Case No. PUR-2020-00251
Sponsor: ("APCO")
Exhibit No. 7

Witness: DAVID DIEBEL
Bailiff: JABARI T. ROBINSON

APCo Exhibit No. ____
Witness: DSD

SUMMARY OF DIRECT TESTIMONY OF DAVID DIEBEL

My direct testimony:

- Supports the Company's petition for approval of five new proposed programs, the continuation of two existing programs, and one new pilot program;
- Discusses how the Company plans to comply with the "Rules Governing the Evaluation, Measurement and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs" defined in 20 VAC 5-318-10, et seq.;
- Describes the cost/benefit test performed for the proposed programs, including addressing certain of the cost/benefit rules defined in 20 VAC 5-304-10, et seq.; and
- Presents the cost/benefit test results for the proposed programs.

APCo Exhibit No. ____
Witness: DSD

DIRECT TESTIMONY OF
DAVID DIEBEL
FOR APPALACHIAN POWER COMPANY
IN VIRGINIA S.C.C. CASE NO. PUR-2020-00251

Q. PLEASE STATE YOUR NAME, BUSINESS ADDRESS, AND POSITION.

A. My name is David Diebel. I am a Principal at ADM Associates, Inc. (ADM). My business address is 3239 Ramos Circle, Sacramento, CA 95827.

Q. PLEASE SUMMARIZE YOUR EDUCATIONAL BACKGROUND AND BUSINESS EXPERIENCE.

A. I received a B.A in Economics from the California State University, Sacramento in 2004 and a M.A. in Economics from the California State University, Sacramento in 2006. I am a Director at ADM. In that capacity, I am responsible for directing the work of ADM's staff for various evaluation and consulting projects. I joined ADM Associates in 2007 as an Associate. My initial responsibilities included data analysis related to lighting technology evaluations. Since then, my role has shifted to program and portfolio evaluation.

Q. ON WHOSE BEHALF ARE YOU TESTIFYING IN THIS PROCEEDING?

A. I am testifying on behalf of Appalachian Power Company (APCo or Company).

Q. WOULD YOU PLEASE DESCRIBE ADM?

A. ADM is a professional services corporation providing energy efficiency program evaluation and research for utilities and other clients across North America. Founded in 1979, ADM's headquarters are in Sacramento, with offices in Reno, and the San Francisco Bay Area. ADM has approximately 125 employees. ADM has evaluated the Company's 2015-2019 programs, and will be evaluating the Company's 2020 programs.

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY IN THIS PROCEEDING?

A. My testimony supports the Company's petition for approval to implement five new energy efficiency programs, implement one pilot program and continue two programs.

My testimony explains how the Company plans to comply with the "Rules Governing the Evaluation, Measurement and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs" (EM&V Rules) issued by the Commission and codified at 20 VAC 5-318-10, et seq. My testimony introduces the Evaluation, Measurement and Verification (EM&V) plans that ADM produced for the programs for which the Company is seeking Commission approval of in this proceeding.

My testimony also presents the cost/benefit test results for the proposed programs, including addressing certain of the Commission's Rules Governing Cost/Benefit Measures Required for Demand-Side Management Programs ("Cost/Benefit Rules") (20 VAC 5-304-10, et seq.).

ADM developed the 2022-2026 cost effectiveness model for the Company. The model includes program specifications including lists of energy efficiency and demand response measures, all associated energy and demand impacts, measure costs, measure lives, and associated program costs for incentives marketing, and program administration.

Q. ARE YOU SPONSORING ANY EXHIBITS IN THIS PROCEEDING?

A. Yes, I am sponsoring:

- APCo Exhibit No. __ (DSD) Schedule 1 - Program Assumptions
- APCo Exhibit No. __ (DSD) Schedule 2 - System Level Assumptions
- APCo Exhibit No. __ (DSD) Schedule 3 - 2022-2026 Programs Cost-Effectiveness Individual Results

- APCo Exhibit No. __ (DSD) Schedule 4 - 2022-2026 Portfolio Cost-Effectiveness Analysis
- APCo Exhibit No. __ (DSD) Schedule 5 - 2022-2026 Programs Cost-Effectiveness Sensitivity Analysis Results
- APCo Exhibit No. __ (DSD) Schedule 6 - 2022-2026 Portfolio Cost-Effectiveness Sensitivity Analysis Results
- APCo Exhibit No. __ (DSD) Schedule 7 - 2022-2026 Portfolio EM&V Plan

Q. HOW IS YOUR TESTIMONY ORGANIZED?

A. My testimony includes:

- A discussion of the Company's EM&V plan and its compliance with applicable EM&V rules;
- An overview of cost effectiveness data sources and methods; and
- A discussion of cost effectiveness test results of proposed programs, individually and as a portfolio.

I. EM&V PLAN AND COMPLIANCE WITH EM&V RULES

Q. PLEASE DESCRIBE HOW THE EM&V RULES WERE PROMULGATED.

A. Between March and November 2017, the Commission evaluated "the establishment of uniform protocols for measuring, verifying, and validating and reporting the impacts of energy efficiency measures implemented by investor-owned electric utilities providing retail electric utility service in the Commonwealth" through Staff research, public hearings and public comments in Case No. PUE-2016-00022. Ultimately, the Commission issued the EM&V Rules, which became effective January 1, 2018, and provided the framework that the Company and ADM are following in planning for the evaluation of, and will be following to evaluate, the Company's proposed new programs and continuation of existing programs and energy efficiency measures going forward.

Q. WHAT IS THE PURPOSE OF THE EM&V RULES?

A. As set forth in 20 VAC 5-318-10, the EM&V Rules set forth the minimum requirements for the EM&V of the effects of utility-sponsored Demand Side Management ("DSM") programs.

Q. PLEASE EXPLAIN THE ADMINISTRATIVE PROCEDURES DETAILED IN THE EM&V RULES.

A. 20 VAC 5-318-30 A requires utilities filing for approval to implement new or to continue existing DSM measures or programs to file a preliminary plan for the EM&V of the proposed measures or programs as part of its application (Plan). The Plan must explain how the utility intends to comply with the minimum requirements for the collection of EM&V data set forth in 20 VAC 5-318-40. ADM developed Plans for each of the DSM Programs that the Company has filed for Commission approval. They are attached as Schedule 7 hereto.

Q. WHAT ARE THE MINIMUM REQUIREMENTS FOR THE COLLECTION OF EM&V DATA?

A. 20 VAC 5-318-40 sets forth the following minimum requirements for the collection of EM&V data for new or continuation of existing DSM measures or programs:

- Where available, utility-specific data should be utilized in evaluating proposed DSM measures or programs. If utility-specific data is not available, the utility should rely on Virginia-specific data and provide an explanation as to why utility-specific data is unavailable or impracticable. If neither utility-specific nor Virginia-specific data is available, the utility may rely on data from non-Virginia jurisdictions, with appropriate citations to the source documents. The utility must also explain why utility-specific and Virginia-specific data is unavailable or impracticable, and why the use of the non-Virginia jurisdictional data is appropriate.
- EM&V reports must include any relevant workpapers, support documents, assumptions, and equations used to develop the measurement and verification methodologies.

- EM&V reports must include measure-level estimates of kilowatt and kilowatt-hour savings, as appropriate. Where appropriate, two estimates should be provided - one that has been adjusted for free-ridership, and one that has not.
- Where appropriate, EM&V should comply with Options A, B, C, or D from the International Performance Measurement and Verification Protocol (January 2012), though alternative methodologies may be considered with sufficient supporting documentation.
- Utilities are encouraged to use emerging technologies, including "advanced measurement and verification" or "evaluation, measurement and verification 2.0" where appropriate and cost-effective.

Q. HOW DO RECENT REGULATORY AND LEGAL DEVELOPMENTS IMPACT THE LEVEL OF EM&V RIGOR REQUIRED?

A. The Virginia Clean Economy Act, the Commission's Final Order in Case No. PUR-2018-00168, and the EM&V Rules have established the need for EM&V to meet new requirements that were previously inapplicable, including the hierarchy of preferred categories of data sources and the need to provide additional documentation for non-Virginia data sources. The approaches outlined in the EM&V plan, which is submitted as Schedule 7, are intended to meet those requirements as well as the requirements outlined in the EM&V Rules.

Q. HOW DO THE APPROACHES OUTLINED IN THE EM&V PLAN COMPLY WITH 20 VAC 5-318-40 FOR THE PROGRAMS THAT ARE THE SUBJECT OF THIS FILING?

A. The EM&V plan accounts for the preferred order of data sources for estimating program and measure savings by taking the preferred hierarchy as a starting point in determining the allocation of finite EM&V resources. In accounting for the preferred order, we seek to balance the rigor of the evaluation with the cost of obtaining the data necessary for it.

For instance, for commercial programs, our approach relies upon site-specific data as inputs to calculation of savings. First, all sampled sites are evaluated based on the site-specific measures installed, and where applicable, baseline conditions. Additionally, in many cases we collect data to analyze use factors such as operating hours obtained through either site-specific schedules, monitored data, or account energy consumption data in estimating savings. In some instances where the measures installed have relatively smaller impacts on program savings and where the cost of collecting site-specific data is relatively high, we reference stipulated values provided by the Mid-Atlantic Technical Resource Manual ("TRM").

The Mid-Atlantic TRM is used in states neighboring Virginia and elsewhere in the mid- Atlantic region of the U.S. (e.g., Maryland, District-of Columbia, Delaware). In the absence of a state-wide TRM in Virginia, it is an industry-standard practice to derive deemed savings equations from a reliable and nearby TRM to apply to the Company's program measures. For program measures that are not available in the Mid-Atlantic TRM, ADM 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.

For impact evaluation of residential programs, we reference site-specific measure characteristics. We also develop region-specific HVAC load and lighting interaction factors. For other inputs, we utilize inputs from the Mid-Atlantic TRM or another source for measures not covered in the Mid-Atlantic TRM. Collecting data on factors such as lighting hours or showers per day in a household, for example, would be costly and

unlikely to result in findings that are more accurate than findings developed from a study referenced in the Mid-Atlantic TRM.

