022

Version	Date	Notes
		▪ Changed “Revision History” section title to “Document Revision History.” ▪ Updated planned penetration table based on 2013 IRP.
Version 5	2015	▪ Removed 2013 planned customer penetration numbers. ▪ Added sentence on PJM requirements to end of “EM&V Method.” ▪ Updated program requirements with more details, as shown below: ▪ Added minimum kW demand requirement of 200 kW to be eligible for this program to the “Program Summary” section. ▪ Added customer notification process of each DG event through e-mail or phone 30 minutes in advance. ▪ Added compliance requirement that participants must be within +/- 5% of committed peak shaving enrolled kW. ▪ Changed “KEMA” to “DNV KEMA.” ▪ Changed “Program Penetration & Initial Baseline Assumptions” section title to “Program Penetration” and removed initial baseline assumptions. ▪ Updated program penetrations and added “Source” column to the “Program Penetration” table. ▪ Changed “Revision History” section title to “Document Revision History.” ▪ Updated planned penetration table based on 2013 IRP.
Version 6	2016	▪ Updated DNV KEMA to DNV Energy. ▪ Clarified that compliance is defined by total monthly average load curtailment that is at least 95% of committed peak shaving enrolled kW (rather than +/- 5% of enrolled kW). ▪ Renamed “Frequency of EM&V Measurement and Timeline” section title to “EM&V Measurement, Timeline and Scope of Work” to reflect the content more accurately in that section. ▪ Added on-going scope that was not explicitly mentioned to “EM&V Measurement, Timeline and Scope of Work” section. ▪ Deleted program penetrations section. ▪ Removed 2013 planned customer penetration numbers. ▪ Added sentence on PJM requirements to end of “EM&V Method.”
Version 7	2017	▪ Clarified that compliance for program participation is 50% of enrolled, but compliance for payments is 95% of enrolled kW. Updated bullet “Semi-annual program tracking summary table (as required).” to “Semi-annual program tracking summary table (ending July 2015). 2015 will be final year of semi-annual reporting, as North Carolina submissions will be changing next year to line up with Virginia. ▪ Updated DNV KEMA to DNV Energy. ▪ Clarified that compliance is defined by total monthly average load curtailment that is at least 95% of committed peak shaving enrolled kW (rather than +/- 5% of enrolled kW). ▪ Renamed “Frequency of EM&V Measurement and Timeline” section title to “EM&V Measurement, Timeline and Scope of Work” to reflect the content more accurately in that section. ▪ Added on-going scope that was not explicitly mentioned to “EM&V Measurement, Timeline and Scope of Work” section. ▪ Deleted program penetrations section. ▪ Updated bullet “Semi-annual program tracking summary table (as required).” to “Semi-annual program tracking summary table (ending July 2015). 2015 will be final year of semi-annual reporting, as North Carolina submissions will be changing next year to line up with Virginia.” ▪ Clarified difference between payment compliance (95% of enrolled load) and program participation compliance (50% of enrolled load).
Version 8	2018	▪ Updated “April 1” report date to “May 1” in “EM&V Measurement, Timeline, and Scope of Work” section.

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Jun 15 2022

Version	Date	Notes
Version 9	2019	▪ Minor edits. ▪ Formatting updates. ▪ Updated from DNV Energy to DNV Energy Insights.
Version 10	2020	▪ Formatting updates.
Version 11	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number. Slight word changes to measure description. Additional detail added to deemed and evaluated savings methodologies in Sections FF.4 and FF.5.
Version 12	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Removed version number from title

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E36. RESIDENTIAL SMART THERMOSTAT REWARDS (DR) PROGRAM EM&V PLAN

E36.1. Program Summary

All residential customers who are not already participation in the Company's DSM Phase I Smart Cooling Rewards Program and who have a qualifying smart thermostat would be offered the opportunity to enroll in a peak demand response program. Demand response would be called by the Company during times of peak system demand throughout the year and thermostats of participating customers would be gradually adjusted to achieve a specified amount of load reduction while maintaining reasonable customer comfort and allowing customers to opt-out of specific events if they choose to do so.

E36.2. Measures

The measures offered by the Residential Smart Thermostat Rewards Program include those listed in Table 36-1.

Table 36-1. Measures Offered by Residential Smart Thermostat Rewards Program

End-use	Measure
HVAC	▪ Heat pump demand response, peak reduction ▪ Air conditioning system demand response, peak reduction

E36.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[212] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach is:

1. Baseline Consumption: Baseline consumption will be calculated from monthly or AMI participant and non-participant consumption data.
2. Evaluated Savings: Load reduction will be determined by the methods described in Section E36.5.2. The evaluated savings will use program tracking data, customer energy consumption data, and other customer data to estimate program savings.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[213] The Smart Thermostat Rewards Program is evaluated annually for the life of the program.