Our EM&V reporting will document all non-utility specific data sources as required by 20 VAC 5-318-40. Our EM&V approach will be consistent with the EM&V plan and EM&V reporting will cite the EM&V plan as part of the documentation of the applied methods. In the event that unforeseen occurrences require a deviation from the approach outlined in the EM&V plan, we will note the discrepancy and provide an explanation regarding how the approach does not adhere to the EM&V plan and why it was selected.

The approaches outlined in the EM&V plan adhere to section 20 VAC 5-318-40. In the EM&V plan, we discuss general sampling requirements and the types of sampling to be performed. The specific sampling plans will be informed by annual program data and discussion of the plans in the EM&V reporting will include descriptions of the statistical calculations upon which the reported data are based.

Table 1, excerpted from the EM&V plan, summarizes how the evaluation will comply with the rules for evaluation, measurement, and verification (EM&V) set forth in Case No. PUR-2017-00047.

Table 1 – Compliance with Case No. PUR-2017-00047 EM&V Rules

Section	Requirement	Response
20VAC5-318-40 (A)	In all filings required by 20VAC5-318-30, the sources of all data or estimates used as inputs for proposed DSM measures or programs, in descending order of preference, shall be: 1. Utility-specific data; 2. Virginia-specific data if utility-specific data is unavailable or impracticable. When Virginia-specific data is used, the utility shall provide an explanation as to why utility-specific data is unavailable or impracticable; 3. Data from non-Virginia jurisdictions or sources, if neither utility-specific data nor Virginia-specific data is available or practicable: a. When data from non-Virginia jurisdictions or sources is used, the utility shall provide an explanation as to why utility-specific data is unavailable or impracticable. b. When data from non-Virginia jurisdictions or sources is used, the utility shall provide an explanation as to why Virginia-specific data is unavailable or impracticable as well as the sources of all data, to include: (1) Titles, version numbers, publication dates, and page numbers of all source documents, as appropriate; and (2) An explanation as to why, in the utility's assessment, use of this data is appropriate.	The methods that will be used to evaluate program impacts is provided in the methodology sections of each program chapter of this plan. The methods comply with the order of preferred data inputs cited in code 20VAC5-318-40 (A). Primary data may be supplemented by secondary data to facilitate cost efficient allocation of EM&V resources.
20VAC5-318-40 (B)	EM&V reports shall include relevant workpapers, support documents, assumptions, and equations used in developing the measurement and verification methodologies of measures or programs reported.	The EM&V reports will describe the methodologies used to estimate savings for the program measures and include citations of relevant workpapers, support documents, assumptions, and equations used in developing the measurement and

Section	Requirement	Response
		verification methodologies of measures or programs reported.
20VAC5-318-40 (C)	EM&V reports shall include measure-level estimates of kilowatt, kilowatt-hour, dekatherm, and pipeline capacity savings as appropriate. An estimate that has been adjusted for free-ridership as well as an estimate that has not been adjusted for free-ridership should be included as appropriate.	The cost-effectiveness analysis file submitted with the EM&V report will present measure-level estimates of peak kW and kWh energy savings.
20VAC5-318-50 (A)	EM&V of approved DSM measures or programs should be consistent with and contrasted to the preliminary EM&V plan set forth in the filings for approval of such measures or programs or as otherwise specified in a commission order approving such measures or programs. The commission recognizes that each utility has unique characteristics, and new or modified energy efficiency measures are constantly being developed. As such, alternative methodologies may be included in reporting provided that sufficient supporting documentation and explanation of appropriateness of alternative methodologies is provided.	The EM&V reports will detail any deviations from the approach submitted within this plan and the reasons for that deviation.
20VAC5-318-50 (B)	EM&V reports of existing measures or programs shall utilize utility-specific data or other data in conformance with 20VAC5-318-40 A when updating the analysis of the cost effectiveness of each measure, program, or portfolio as appropriate and practicable. EM&V reports of existing measures or programs shall include the information required by 20VAC5-318-40 B and C.	The EM&V reports will include this information.
20VAC5-318-50 (C)	Any changes to or variances from originally approved measure-level inputs and assumptions shall be documented and explained, and the impact of such changes on original cost/benefit estimates for DSM programs or measures shall be quantified.	The EMV&V report will present cost effectiveness analysis based on the ex ante savings estimates to characterize the discrepancy between the benefits resulting from the ex ante estimates and the ex post estimates. The presentation of savings results will include discussion of the

Section	Requirement	Response
		reasons for differences between the ex ante savings and ex post savings estimates.
20VAC5-318-50 (D)	EM&V reports shall describe the methodologies by which the measured data was collected, including at a minimum: 1. The sampling plan; and 2. Statistical calculations upon which the reported data is based when applicable.	The sampling approach will be presented in the methodology section of the evaluation reports.
20VAC5-318-50 (E)	EM&V reports for ongoing DSM measures or programs shall include an explanation of eligibility requirements for each rate schedule to which the measures or programs are being offered.	The EM&V reports will provide a description of the program that includes information on the measure or program eligibility requirements as provide by the Company.
20VAC5-318-50 (F)	EM&V reports for ongoing DSM measures or programs shall include a comparison of the measured annual measure or program savings estimates to the annual usage of the average rate schedule usage and eligible customer in each rate schedule to which the measures or programs is being offered. A comparison to originally approved estimated savings for the measures or programs that were approved by the commission shall also be provided. This will include a calculation of the expected savings as a percentage of the annual usage of the average rate schedule usage and eligible customer as appropriate and practicable.	The EM&V reports will present a table for each program and rate class, based on data provided by the Company, that summarizes the following information: Program Name, Rate Class, Total kWh Savings, Number of Participating Customer Accounts, Average kWh Savings per Customer Account, and Average Consumption per Account for the Rate Class
20VAC5-318-50 (G)	EM&V reports for ongoing DSM measures or programs shall include a description of the controls undertaken by the utility to verify proper installation of the measures or programs, as appropriate. Additionally, utilities shall require the contractors and subcontractors that will be implementing the measures or programs, if applicable and practicable, to record details of	The EM&V reports will include the following information as provided by the Company or otherwise determined through the evaluation effort: 1) a description of program installation quality controls.

Section	Requirement	Response
	serviced or replaced equipment, to include at a minimum: 1. Nameplate efficiency ratings; 2. Serial numbers; and 3. Model numbers. This information will be made available to commission staff upon request.	2) a description of equipment specification data recorded by the program.
20VAC5-318-50 (H)	EM&V reports should include actual costs incurred by the utility and each EM&V contractor for (i) the development of the most recent EM&V plan and (ii) the administration of EM&V activities for the reporting period.	Unless otherwise noted, where applicable, costs presented in the cost effectiveness analysis chapter of the EM&V reports are inclusive of actual costs incurred by the utility and each EM&V contractor for the development of the most recent EM&V plan and the administration of EM&V activities for the reporting period.

Q. HOW DOES THE EM&V PLAN MEET THE NEED FOR A HEIGHTENED LEVEL OF EM&V RIGOR?

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

ADM will supplement the impact evaluation with International Performance Measurement and Verification Protocol ("IPMVP") Option C by performing regression analysis to assess the presence of energy savings during the period subsequent to

implementation of program measures where feasible. National Renewable Energy Laboratory ("NREL") guidance on the use of Option C analysis includes the restriction that it should be applied when expected energy savings are likely to exceed 10% of building energy consumption. Furthermore, there needs to be sufficient pre- and post-implementation data, ideally in full-year increments (e.g., 12 or 24 months pre and post).

With these limitations in mind, ADM plans to use Option C analysis for the following programs to assess the presence of energy savings:

- Commercial and Industrial (for projects completed in the first six months of the program year)
- Home Performance

Typically, Small Business Direct Install ("SBDI") project savings are less than 10% of building consumption. This is also the case for the Efficient Products and Energy Efficiency Kits programs. The evaluation of Home Energy Reports will use a randomized control group design to assess savings.

Q. PLEASE DESCRIBE THE STANDARD EM&V REPORTING REQUIREMENTS THAT WILL APPLY TO THESE PROGRAMS.

A. The standard EM&V reporting requirements are set forth in 20 VAC 5-318-50 that will apply to these new and continued DSM Programs are as follows:

- The EM&V of approved DSM measures or programs must be consistent with the Plan. Alternative methodologies may be included in the report where necessary, if appropriate documentation is provided.
- As discussed above, reports should include utility-specific data (where available), any relevant workpapers or supporting documentation, and measure-level estimates of kilowatt, kilowatt-hour, as appropriate.
- Any variances from originally approved measure-level inputs and assumptions must be documented and explained, and the impact of any such changes on original cost-benefit estimates must be quantified.

- Reports must describe the sampling plan used to collect data, any statistical calculations upon which the reported data are based, and any other methodologies relevant to data collection.
- Reports must include the actual costs incurred by the utility and each EM&V contractor for developing the EM&V plan and administering the EM&V activities in the current reporting period.
- Reports that describe any ongoing DSM measures or programs must:
    - explain the eligibility requirements for each rate schedule· to which the measures or programs are being offered;
    - include a comparison of the measured annual measure or program savings estimates to: (1) the annual usage of the average rate schedule usage and
    - eligible customer in each rate schedule to which the measures or programs are being offered; and (2) originally approved estimated savings for the measures or programs that were approved by the commission, including calculation of the expected savings as a percentage of the annual usage of the average rate schedule usage and eligible customer, as appropriate; and describe the controls used by the utility to verify that the measures were properly installed, and confirm that the Company has required its implementation contractors to record details of serviced or replaced equipment (where applicable and practicable), to include at a minimum:
        - nameplate efficiency ratings;
        - serial numbers; and
        - model numbers.

Q. WILL THE COMPANY COMPLY WITH THESE STANDARD EM&V REPORTING REQUIREMENTS PURSUANT TO 20 V AC 5-318-50 FOR NEW AND CONTINUED DSM PROGRAMS?

A. Yes. The Company and ADM intend to comply with all requirements pursuant to 20 VAC 5-318-50 for new and continued DSM Programs. The Company and ADM intend to conduct the EM&V consistent with the approaches outlined in the EM&V Plans attached hereto. If alternative methodologies are necessary, the adjustment will be described in the EM&V report along with appropriate documentation.

When impact evaluations and/or net-to-gross studies are reported, all data collection methodologies, including sampling plans, will be documented along with the results. ADM will work with the Company to include explanations of the eligibility requirements for each rate schedule to which the measures or programs are being offered in the EM&V report, and include a comparison of the EM&V reported annual measure or program savings estimates to: (1) the annual usage of the average rate schedule usage and eligible customer in each rate schedule to which the measures or programs are being offered; and (2) originally approved estimated savings for the measures or programs that were approved by the commission, including a calculation of the expected savings as a percentage of the annual usage of the average rate schedule usage and eligible customer, as appropriate.

ADM will work with the Company to describe the controls used by the utility to verify that the measures were properly installed, and confirm that the Company has required the implementation contractors to record details of services to replaced equipment, to include at a minimum, as applicable:

1. Nameplate efficiency ratings;
2. Serial numbers; and
3. Model numbers.

II. COST/BENEFIT TEST SCREENING CRITERIA AND INPUTS

Q. PLEASE DESCRIBE EACH OF THE COST/BENEFIT TESTS USED TO EVALUATE DSM PROGRAMS.

A. The Commission's cost/benefit rules require the Company to analyze its DSM programs from a multi-perspective approach using four of the standard tests from the California Standards Practice Manual: (i) the Participant Cost Test ("PCT"), (ii) Utility Cost Test ("UCT"), (iii) Total Resource Cost ("TRC") Test, and (iv) Ratepayer Impact Measure ("RIM") Test. I will briefly describe each of the tests used in the analysis of the DSM Programs. Please note that each test uses the net present value ("NPV") of costs and benefits.

Participant Cost Test

The participant cost test is the measure of the quantifiable benefits and costs to program participants due to enrollment in a program. This test indicates whether the program or measure is economically attractive to the customer. Benefits include the participant's retail bill savings over time, plus any incentives offered by the utility. Only the participant's costs are considered. The PCT is calculated by the following formula:

PCT Score = (Participant Bill Reduction + Incentives) / Participant's Cost

A PCT test result of 1.0 or higher indicates that a program passes the PCT.

Utility Cost Test

The utility cost test compares the cost to the utility to implement a program to the cost that should be avoided as a result of the program. The UCT measures the net costs and benefits of a program as a resource option, based on the costs and benefits incurred

by the utility, including incentive costs and excluding any net costs incurred by the participant. The UCT is calculated by the following formula:

UCT Score = (Avoided Capacity Benefit + Avoided Energy Benefit) / (Utility Administrative Cost + Utility Incentive Payments)

A UCT test result of 1.0 or higher indicates that a program passes the UCT.

<u>Total Resource Cost Test</u>

The total resource cost test compares the total costs and benefits to the utility and participants, relative to the costs to the utility and participants. It can also be seen as a combination of the PCT and the RIM test, measuring the impacts to the utility and all program participants as if they were treated as one group. Additionally, this test considers customer incentives as a pass through benefit to customers and, therefore, does not include customer incentives. The TRC test measures the net costs and benefits of a program as a resource option based on the total costs and benefits of the program, including both the participants' and the utility's costs and benefits. The TRC test is calculated by the following formula:

TRC Test Score = (Avoided Capacity Benefit + Avoided Energy Benefit) / (Utility Administrative Cost + Customer Costs)

A TRC test result of 1.0 or higher indicates that a program passes the TRC test.

<u>Ratepayer Impact Measure Test</u>

The ratepayer impact measure test considers equity issues related to a program. This test determines the impact a program will have on non-participants, and measures what happens to customer bills or rates due to changes in utility revenues and operating

costs attributed to the program. A RIM test score of greater than 1.0 indicates that the program is beneficial for both participants and non-participants, because it should have the effect of lowering bills or rates even for customers not participating in the program. Conversely, a score on the RIM test score of less than 1.0 indicates that the program is not as beneficial to non-participants as a group because the costs to implement the program exceed the benefits shared by all customers, including non-participants. The RIM test is calculated by the following formula:

RIM Test Score = (Avoided Capacity Benefit + Avoided Energy Benefits) / (Utility Administrative Cost + Utility Incentive Payments + Utility Lost Revenues)

A RIM test result of 1.0 or higher indicates that a program passes the RIM test.

Q. PLEASE ELABORATE ON WHAT IS INDICATED BY TEST SCORES ABOVE 1.0.

A. If the PCT score is above 1.0, this indicates that the participants will benefit from the program. If the UCT score is above 1.0, this is a lower-cost option for the utility to select, as opposed to the optimized supply-side resource mix without the program, and the utility's revenue requirement would be less overall. If the TRC test score is above 1.0, the participants and the utility are both better off with the program. If the RIM test score is above 1.0, then both participating and non-participating customers will benefit because of downward pressure on rates.

Q. PLEASE ELABORATE ON WHAT IS INDICATED BY TEST SCORES BELOW 1.0.

A. If the PCT score is below 1.0, this indicates that the participants are worse off as a result of participating in the program, and it would not likely be feasible for the utility to operate the program since most customers would not choose to participate. If the UCT score is below 1.0, this is a more costly option for the utility to select, as opposed to the optimized supply-side resource mix without the program. If the TRC test score is below 1.0, then the participants and the utility are better off financially by pursuing the optimized supply-side resource mix. If the RIM test score is below 1.0, then this indicates there may be upward pressure on rates over the long term due to a change in revenue.

Q. WHAT SCREENING CRITERIA WERE EMPLOYED IN EVALUATING PROGRAMS INCLUDED IN THIS APPLICATION?

A. All cost/benefit tests scores and NPV net benefit results were referenced in evaluating potential programs. As stated in Virginia Code Title 56 § 56-576:

"In the public interest," for purposes of assessing energy efficiency programs, describes an energy efficiency program if the Commission determines that the net present value of the benefits exceeds the net present value of the costs as determined by not less than any three of the following four tests: (i) the Total Resource Cost Test; (ii) the Utility Cost Test (also referred to as the Program Administrator Test); (iii) the Participant Test; and (iv) the Ratepayer Impact Measure Test. Such determination shall include an analysis of all four tests, and a program or portfolio of programs shall be approved if the net present value of the benefits exceeds the net present value of the costs as determined

by not less than any three of the four tests... In addition, an energy efficiency program may be deemed to be "in the public interest" if the program provides measurable and verifiable energy savings to low-income customers or elderly customers.

Additionally, all program measures were screened to confirm that the projected net present value of utility benefits associated with gross energy and demand savings exceed measure incremental cost, on average, during the 2022-2026 program years.

Q. PLEASE DESCRIBE THE DATA THAT SERVE AS INPUTS TO THE COST EFFECTIVENESS SCREENING.

A. The following are inputs to the analysis of program and portfolio cost effectiveness:

- Gross energy and demand savings.
    - ADM reviewed measure-level energy and demand savings assumptions, which are mainly sourced from the Mid-Atlantic TRM.
- Net-to-gross estimates
    - Recent evaluation research was referenced to develop program-level net-to-gross ratios for a number of programs:
        - Business Energy Solutions: Average of the program-level net-to-gross ("NTG") ratios of the 2017 Commercial & Industrial Program, 2018 Commercial & Industrial Program, 2019 C&I Standard Program, and 2019 C&I Lighting Program.
        - Small Business Direct Install: NTG ratio of the 2019 Small Business Direct Install Program.
        - Home Performance: Average of the program-level NTG ratios of the 2016 Residential Home Performance Program, 2017 Residential Home Performance Program, 2018 Residential Home Performance Program, and 2019 eScore Program.
        - Efficient Products: Average of the program-level NTG ratio of the 2017 Residential Efficient Products Program and 2018 Residential Efficient Products Program.
        - Energy Efficiency Kits: Average of the program-level NTG ratio of the 2016 Residential Home Performance Program, 2017 Residential

Home Performance Program, 2018 Residential Home Performance Program, and 2019 eScore Program.

- Bring Your Own Thermostat: NTG ratio of 1.0. The occurrence and timing of the load reducing events are under the direct control of the Company and are implemented within the context of the program.
- Home Energy Reports: NTG ratio of 1.0. Ex post net savings are estimated through randomized control group analysis in conjunction with uplift analysis, as described in Schedule 7.

- The number of measures per year
- Budgets for inducements, administration costs, program delivery costs, and EM&V costs.
- Utility Avoided Energy, Capacity, Transmission and Distribution Costs
  - These values are provided by the Company and are consistent with the latest IRP.
- Customer incremental costs
  - Measure incremental costs are taken from sources including the Mid-Atlantic TRM, the Illinois TRM, the Pennsylvania Incremental Cost Database, and other online costing resources.
- Effective useful life (EUL)
  - Measure EUL is taken from the Mid-Atlantic TRM, the Illinois TRM, the Pennsylvania TRM, and other sources. Schedule 1 presents the energy savings-weighted average EUL by program.
- Load shapes
  - These values are provided by the Company. Load shapes are applied to all program measures and used to estimate the portion of measure energy savings occurring during on-peak and off-peak times.
- System-level inputs
  - System-level inputs include the Company and customer discount rates, line losses, and avoided transmission and distribution costs. These values are provided by the company and are reflected in Schedule 2.

III. COST EFFECTIVENESS TEST RESULTS OF PROPOSED DSM PROGRAMS, INDIVIDUALLY AND AS A PORTFOLIO

Q. DID THE COMPANY CALCULATE A BENEFIT-COST RATIO FOR EACH OF THE PROGRAMS WITH MEASURABLE IMPACTS?

A. Yes, the Company calculated benefit-cost ratios for each proposed program.

Q. WHAT WERE THE COST-EFFECTIVENESS ANALYSIS RESULTS?

A. The cost effectiveness results for the combined portfolio are summarized in Table 2 below.

Table 2 – Cost-Effectiveness Results for the 2022-2026 DSM Portfolio

Metric	Participant Cost Test	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure
Benefit/Cost Ratio	8.13	2.21	1.83	0.38
Net Benefits ($000s)	278,845	64,423	53,403	-188,514
Total Benefits ($000s)	317,941	117,809	117,809	117,809
Total Costs ($000s)	39,096	53,386	64,407	306,324

Individual program cost-benefit test results are shown in Table 3 below.