E36.4. Deemed Savings Approach

Estimates of load reduction in demand response programs are not deemed.

[212] 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

[213] Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order.

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E36.5. Evaluated Savings Approach

E36.5.1. Load Reduction Estimation for Demand Response

This EM&V plan calls for an annual impact evaluation. The evaluation reports ex post impacts by event hour and THI, event average THI's, event opt-out percentages, and ex ante estimates by event hour and THI.

E36.5.2. Data

Four sources of data are used in the impact analysis:

- Event records of controlled participants
- Half-hourly AMI customer consumption data collected from customer meters
- Regional weather data to account for customer-specific temperature and humidity for each event hour.[214]

E36.5.3. Methodology

The following steps are used to calculate the kW impact demand reduction estimates for the program:

1. AMI interval data are merged with the record of controlled customers for each event.
2. Using AMI data, event control data, and weather data, regression analysis is used to predict event-day baseline consumption for each controlled AMI-enabled account. The predicted and actual consumption for AMI-enabled accounts is weighted to the full program population and the difference between baseline predicted consumption and actual consumption is the calculated ex post impact.
3. The ex ante estimates are calculated using a regression analysis of the ex post impacts for each event-hour as the dependent variable and temperature humidity index (THI) as the independent variable. Ex ante results are the predicted impacts for each event hour and THI and are used to estimate the program impacts at the Company's peak planning conditions of 95°F at 43% relative humidity at hour-ending 17 (THI 83.4).[215]
4. AMI customer accounts are assigned weights based on state, connected loads, and the participant's location within the Company's service territory to ensure that the AMI population is representative of the program population

E36.5.4. Sample Design Considerations

For customers who already have AMI meters installed, the evaluation will be performed on a census of these sites. For customers without AMI meters, it will be necessary to develop a representative sample and install AMI meters at customer households designated for the sample.

E36.6. Lost Revenue Methodology

Not applicable.

E36.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 1 of each year following program launch).

[214] National Oceanic and Atmospheric Association (NOAA), National Centers for Environmental Information, Local Climatological Data.

[215] Dominions Energy's peak planning condition is hour-ending 17 at 95°F at 43% RH, or 83.4 THI. Temperature Humidity Index = THI = Td – (0.55 – 0.55*RH) * (Td – 58) where Td is dry bulb temperature and RH is relative humidity. Source: PJM Glossary: http://www.pjm.com/Glossary.aspx

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- Annually update The DE TRM, as needed, to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

E36.8. Residential Smart Thermostat Rewards Program Revision History

Table 36-2. Revision History for Smart Thermostat Rewards Program EM&V Plan

Version	Date	Notes
Version 1	11/26/2019	▪ Initial release
Version 2	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number.
Version 3	4/22/2022	▪ Provided additional detail to evaluated savings method. ▪ Removed reference to the PJM sample size approach ▪ Changed program name from Smart Thermostat Demand Response Program to Smart Cooling Rewards Program ▪ Added reference to annual evaluation ▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Removed version number from title

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E37. RESIDENTIAL ELECTRIC VEHICLE REWARDS PROGRAM (DR) EM&V PLAN

E37.1. Program Summary

The peak shaving program would provide customers who already have a qualifying level 2 electric vehicle (EV) charger and wish to participate in the demand response (DR) component only (no purchase incentive)

E37.2. Measures

The measures offered by the Residential Electric Vehicle Rewards (DR) Program are as shown in Table 37-1.

Table 37-1. Measures Offered by Residential Electric Vehicle Rewards (DR) Program

End-use	Measure
Plug Load	▪ EV charging demand response events

E37.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[216] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach is:

1. Baseline Consumption: Baseline consumption will be calculated from AMI participant data, charger data, and non-participant AMI consumption and charger data, if available.
2. Evaluated Savings: Load reduction will be determined by the methods described in Section E37.5. The evaluated demand reduction will use program tracking data, customer energy consumption data, EV charger data, and other customer data to estimate program savings.

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").

E37.4. Deemed Savings Approach

Estimates of load reduction in demand response programs are not deemed.

E37.5. Evaluated Savings Approach

E37.5.1. Load Reduction Estimation for Demand Response

Using AMI data, EV charging and event data, and weather data, regression analysis is used to calculate ex post impacts for each event hour. The ex ante estimates are calculated using a regression analysis of the ex post impacts for each event-hour and temperature humidity index (THI).

[216] 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

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E37.5.2. Sample Design Considerations

There are several sampling options based on the size of the program and the number of AMI-enabled participants.

The evaluation will be performed on the census of AMI-enabled customers. The AMI accounts are assigned weights based on connected loads and the service divisions of all participants to ensure that the AMI analysis is representative of the program population.