Table 3 – Cost-Effectiveness Results for Each 2022-2026 DSM Program

Program	Participant Cost Test	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure
Business Energy Solutions	7.20	3.57	2.05	0.37
Small Business Direct Install	9.81	2.21	1.91	0.36
Home Performance	4.81	1.35	1.35	0.50
Efficient Products	11.78	1.41	2.03	0.35
Energy Efficiency Kits	23.10	2.01	2.02	0.34
Home Energy Reports	>>1	1.63	1.49	0.31
Bring Your Own Thermostat	>>1	1.02	1.31	1.00

The results show that the Bring Your Own Thermostat Program passes all tests, and all other programs pass all tests except for the RIM test. Detail relating to program-level cost-effectiveness results is presented in Schedule 3.

Q. DID THE COMPANY RUN SENSITIVITY ANALYSES IN ACCORDANCE WITH RULE 30(7) OF THE COMMISSION'S COST/BENEFIT RULES 20 VAC 5-304-3 (7) AND AS REQUIRED IN THE COMMISSION'S FINAL ORDER IN THE 2017 DSM PROCEEDING?

A. Yes. The Company performed sensitivity analyses by running models in which avoided energy and capacity costs varied from the base case. The high case sensitivity analysis is premised on avoided costs being equal to 115% of the base case avoided costs. The low case sensitivity analysis is premised on avoided costs being equal to 85% of the base case avoided costs. The sensitivity cost-effectiveness analyses were performed for each program individually and for the portfolio as a whole. The results of the sensitivity analyses are reflected in Schedule 5 and Schedule 6.

Q. DOES THIS CONCLUDE YOUR TESTIMONY?

A. Yes.

APCo Exhibit No. __ (DSD) Schedule 1 - Program Assumptions

Program	Average Effective Useful Life	Net-To-Gross Ratio
Business Energy Solutions	11.1	87.6%
Small Business Direct Install	8.2	90.6%
Home Performance	14.6	90.9%
Efficient Products	13.6	63.1%
Energy Efficiency Kits	10.3	90.9%
Home Energy Reports	1.0	100.0%
Bring Your Own Thermostat	1.0	100.0%

APCo Exhibit No. __ (DSD) Schedule 2 - System Level Assumptions

Variable	Value
Utility Discount Rate	7.27%
Customer Discount Rate	7.27%
kWh Line Loss Factor	1.09
kW Line Loss Factor	1.11
Avoided Transmission and Distribution Costs ($/kW)	$ 0.00

APCo Exhibit No. __ (DSD) Schedule 3 - 2022-2026 Programs Cost-Effectiveness Individual Results (000's)

Business Energy Solutions				
Variable	PCT	UCT	TRC	RIM
Total NPV Benefits	$ 189,138	$ 64,671	$ 64,671	$ 64,671
Total NPV Costs	$ 26,257	$ 18,136	$ 31,492	$ 174,942
Net Benefits NPV	$ 162,880	$ 46,535	$ 33,180	$ (110,271)
Benefit Cost Ratio	7.2	3.57	2.05	0.37

Small Business Direct Install				
Variable	PCT	UCT	TRC	RIM
Total NPV Benefits	$ 32,722	$ 11,986	$ 11,986	$ 11,986
Total NPV Costs	$ 3,336	$ 5,417	$ 6,264	$ 32,936
Net Benefits NPV	$ 29,386	$ 6,568	$ 5,722	$ (20,950)
Benefit Cost Ratio	9.81	2.21	1.91	0.36

Home Performance				
Variable	PCT	UCT	TRC	RIM
Total NPV Benefits	$ 27,088	$ 15,298	$ 15,298	$ 15,298
Total NPV Costs	$ 5,635	$ 11,302	$ 11,300	$ 30,889
Net Benefits NPV	$ 21,454	$ 3,996	$ 3,999	$ (15,591)
Benefit Cost Ratio	4.81	1.35	1.35	0.50

Efficient Products				
Variable	PCT	UCT	TRC	RIM
Total NPV Benefits	$ 41,715	$ 11,232	$ 11,232	$ 11,232
Total NPV Costs	$ 3,542	$ 7,979	$ 5,533	$ 32,285
Net Benefits NPV	$ 38,172	$ 3,253	$ 5,699	$ (21,053)
Benefit Cost Ratio	11.78	1.41	2.03	0.35

Energy Efficiency Kits				
Variable	PCT	UCT	TRC	RIM
Total NPV Benefits	$ 7,529	$ 2,644	$ 2,644	$ 2,644
Total NPV Costs	$ 326	$ 1,314	$ 1,309	$ 7,883
Net Benefits NPV	$ 7,203	$ 1,330	$ 1,335	$ (5,238)
Benefit Cost Ratio	23.1	2.01	2.02	0.34

Home Energy Reports				
Variable	PCT	UCT	TRC	RIM
Total NPV Benefits	$ 18,065	$ 6,795	$ 6,795	$ 6,795
Total NPV Costs	$ -	$ 4,163	$ 4,556	$ 22,228
Net Benefits NPV	$ 18,065	$ 2,632	$ 2,240	$ (15,433)
Benefit Cost Ratio	>>1	1.63	1.49	0.31

Bring Your Own Thermostat				
Variable	PCT	UCT	TRC	RIM
Total NPV Benefits	$ 1,684	$ 5,182	$ 5,182	$ 5,182
Total NPV Costs	$ -	$ 5,073	$ 3,954	$ 5,160
Net Benefits NPV	$ 1,684	$ 109	$ 1,229	$ 22
Benefit Cost Ratio	>>1	1.02	1.31	1.00

APCo Exhibit No. __ (DSD) Schedule 4 - 2022-2026 Portfolio Cost-Effectiveness Analysis

Program	Participant Cost Test	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure
Business Energy Solutions	7.20	3.57	2.05	0.37
Small Business Direct Install	9.81	2.21	1.91	0.36
Home Performance	4.81	1.35	1.35	0.50
Efficient Products	11.78	1.41	2.03	0.35
Energy Efficiency Kits	23.10	2.01	2.02	0.34
Home Energy Reports	>>1	1.63	1.49	0.31
Bring Your Own Thermostat	>>1	1.02	1.31	1.00

APCo Exhibit No. __ (DSD) Schedule 5 - 2022-2026 Programs Cost-Effectiveness Sensitivity Analysis Results

Business Energy Solutions (Low Case)				
Variable	PCT	UCT	TRC	RIM
Total NPV Benefits	$ 190,344	$ 55,331	$ 55,331	$ 55,331
Total NPV Costs	$ 26,422	$ 18,249	$ 31,687	$ 176,056
Net Benefits NPV	$ 163,923	$ 37,082	$ 23,643	$ (120,725)
Benefit Cost Ratio	7.2	3.03	1.75	0.31

Small Business Direct Install (Low Case)				
Variable	PCT	UCT	TRC	RIM
Total NPV Benefits	$ 32,930	$ 10,255	$ 10,255	$ 10,255
Total NPV Costs	$ 3,357	$ 5,451	$ 6,302	$ 33,144
Net Benefits NPV	$ 29,573	$ 4,804	$ 3,952	$ (22,890)
Benefit Cost Ratio	9.81	1.88	1.63	0.31

Home Performance (Low Case)				
Variable	PCT	UCT	TRC	RIM
Total NPV Benefits	$ 27,260	$ 13,088	$ 13,088	$ 13,088
Total NPV Costs	$ 5,670	$ 11,372	$ 11,370	$ 31,084
Net Benefits NPV	$ 21,590	$ 1,716	$ 1,718	$ (17,996)
Benefit Cost Ratio	4.81	1.15	1.15	0.42

Efficient Products (Low Case)				
Variable	PCT	UCT	TRC	RIM
Total NPV Benefits	$ 41,981	$ 9,610	$ 9,610	$ 9,610
Total NPV Costs	$ 3,565	$ 8,029	$ 5,568	$ 32,492
Net Benefits NPV	$ 38,416	$ 1,581	$ 4,042	$ (22,882)
Benefit Cost Ratio	11.78	1.2	1.73	0.30

Energy Efficiency Kits (Low Case)				
Variable	PCT	UCT	TRC	RIM
Total NPV Benefits	$ 7,577	$ 2,262	$ 2,262	$ 2,262
Total NPV Costs	$ 328	$ 1,323	$ 1,318	$ 7,933
Net Benefits NPV	$ 7,249	$ 940	$ 945	$ (5,671)
Benefit Cost Ratio	23.1	1.71	1.72	0.29

Home Energy Reports (Low Case)				
Variable	PCT	UCT	TRC	RIM
Total NPV Benefits	$ 18,194	$ 5,818	$ 5,818	$ 5,818
Total NPV Costs	$ -	$ 4,189	$ 4,584	$ 22,383
Net Benefits NPV	$ 18,194	$ 1,629	$ 1,235	$ (16,565)
Benefit Cost Ratio	>>1	1.39	1.27	0.26

Bring Your Own Thermostat (Low Case)				
Variable	PCT	UCT	TRC	RIM
Total NPV Benefits	$ 1,696	$ 4,439	$ 4,439	$ 4,439
Total NPV Costs	$ -	$ 5,108	$ 3,981	$ 5,196
Net Benefits NPV	$ 1,696	$ (670)	$ 458	$ (757)
Benefit Cost Ratio	>>1	0.87	1.12	0.85

Business Energy Solutions (High Case)				
Variable	PCT	UCT	TRC	RIM
Total NPV Benefits	$ 187,946	$ 73,891	$ 73,891	$ 73,891
Total NPV Costs	$ 26,095	$ 18,026	$ 31,298	$ 173,843
Net Benefits NPV	$ 161,851	$ 55,865	$ 42,593	$ (99,952)
Benefit Cost Ratio	7.2	4.1	2.36	0.43

Small Business Direct Install (High Case)				
Variable	PCT	UCT	TRC	RIM
Total NPV Benefits	$ 32,516	$ 13,694	$ 13,694	$ 13,694
Total NPV Costs	$ 3,315	$ 5,385	$ 6,226	$ 32,730
Net Benefits NPV	$ 29,201	$ 8,310	$ 7,469	$ (19,036)
Benefit Cost Ratio	9.81	2.54	2.2	0.42

Home Performance (High Case)				
Variable	PCT	UCT	TRC	RIM
Total NPV Benefits	$ 26,919	$ 17,480	$ 17,480	$ 17,480
Total NPV Costs	$ 5,600	$ 11,233	$ 11,230	$ 30,696
Net Benefits NPV	$ 21,319	$ 6,248	$ 6,250	$ (13,216)
Benefit Cost Ratio	4.81	1.56	1.56	0.57

Efficient Products (High Case)				
Variable	PCT	UCT	TRC	RIM
Total NPV Benefits	$ 41,451	$ 12,834	$ 12,834	$ 12,834
Total NPV Costs	$ 3,520	$ 7,929	$ 5,499	$ 32,081
Net Benefits NPV	$ 37,931	$ 4,904	$ 7,335	$ (19,247)
Benefit Cost Ratio	11.78	1.62	2.33	0.40

Energy Efficiency Kits (High Case)				
Variable	PCT	UCT	TRC	RIM
Total NPV Benefits	$ 7,482	$ 3,021	$ 3,021	$ 3,021
Total NPV Costs	$ 324	$ 1,306	$ 1,301	$ 7,833
Net Benefits NPV	$ 7,158	$ 1,715	$ 1,720	$ (4,812)
Benefit Cost Ratio	23.1	2.31	2.32	0.39

Home Energy Reports (High Case)				
Variable	PCT	UCT	TRC	RIM
Total NPV Benefits	$ 17,937	$ 7,758	$ 7,758	$ 7,758
Total NPV Costs	$ -	$ 4,138	$ 4,528	$ 22,076
Net Benefits NPV	$ 17,937	$ 3,620	$ 3,230	$ (14,318)
Benefit Cost Ratio	>>1	1.87	1.71	0.35

Bring Your Own Thermostat (High Case)				
Variable	PCT	UCT	TRC	RIM
Total NPV Benefits	$ 1,672	$ 5,915	$ 5,915	$ 5,915
Total NPV Costs	$ -	$ 5,039	$ 3,927	$ 5,125
Net Benefits NPV	$ 1,672	$ 876	$ 1,988	$ 790
Benefit Cost Ratio	>>1	1.17	1.51	1.15

APCo Exhibit No. __ (DSD) Schedule 6 - 2022-2026 Portfolio Cost-Effectiveness Sensitivity Analysis Results

APCo Virginia Proposed Portfolio Cost-Effectiveness Test Results Sensitivity Summary (High Case)				
Program	Participant Cost Test	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure
Business Energy Solutions	7.20	4.10	2.36	0.43
Small Business Direct Install	9.81	2.54	2.20	0.42
Home Performance	4.81	1.56	1.56	0.57
Efficient Products	11.78	1.62	2.33	0.40
Energy Efficiency Kits	23.10	2.31	2.32	0.39
Home Energy Reports	>>1	1.87	1.71	0.35
Bring Your Own Thermostat	>>1	1.17	1.51	1.15

APCo Virginia Proposed Portfolio Cost-Effectiveness Test Results Sensitivity Summary (Low Case)				
Program	Participant Cost Test	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure
Business Energy Solutions	7.20	3.03	1.75	0.31
Small Business Direct Install	9.81	1.88	1.63	0.31
Home Performance	4.81	1.15	1.15	0.42
Efficient Products	11.78	1.20	1.73	0.30
Energy Efficiency Kits	23.10	1.71	1.72	0.29
Home Energy Reports	>>1	1.39	1.27	0.26
Bring Your Own Thermostat	>>1	0.87	1.12	0.85

APCo Exhibit No. __ (DSD) Schedule 7 2022-2026 Portfolio EM&V Plan

ENERGY RESEARCH
AND EVALUATION

2022-2026 Appalachian Power Company Portfolio EM&V Plan

November 2020

PREPARED BY

ADM Associates, Inc.

PREPARED FOR

Appalachian Power Company

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1. Introduction

This document presents ADM Associates, Inc., (ADM) proposed approach to performing evaluation, measurement and verification (EM&V) activities for the programs proposed by Appalachian Power Company (herein referred to as the "Company" or "APCo") for the 2022- 2026 period. ADM has prepared an EM&V plan for each program for which EM&V is required. This document is the EM&V plan for the programs proposed by the Company.

1.1 Plan Document Structure

The document presents individual program EM&V plans in the following chapters:

- Charter 1 presents cross-cutting EM&V plan information;
- Chapter 2 presents the evaluation plan for the Commercial and Industrial program;
- Chapter 3 presents the evaluation plan for the Small Business Direct Install program;
- Chapter 4 presents the evaluation plan for the Home Performance program;
- Chapter 5 presents the evaluation plan for the Efficient Products program;
- Chapter 6 presents the evaluation plan for the Energy Efficiency Kits program;
- Chapter 7 presents the evaluation plan for the Home Energy Reports program;
- Chapter 8 presents the evaluation plan for the Bring Your Own Thermostat program; and
- Chapter 9 presents the evaluation plan for the VoltVar Voltage Control program.

1.2 Cross-Cutting EM&V Plan Information

1.2.1 EM&V Report Structure

This document describes the data collection and analysis activities that will be performed to evaluate the program portfolio. The analysis results will be presented in annual EM&V reporting. Table 1-1 presents the names of EM&V reports that ADM will deliver, along with the names of the programs associated with each report. The Commercial & Industrial Portfolio EM&V Report and the Residential Portfolio EM&V Report will each be segmented into two volumes, with the second volumes containing report appendices.

Table 1-1 List of EM&V Report Names and Associated Programs

EM&V Report Name	Names of Programs Characterized in EM&V Report
Commercial & Industrial Portfolio EM&V Report	Commercial and Industrial
	Small Business Direct Install
Residential Portfolio EM&V Report	Home Performance
	Efficient Products
	Energy Efficiency Kits
	Home Energy Reports

VoltVar Voltage Control EM&V Report	VoltVar Voltage Control

1.2.2 Estimation of Gross Energy Savings and Peak Demand Reduction

ADM will estimate the program gross energy savings (kWh) and peak demand reductions (kW) each year of the five-year period.

1.2.2.1 Compliance with Case No. PUR-2017-00047 EM&V Rules

Table 1-2 summarizes how the evaluation will comply with the rules for evaluation, measurement, and verification (EM&V) set forth in Case No. PUR-2017-00047.

Table 1-2 Compliance with Case No. PUR-2017-00047 EM&V Rules

Section	Requirement	Response
20VAC5-318-40 (A)	In all filings required by 20VAC5-318-30, the sources of all data or estimates used as inputs for proposed DSM measures or programs, in descending order of preference, shall be: 1. Utility-specific data; 2. Virginia-specific data if utility-specific data is unavailable or impracticable. When Virginia-specific data is used, the utility shall provide an explanation as to why utility-specific data is unavailable or impracticable; 3. Data from non-Virginia jurisdictions or sources, if neither utility-specific data nor Virginia-specific data is available or practicable: a. When data from non-Virginia jurisdictions or sources is used, the utility shall provide an explanation as to why utility-specific data is unavailable or impracticable. b. When data from non-Virginia jurisdictions or sources is used, the utility shall provide an explanation as to why Virginia-specific data is unavailable or impracticable as well as the sources of all data, to include: (1) Titles, version numbers, publication dates, and page numbers of all source documents, as appropriate; and (2) An explanation as to why, in the utility's assessment, use of this data is appropriate.	The methods that will be used to evaluate program impacts is provided in the methodology sections of each program chapter of this plan. The methods comply with the order of preferred data inputs cited in code 20VAC5-318-40 (A). Primary data may be supplemented by secondary data to facilitate cost efficient allocation of EM&V resources.

Section	Requirement	Response
20VAC5-318-40 (B)	EM&V reports shall include relevant workpapers, support documents, assumptions, and equations used in developing the measurement and verification methodologies of measures or programs reported.	The EM&V reports will describe the methodologies used to estimate savings for the program measures and include citations of relevant workpapers, support documents, assumptions, and equations used in developing the measurement and verification methodologies of measures or programs reported.
20VAC5-318-40 (C)	EM&V reports shall include measure-level estimates of kilowatt, kilowatt-hour, dekatherm, and pipeline capacity savings as appropriate. An estimate that has been adjusted for free-ridership as well as an estimate that has not been adjusted for free-ridership should be included as appropriate.	The cost-effectiveness analysis file submitted with the EM&V report will present measure-level estimates of peak kW and kWh energy savings.
20VAC5-318-50 (A)	EM&V of approved DSM measures or programs should be consistent with and contrasted to the preliminary EM&V plan set forth in the filings for approval of such measures or programs or as otherwise specified in a commission order approving such measures or programs. The commission recognizes that each utility has unique characteristics, and new or modified energy efficiency measures are constantly being developed. As such, alternative methodologies may be included in reporting provided that sufficient supporting documentation and explanation of appropriateness of alternative methodologies is provided.	The EM&V reports will detail any deviations from the approach submitted within this plan and the reasons for that deviation.
20VAC5-318-50 (B)	EM&V reports of existing measures or programs shall utilize utility-specific data or other data in conformance with 20VAC5-318-40 A when updating the analysis of the cost effectiveness of each measure, program, or portfolio as appropriate and practicable. EM&V reports of existing measures or	The EM&V reports will include this information.

Section	Requirement	Response
	programs shall include the information required by 20VAC5-318-40 B and C.	
20VAC5-318-50 (C)	Any changes to or variances from originally approved measure-level inputs and assumptions shall be documented and explained, and the impact of such changes on original cost/benefit estimates for DSM programs or measures shall be quantified.	The EMV&V report will present cost effectiveness analysis based on the ex ante savings estimates to characterize the discrepancy between the benefits resulting from the ex ante estimates and the ex post estimates. The presentation of savings results will include discussion of the reasons for differences between the ex ante savings and ex post savings estimates.
20VAC5-318-50 (D)	EM&V reports shall describe the methodologies by which the measured data was collected, including at a minimum: 1. The sampling plan; and 2. Statistical calculations upon which the reported data is based when applicable.	The sampling approach will be presented in the methodology section of the evaluation reports.
20VAC5-318-50 (E)	EM&V reports for ongoing DSM measures or programs shall include an explanation of eligibility requirements for each rate schedule to which the measures or programs are being offered.	The EM&V reports will provide a description of the program that includes information on the measure or program eligibility requirements as provide by the Company.
20VAC5-318-50 (F)	EM&V reports for ongoing DSM measures or programs shall include a comparison of the measured annual measure or program savings estimates to the annual usage of the average rate schedule usage and eligible customer in each rate schedule to which the measures or programs is being offered. A comparison to originally approved estimated savings for the measures or programs that were approved by the commission shall also be provided. This will include a calculation of the expected savings as a percentage of the annual usage of	The EM&V reports will present a table for each program and rate class, based on data provided by the Company, that summarizes the following information: Program Name, Rate Class, Total kWh Savings, Number of Participating Customer Accounts, Average kWh Savings per Customer

Section	Requirement	Response
	the average rate schedule usage and eligible customer as appropriate and practicable.	Account, and Average Consumption per Account for the Rate Class
20VAC5-318-50 (G)	EM&V reports for ongoing DSM measures or programs shall include a description of the controls undertaken by the utility to verify proper installation of the measures or programs, as appropriate. Additionally, utilities shall require the contractors and subcontractors that will be implementing the measures or programs, if applicable and practicable, to record details of serviced or replaced equipment, to include at a minimum: 1. Nameplate efficiency ratings; 2. Serial numbers; and 3. Model numbers. This information will be made available to commission staff upon request.	The EM&V reports will include the following information as provided by the Company or otherwise determined through the evaluation effort: 1) a description of program installation quality controls. 2) a description of equipment specification data recorded by the program.
20VAC5-318-50 (H)	EM&V reports should include actual costs incurred by the utility and each EM&V contractor for (i) the development of the most recent EM&V plan and (ii) the administration of EM&V activities for the reporting period.	Unless otherwise noted, where applicable, costs presented in the cost effectiveness analysis chapter of the EM&V reports are inclusive of actual costs incurred by the utility and each EM&V contractor for the development of the most recent EM&V plan and the administration of EM&V activities for the reporting period.