If an insufficient number of AMI participants enter the program, it may be necessary to develop a representative sample of participants and install AMI or interval meters at customer households designated for the sample.

Both approaches will make use of AMI or interval data from Dominion Energy's customers to produce an estimate of the necessary sample size required to meet precision requirements for load reduction estimates.

E37.6. Lost Revenue Methodology

Not applicable.

E37.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 1 of each year following program launch).
- Annually update The DE TRM, as needed, to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

E37.8. Residential Electric Vehicle Rewards (DR) Program–Revision History

Table 37-2. Revision History for Residential Electric Vehicle Rewards (DR) Program EM&V Plan

Version	Date	Notes
Version 1	11/26/2019	▪ Initial release
Version 2	3/21/2021	▪ Added date to revision history and removed "Document" from "Document Revision History." Removed decimal place from version number.
Version 3	4/22/2021	▪ Replaced section head "Load Reduction Estimation for Demand Response" with "Evaluated Savings Approach."
Version 4	4/22/2022	▪ Updated program name from "Residential Electric Vehicle (DR) Program" to "Residential Electric Vehicle Rewards (DR) Program" ▪ Updated the title of "STEP Manual" to the "Dominion Energy Virginia and North Carolina Technical Reference Manual" (DE TRM) ▪ Replaced "DNV EM&V approach" to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Removed version number from title

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E38. RESIDENTIAL WATER SAVINGS (DR) PROGRAM EM&V PLAN

E38.1. Program Summary

As part of the proposed Residential Water Savings (DR) Program, all customers who purchase and install a qualified product (EE component) will be offered the opportunity to enroll in the peak demand reduction (DR) component of the DR Program. Customers who have previously purchased a qualifying product and who have the eligible products installed, will be offered the opportunity to enroll in the DR component of the Program. Customers will be offered an annual incentive (above and beyond the product purchase incentive amount) to participate in the peak reduction component year-round and an additional reduced incentive for each subsequent year they continue to participate. Customers would be allowed to opt out of a certain number of events.

E38.2. Measures

The measure offered by the Residential Water Savings (DR) are as shown in Table 38-1.

Table 38-1. Measures Offered by Residential Water Savings Program (DR)

End-Use	Measure
Domestic Hot Water	▪ Heat pump water heater
Recreation	▪ Variable speed pool pump

E38.3. Evaluation, Measurement, and Verification Overview

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[217]

The basis for DNV's savings evaluation approach for the program is:

1. Baseline Consumption: Baseline consumption will be calculated from AMI participant data and non-participant AMI consumption and charger data if it's available.
2. Evaluated Savings: Load reduction will be determined by the methods described in Section E38.5. The evaluated savings will use program tracking data, customer energy consumption data, and other customer data to estimate program savings.

The Residential Water Savings Program (DR) is evaluated annually for the life of the program.

E38.4. Deemed Savings Approach.

Estimates of load reduction in demand response programs are not based on deemed calculations methods.

[217] 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018; Virginia State Corporation Commission, PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.], Final Order. Effective Date: October 27, 2021.

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E38.5. Evaluated Savings Approach

E38.5.1. Load Reduction Estimation for Demand Response

Most evaluation methods assume that telemetry run-time data from the water heaters and pool pumps will be available. The best approach to estimating a baseline is using a randomly assigned control group that is not dispatched for the event. A subset of participants can be in the control group for any single event and provide an accurate estimate of baseline run-time. The reduction in run-time of dispatched water heaters and pool pumps relative to this baseline is transformed to a load reduction estimate using unit connected load.

In the absence of a control group, a regression-based estimate will be tested which will provide a baseline estimate of run-time.

E38.5.2. Sample Design Considerations

The evaluation will be performed on a census of AMI-enabled participants. For customers without AMI meters, it may be necessary to use AMR data or develop a representative sample and install interval meters at customer households designated for the sample. The following characteristics will be considered:

- Confidence interval: 85%
- Relative precision: 10–15%
- Budget and schedule

E38.5.3. Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

E38.6. Lost Revenue Methodology

Lost revenue is not calculated for demand response programs.

E38.7. Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15 of each year following program launch).
- Update The DE TRM annually to account for updates to referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.

E38.8. Residential Water Savings Program (DR) – Revision History

Table 38-2. Revision History for Residential Water Savings (DR) EM&V Plan

Version	Date	Notes
Version 1	Nov. 2020	Initial release
Version 2	3/22/2021	▪ Added date to revision history and removed “Document” from “Document Revision History.” Removed decimal place from version number.

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Version	Date	Notes
Version 4	4/22/2022	▪ Updated the title of “STEP Manual” to the “Dominion Energy Virginia and North Carolina Technical Reference Manual” (DE TRM) ▪ Replaced “DNV EM&V approach” to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Removed version number from title ▪ In sample design considerations, removed reference to the PJM sample size