1.2.2.2 Supplementary Econometric Analysis of Energy Savings

ADM will supplement the impact evalution with IPMVP Option C by performing regression analysis to assess the presence of energy savings during the period subsequent to implementation of program measures where feasible. NREL guidance on the use of Option C analysis includes the restriction that it should be applied when expected energy savings are likely to exceed 10% of building energy consumption.

Furthermore, there needs to be sufficient pre- and post-implementation data, ideally in full-year increments (e.g., 12 or 24 months pre and post).[1]

With these limitations in mind, ADM plans to use Option C analysis for the following programs to assess the presence of energy savings:

- Commercial and Industrial (For projects completed in the first six months of the program year)
- Home Performance

Typically, Small Commercial Direct Install (SBDI) project savings are less than 10% of building consumption. This is also the case for the Efficient Products and Energy Efficiency Kits programs. The evaluation of Home Energy Reports will use a randomized control group design to assess savings (discussed in Chapter 7).

For the Commercial and Industrial Program, the Option C analysis is performed on individual sites. A site-specific approach is taken to estimate assess the presence of energy savings from program projects using consumption data. The approach uses the following regression model:

$$kWh_{monthly} = \beta 1 \#Days + \beta 2\ CDD + \beta 3\ HDD + \beta 4\ Pre_{Post} + \varepsilon$$

Table 1-3 summarizes the variables used in the model.

Table 1-3 Analysis Model Variables

Variable Name	Variable Description
$kWh_{monthly}$	Monthly kWh consumption
$\beta 1 \#Days$	Number of days for the month
$\beta 2\ CDD$	Cooling Degree Days for the month
$\beta 3\ HDD$	Heating Degree Days for the month
$\beta 4\ Pre_{Post}$	Binary Flag for Pre and Post Retrofit (Pre = 0, Post = 1)

The Option C analysis for Home Performance will use a mixed effects regression analysis with robust standard errors. Data will be limited to participants with at least six months of energy use data post measure implementation. The analysis will adjust for weather variation using site cooling degree and heating degree hours. The regression equation to be modeled is:

$$kWhit = \beta 0 + \beta 1 Post_{it} + \beta 2 CDH_{it} + \beta HDH_{it} + e_{it}$$

Table 1-4 summarizes the variables that will be used in the regression equation.

Table 1-4 Analysis Model Variables

Variable Name	Variable Description

[1] International Performance Measurement & Verification Protocol. Concepts and Options for Determining Energy and Water Savings. Volume I. Revised March 2002.

kWh	Dependent variable; participant monthly energy use.
CDH	MAX (Outdoor Temperature - 65°F, 0) calculated hourly and averaged across month.
HDH	MAX (65°F - Outdoor Temperature, 0) calculated hourly and averaged across month.
Post	1 during post-implementation period; otherwise 0.

The results of the supplementary econometric analyses will be referenced to estimate associated upper and lower bounds of estimated energy savings based on the coefficient and statistical significance of the coefficient of interest.

1.2.2.3 Calculation of kW Demand Reductions

The following methods to calculate ex post gross kW demand reduction will be applied:

- Secondary research. The Mid-Atlantic TRM or other secondary research may be referenced to calculate the measure ex post gross kW demand reductions.
- Hourly energy savings profile. In cases in which ADM has developed an 8,760 hour annual kWh savings profile, ADM may use this information to calculate ex post gross kW demand reductions. In this case, the applicable peak period referenced in the calculation of program ex post gross kW demand reductions is June through August on weekdays between 2:00 PM and 6:00 PM. The ex post gross kWh savings occurring during that time period are divided by the number of hours occurring during that time period to calculate ex post gross kW demand reductions.
- PJM 5CP. For some programs, ADM will calculate kW demand reduction as the average kW reduction occurring during the summer PJM coincident peaks (5CP). For cases in which this means of calculating kW demand reduction is applicable, the single program-level peak demand reduction will account for the kW demand reduction occurring during coincident peak hours.

Table 1-5 shows which methods to calculate ex post gross kW demand reduction will be applied to each program.

Table 1-5 Program-Level Applicability of Methods to Calculate Ex Post Gross kW Demand Reduction

Program	Secondary Research	Hourly Energy Savings Profile	PJM 5CP
Commercial and Industrial	✓	✓	
Small Business Direct Install	✓	✓	
Home Performance	✓		
Efficient Products	✓		
Energy Efficiency Kits	✓		
Home Energy Reports		✓	
Bring Your Own Thermostat			✓
VoltVar Voltage Control			✓

1.2.3 Estimation of Net Savings

Table 1-6 summarizes the net savings approach that will be used to estimate the program net savings impacts.

Table 1-6 Net Savings Approach by Program

Program and Component	Net Savings Approach
Commercial and Industrial	Participant Self-Report
Small Business Direct Install	Participant Self-Report
Home Performance	Participant Self-Report
Efficient Products (Downstream Rebates)	Participant Self-Report
Efficient Products (Midstream Lighting)	Price-Response Modeling
Energy Efficiency Kits	Participant Self-Report
Home Energy Reports	Randomized Control Group Analysis
Bring Your Own Thermostat	Stipulated NTG ratio of 1.0. The occurrence and timing of the load reducing events are under the direct control of the Company and are implemented within the context of the program.
VoltVar Voltage Control	Stipulated NTG ratio of 1.0. The voltage regulating equipment is directly under the control of the Company and is implemented within the context of the program.

Table 1-7 summarizes the program years for which ADM plans to collect self-report data to estimate net savings. For each year of the five-year period, we will collect self-report data for the Commercial and Industrial program because projects completed through commercial and industrial programs that serve larger businesses can vary significantly in size and this variation can result in varying net savings estimates from year-to-year. For the other programs, the net savings estimates tend to be relatively consistent from year-to-year. For this reason, we will use primary data collected from participants to estimate net savings twice during the five year period and apply the estimated net-to-gross ratio developed from that data to the gross savings in subsequent years subsequent years (i.e., the PY2022 estimate will be applied to PY2023 and PY2024, and the PY2025 estimate will be applied to PY2026).

What follows is a high-level description of the net savings approaches. Additional details are discussed within the individual program chapters.

Table 1-7 Program Years when Self-Report Data Will be Collected to Estimate Net Savings

Program and Component	PY2022	PY2023	PY2024	PY2025	PY2026
Commercial and Industrial	Yes	Yes	Yes	Yes	Yes
Small Business Direct Install	Yes	No	No	Yes	No
Home Performance	Yes	No	No	Yes	No
Efficient Products (Downstream Rebates)	Yes	No	No	Yes	No
Energy Efficiency Kits	Yes	No	No	Yes	No

1.2.3.1 Participant Self-Report

Participant self-report approaches use participant responses on how the program influenced the decision to install or implement the efficiency measure. Although the specifics vary by program market intervention approach, in general, the self-report methodologies use respondents' prior experience with the program measures, prior plans to install the measures, ability to afford the cost of the measures, and assessments of how the program influenced the decision to implement the measures to estimate free ridership.

We also use self-report to estimate program spillovers, or measures installed outside of the program and influenced by the program. Spillover assessment uses respondents' ratings of program influence on the decision to install the additional measures as well as self-reported characteristics of the measures to estimate additional savings attributable to the program.

1.2.3.2 Price Response Modeling

Price response modeling will be used to estimate the net impacts of midstream lighting discounts. This approach is based upon modeling the relationship between the price of the discounted bulbs and program promotional activities and the number of units sold to estimate a magnitude of the relationship between program pricing and sales. The estimate of the relationship is then used to predict the number of program sales that would occur had the program not been in place. The share of program sales that would have occurred in the absence of the program is the estimate of the net impact of the program.

1.2.3.3 Randomized Control Group Analysis

The analysis of savings resulting from the Home Energy Reports uses a randomized control group analysis and the result of the analysis is an estimate of net savings. In this savings estimation approach, the use of a randomized control allows for the estimate of the treatment effect accounting for any naturally occurring savings that may occur within the population.

1.2.3.4 Applied Net-to-Gross Ratios

ADM will apply net-to-gross ratios of 1.0 for the Bring Your Own Thermostat and VoltVar Voltage Control programs. A net-to-gross ratio of 1.0 is applied to Bring Your Own Thermostat because the timing and frequency of demand events are fully controlled by the program. Should the program not call an event, the demand event will not occur and there will not be a reduction in load. Similarly, the equipment used

to regulate voltage through the VoltVar Voltage Control program is installed and controlled by the Company and is implemented as part of the energy conservation program.

1.2.4 Process Evaluation

ADM will a process evaluation of each program twice during the five-year period. Table 1-8 summarizes the years for which a process evaluation will be completed. As shown, process evaluations will be completed for the commercial programs and the Home Performance Program in PY2022 and PY2025, and in PY2023 and PY2026 for the other residential programs. The process evaluations are staggered to effectively use evaluation resources. We selected to complete the Commercial and Industrial, Small Business Direct Install, and Home Performance programs in the first year of the five year period because each of these programs are largely trade ally driven and thus require greater coordination to be effective.

The individual program chapters discuss the planned approach to process evaluation.

Table 1-8 Program Years when Process Evaluation will be Completed

Program and Component	PY2022	PY2023	PY2024	PY2025	PY2026
Commercial and Industrial	Yes	No	No	Yes	No
Small Business Direct Install	Yes	No	No	Yes	No
Home Performance	Yes	No	No	Yes	No
Efficient Products (Downstream Rebates)	No	Yes	No	No	Yes
Energy Efficiency Kits	No	Yes	No	No	Yes
Home Energy Reports	No	Yes	No	No	Yes
Bring Your Own Thermostat	No	Yes	No	No	Yes

1.2.5 Cost Effectiveness Evaluation

ADM will analyze the final, post-implementation cost effectiveness of each program and the overall portfolio. The results of the cost effectiveness evaluation will be presented in EM&V reporting. ADM will calculate cost effectiveness using the five most widely accepted tests conducted in evaluations of energy efficiency programs across North America. These tests are summarized below :

- Utility Cost Test (UCT): Comparison of program administrator costs to resource supply costs.
- Total Resource Cost Test (TRC): Comparison of program administrator and customer costs to utility resource savings.
- Ratepayer Impact Measure Test (RIM): Impact of the program on all ratepayers, including non-participants.
- Societal Cost Test (SCT): Comparison of total societal costs to resource savings and non-monetized benefits.
- Participant Cost Test (PCT): Comparison of costs and benefits from the perspective of the customer implementing the measures.

The inputs to the cost effectiveness analysis come from multiple sources:

- The Company will provide information on avoided energy production and capacity costs, avoided costs from transmission and distribution system losses, applicable discount rates, and any administration or portfolio level costs as allocated across the portfolio of programs.
- ADM will provide net energy savings and peak demand impacts determined by the EM&V process.
- ADM will reference the following hierarchy of sources to obtain measure type, end use, incremental cost and measure life:

  1. Company planning data
  2. Mid-Atlantic TRM
  3. Program tracking data
  4. Other secondary sources, to be specified in the cost effectiveness analysis.

1.2.6 Special Studies

At the direction of the Company, ADM will complete focused technical or market studies aimed at supporting EM&V of the programs.

1.2.7 Updates to the EM&V Plan

The EM&V plan will be updated on an annual basis. Plan updates may account for revisions to the methods and data sources referenced in performing EM&V activities.

2. Commercial and Industrial

2.1 Program Description

The Commercial and Industrial program will provide standard and custom incentives to encourage businesses to make energy saving improvements to their facilities.

2.2 Data Collection

This section summarizes sampling and data collection procedures for the evaluation of the Commercial and Industrial Program.

2.2.1 Onsite and Remote Site Visits and Data Collection

2.2.1.1 Sampling Approach

ADM will select a sample of Commercial and Industrial Program projects for which ADM will perform measurement and verification (M&V) and calculate gross realized kWh savings and kW demand reductions.

A stratified sampling approach will be used to develop the M&V sample. A stratified sampling approach allows for a given statistical precision and confidence level target to be met with a smaller sample size than would be allowed by simple random sampling. Strata boundaries will be based on ex ante kWh energy savings. ADM will select a sample with a sufficient number of sample units to facilitate estimation of program ex post kWh energy savings with 10% statistical precision at a 90% confidence level.

Completed program projects accumulate over time as the program is implemented, and sample selection will likely occur at multiple points in time. The timing of sample selection will be contingent upon the timing of the completion of projects during the program year.

2.2.1.2 Data Collection

ADM anticipates that data collection for the Commercial and Industrial Program will include a mixture of remote and onsite verification. If current health conditions prevent onsite verification, ADM will use remote verification approaches.

During an on-site visit, ADM staff will accomplish three major tasks:

- First, they will verify the implementation status of all measures for which customers received incentives. They will verify that the energy efficiency measures were indeed installed, that they were installed correctly and that they still functioned properly.
- Second, they will collect the physical data, when necessary, needed to analyze the energy savings that have been realized from the installed improvements and measures. Data will be collected using a form that will be prepared specifically for the project in question after an in-house review of the project file.
- Third, they will interview the contact personnel at a facility to obtain additional information on the installed system to complement the data collected from other sources.

Monitoring may be conducted to gather additional information on the operating hours of the installed measures. Monitoring is conducted at sites for which ADM staff members determine that monitored data are necessary to minimize uncertainty associated with savings calculation of energy impacts. Monitoring is not considered necessary for sites for which other data sources and methods will support estimation of energy impacts with relatively less uncertainty.

Under certain circumstances, M&V may be completed through remote verification in lieu of site visits.

- Use a phone application that allows site staff to perform a walkthrough captured on video.
- Use telephone or email verification to perform remote verification and collect data on factors such as building operation schedules or heating and cooling types.
- For cases where Option B (retrofit isolation) would be applied, ADM may request energy use data collected through EMS systems or other onsite monitoring efforts implemented by site staff or their contractors, if available. As needed, and if acceptable to the customer, ADM will schedule video conferencing with our experienced engineers and field staff to assist customers with getting this data. As mentioned above, ADM may mail and ask customers to install and mail back monitoring equipment where the site staff have the technical resources to support the data collection effort and other M&V approaches are not viable. We will only take this approach for equipment that involves no safety risks to the customer.
- Application of IPMVP Option C (whole building analysis) for custom measures where feasible, supplemented by information collected by telephone or email on schedule and equipment changes that may have occurred during the pre-and post-installation period.

2.2.2 Participant Surveys

ADM will collect data from project decision makers to support net-to-gross and the process evaluation through online and telephone surveys. Online surveying will be the primary mode for data collection and telephone surveying will be used secondarily to reach contacts not responsive to email recruitment used for the online survey.

2.2.3 Trade ally Interviews

ADM will complete interviews with program trade allies during the years that a process evaluation is planned. The interviews will use a semi-structured interview guide to focus the discussion but allow for addressing any issues raised during the interview. We will seek to complete interviews with up to 10 trade allies. We will employ a purposive sampling approach to target interviews with a trade allies who have a mix of experience with the program and who provide varying services (e.g., lighting contractors, HVAC designers). We will offer a $50 gift card to participating trade allies and expect the interviews to last approximately 20 minutes.

2.2.4 Program Staff Interviews

ADM will complete interviews with the Company's program manager and the implementation contractors program manager during years that a process evaluation is planned. Interviews may occur during years that a process evaluation is not planned as necessary to understand changes in program design or performance.

2.3 Gross Impact Evaluation Approach

2.3.1 Review Program M&V and Due Diligence Procedures

The Company's program implementation contractor will provide documentation for the sampled energy efficiency projects undertaken at customer facilities. The first step in the evaluation effort will be to review this documentation and other program materials that are relevant to the evaluation effort.

For each sampled project, the available documentation (e.g., audit reports, savings calculation work papers, etc.) for each rebated measure will be reviewed, with attention given to the calculation procedures and documentation for savings estimates. Documentation that will be reviewed for all

sampled projects includes program forms, reports, billing system data, weather data, and any other potentially useful data. Each application will be reviewed to determine whether the following types of information had been provided:

- Documentation for the equipment changed, including (1) descriptions, (2) schematics, (3) performance data, and (4) other supporting information
- Documentation for the new equipment installed, including (1) descriptions, (2) schematics, (3) performance data, and (4) other supporting information
- Information about the savings calculation methodology, including (1) what methodology was used, (2) specifications of assumptions and sources for these specifications, and (3) correctness of calculations.

Following this review, ADM will develop recommended quality assurance/quality control (QA/QC) and due diligence procedures for program implementation contractors with the goal of minimizing the variance between ex ante and ex post energy impacts to the extent feasible and practical. Recommended QA/QC protocols may include:

- Procedures for program implementation contractors to use to document measure installation and facilitate post implementation verification;
- Recommendations for changes to data collection forms and tracking data in those cases where data necessary to estimate energy savings in accordance with the Indiana TRM is not being collected; and
- Procedures for determining baseline energy use.

In addition to the above activities, ADM will complete a review of program tracking data. The purpose of the review is to assess the sufficiency of the tracking data for supporting program implementation and evaluation. To this end, ADM will review the program data to verify that the following fields are tracked, that the fields are populated (i.e., the data is not missing), and that the values are reasonable.

- Unique customer identifier, such as customer account number;
- Customer specific such as contact name and information, building type;
- Project milestone dates such as application submission date, application approval, incentive payment (where applicable);
- Measure specific information such as:
    - type of measure;
    - specific measure;
    - ex ante measure kWh energy savings and peak kW reductions;
    - measure attributes necessary to estimate measure savings (where applicable);
    - unique measure identifier (e.g., numeric or alpha-numeric code);
    - unit serial number (where applicable);
    - incremental costs / project costs
- Vendor/Contractor business name, contact name and information (where applicable);
- Incentive amounts; and
- Application status.

2.3.2 Estimation of Sample Project Gross Savings

The method ADM employs to determine gross savings impacts is dependent upon the types of measures being analyzed. ADM typically employs a specific set of methods to determine project gross savings that is dependent upon the type of measure being analyzed. These methods are summarized in Table 2-1.

Table 2-1 Typical Methods to Determine Savings for C&I Measures

Type of Measure	Methods to Determine Savings
Lighting	Reference to data on wattages of newly-installed measures, hours-of-use data obtained from site-specific data collection (e.g., monitoring), with baseline data informed by applicable standards or pre-existing equipment characteristics. Mid-Atlantic TRM energy savings algorithm variable inputs.
HVAC (including packaged units, chillers, cooling towers, controls/EMS)s	eQUEST model using DOE-2 as its analytical engine estimating HVAC loads and calibrated with site-level billing data for large projects. Econometric analysis referencing pre- and post-implementation energy usage data and weather data. Mid-Atlantic TRM or other secondary sources if needed for smaller measures.
Motors and VFDs	Mid-Atlantic TRM. eQUEST model using DOE-2 as its analytical engine for estimating HVAC loads and calibrated with site-level billing data to establish a benchmark.
Refrigeration	Mid-Atlantic TRM; doors, controls and operation parameters verified on-site. Simulation utilizing DEER prototypical models used for refrigerated case door retrofits. Engineering analysis referencing Energy Star equations and variables.
Commercial Kitchen Equipment	Mid-Atlantic TRM or other secondary sources, if needed

Activities specified in Table 2-1 produce verified gross savings calculations for each sampled project.

A kWh energy savings gross realization rate and a peak kW reduction gross realization rate is calculated for each site that is part of the M&V sample. Sites with relatively high or low gross realization rates are analyzed to determine the reasons for the discrepancy between ex ante and ex post energy savings. The site-level gross impact analysis results for each M&V sample site will be presented in the annual program EM&V report.

2.3.3 Estimation of Program-Level kWh Energy Savings and kW Peak Reductions

The kWh gross realization rate is the ratio of sampled measure ex post gross kWh energy savings to sampled measure ex ante kWh energy savings. The kW gross realization rate is the ratio of sampled measure ex post gross kW demand savings to sampled measure ex ante kW demand savings. Since a stratified sampling approach is employed for this program, stratum-level kWh and kW gross realization rates will be developed for each sampling stratum.

Program-level gross ex post gross kWh energy savings are calculated as follows:

- The ex ante kWh energy savings of non-sampled measures are factored by the applicable stratum-level kWh gross realization rates to calculate ex post gross kWh energy savings for non-sampled measures.
- The ex post gross kWh energy savings of all sampled measures and all non-sampled measures are summed.

Program-level gross ex post gross kW demand savings are calculated as follows:

- The ex ante kW demand savings of non-sampled measures are factored by the applicable stratum-level kW gross realization rates to calculate ex post gross kW savings for non-sampled measures.
- The ex post gross kW demand savings of all sampled measures and all non-sampled measures are summed.

2.4 Net Impact Evaluation Approach

The net savings analysis is used to determine what part of the gross energy savings achieved by program participants can be attributed to the effects of the program. The net savings attributable to program participants are the gross savings less free ridership, plus spillover.

2.4.1 Estimation of Free Ridership

Information collected through a survey of a sample of program participants will be used for the net-to-gross analysis.

All survey response data are systematically reviewed by a researcher who is familiar with the program, the individual project, and the social science theory underlying the decision maker survey instrument. As part of this review, the researcher may determine whether the available information justifies modifying the free ridership score calculated in accordance with the algorithm outlined below. The free ridership score calculated in accordance with the algorithm outlined below may be revised in instances in which there are significant apparent inconsistencies between responses provided by the decision maker or in cases in which the responses are apparently invalidated by other information regarding the project. As part of this review, the researcher may communicate with the decision maker to attempt to resolve any apparent inconsistency. In some cases in which the decision maker responses are apparently inconsistent, the researcher may drop the sample point. Information on any modifications to the free ridership score along with associated rationale and references to supporting data will be presented in the EM&V reporting.

- Several factors are considered in the determination of the presence of free ridership. These include:
- Financial ability to afford the installed measure without a program rebate;
- Plans and intentions of the firm to install a measure even without support from the program;
- Influence that the program had on the decision to install a measure; and
- A firm's previous experience with a measure installed under the program.

To assess these factors, program participants are asked a series of questions about the decision to implement the program project. Based on their responses, respondents are assigned a free ridership score used to estimate the extent of project free ridership.

Several criteria are used to determine what portion of a customer's savings for a particular project should be attributed to free ridership. The first criterion is based on the response to the following two questions:

- Would you have been financially able to install the equipment or measures without the financial incentive from the [Program Name]?
- To confirm, your organization would NOT have allocated the funds to complete a similar energy saving project if the program incentive was not available. Is that correct?

If a customer answers "No" to the first question and "Yes, that is correct" to the second, a free ridership score of 0 is assigned to the project. That is, if a customer required financial assistance from the program to undertake a project, then that customer is not deemed a free rider.

For decision makers that indicate that they are able to undertake energy efficiency projects without financial assistance from the program, three factors are analyzed to determine what percentage of savings may be attributable to free ridership. The three factors are:

- Plans and intentions of firm to install a measure even without support from the program;
- Influence that the program had on the decision to install a measure; and
- A firm's previous experience with a measure installed under the program.

For each of these factors, rules are applied to develop binary variables indicating whether a participant's behavior shows free ridership. These rules make use of answers to questions on the decision maker survey questionnaire.

The first factor requires determining if a participant's intention was to install an energy efficiency measure even without the program. The answers to a combination of several questions are used with a set of rules to determine whether a participant's behavior indicates likely free ridership. Two binary variables account for customer plans and intentions: one, based on a more restrictive set of criteria that may describe a high likelihood of free ridership, and a second, based on a less restrictive set of criteria that may describe a relatively lower likelihood of free ridership.

The first, more restrictive criteria indicating customer plans and intentions that likely signify free ridership are as follows:

- The respondent answers "yes" to the following two questions: "Did you have plans to install the measure before participating in the program?" and "Would you completed the [MEASURE] project even if you had not participated in the program?"
- The respondent answers "definitely would have installed" to the following question: "If the financial incentive from the [PROGRAM] had not been available, how likely is it that you would have installed [MEASURE] anyway?"
- The respondent answers "did not affect timing of purchase and installation" to the following question: "How did the availability of information and financial incentives through the [PROGRAM] affect the timing of your purchase and installation of [MEASURE]?"
- The respondent answers "no, the program did not affect level of efficiency that we chose for equipment" in response to the following question: "Did you purchase and install the [MEASURE] earlier than you otherwise would have without the program?"

The second, less restrictive criteria indicating customer plans and intentions that likely signify free ridership are as follows:

- The respondent answers "yes" to the following two questions: "Did you have plans to install the [MEASURE] before participating in the program?" and "Would you completed the [MEASURE] project even if you had not participated in the program?"

- Either the respondent answers "definitely would have installed" or "probably would have installed" to the following question: "If the financial incentive from the [PROGRAM] had not been available, how likely is it that you would have installed [MEASURE] anyway?"
- Either the respondent answers "did not affect timing of purchase and installation" to the question: "Did you purchase and install the [MEASURE] earlier than you otherwise would have without the program?" or the respondent indicates that that while program information and financial incentives did affect the timing of equipment purchase and installation, in the absence of the program they would have purchased and installed the equipment within the next two years.
- The respondent answers "no, the program did not affect level of efficiency that we chose for equipment" in response to the following question: "Did you choose equipment that was more energy efficient than you would have chosen because of the program?"

The second factor requires determining if a customer reports that a recommendation from a Program representative or experience with the program was influential in the decision to install a particular piece of equipment or measure.

The criterion indicating that program influence may signify a lower likelihood of free ridership is that either of the following conditions is true:

- The respondent answers "very important" to the following question: "How important was previous experience with the [Program Name] in making your decision to install [Equipment/Measure]?
- The respondent answers "yes" to the following question: "Did a representative of the [Program Name] recommend that you install [Equipment/Measure]?"

The third factor requires determining if a participant in the program indicates that he or she had previously installed an energy efficiency measure similar to one that they installed under the program without an energy efficiency program incentive during the last three years. A participant indicating that he or she had installed a similar measure is considered to have a likelihood of free ridership.

The criteria indicating that previous experience may signify a higher likelihood of free ridership are as follows:

- The respondent answers "yes" to the following question: "Before participating in the [Program Name], had you installed any equipment or measure similar to [Rebated Equipment/Measure] at your facility?"
- The respondent answers "yes, purchased energy efficient equipment but did not apply for financial incentive." to the following question: "Has your organization purchased any energy efficient equipment in the last three years for which you did not apply for a financial incentive through the [Program Name?"

The four sets of rules just described are used to construct four different indicator variables that address free ridership behavior. For each customer, a free ridership value is assigned based on the combination of variables. With the four indicator variables, there are 12 applicable combinations for assigning free ridership scores for each respondent, depending on the combination of answers to the questions creating the indicator variables. Table 2-2 shows these values.

Table 2-2 Free Ridership Scoring

Indicator Variables				Free Ridership Score
Had Plans and Intentions to Install Measure without the Program? (Definition 1)	**Had Plans and Intentions to Install Measure without the Program? (Definition 2)**	**The Program had influence on Decision to Install Measure?**	**Had Previous Experience with Measure?**	
Y	N/A	Y	Y	100%
Y	N/A	N	N	100%
Y	N/A	N	Y	100%
Y	N/A	Y	N	67%
N	Y	N	Y	67%
N	Y	N	N	33%
N	N	N	Y	33%
N	Y	Y	Y	33%
N	Y	Y	N	0%
N	N	N	N	0%
N	N	Y	N	0%
N	N	Y	Y	0%

2.4.2 Estimation of Participant Spillover

Program participants may implement additional energy saving measures without receiving a program incentive because of their participation in the program. The energy savings resulting from these additional measures constitute program participant spillover effects.

To assess participant spillover savings, survey respondents are asked whether they implemented any additional energy saving measures for which they did not receive a program incentive. Respondents are also asked to provide information on the measures implemented for use in estimating the associated energy savings.

To determine if the savings from the reported measures are attributable to the program, survey respondents are asked questions about the degree to which their experience with the program influenced them to implement the measures and the likelihood of implementing the measures in the absence of the program. Specifically, respondents are asked the following questions:

- SO1: How important was your experience with the [PROGRAM_NAME] in your decision to install this lighting equipment?
- SO2: If you had NOT participated in the [PROGRAM_NAME], how likely is it that your organization would still have installed this lighting equipment?

The responses to these questions are used to develop a spillover score as follows:

$$\text{Spillover} = \text{Average}(SO1, 10 - SO2)$$

Savings from measures associated with a spillover score greater than 7 are considered attributable to the program.

All survey response data are systematically reviewed by a researcher who is familiar with the portfolio and the survey instrument. As part of this review, the researcher may determine whether the available information justifies modifying the spillover score calculated in accordance with the algorithm outlined below. The spillover score calculated in accordance with the algorithm outlined above may be revised in instances in which there are significant apparent inconsistencies between responses provided by the decision maker or in cases in which the responses are apparently invalidated by other information regarding the measure(s). As part of this review, the researcher may communicate with the respondent to attempt to resolve any apparent inconsistency. In some cases in which the responses are apparently inconsistent, the researcher may drop the sample point. Information on any modifications to the spillover score along with associated rationale and references to supporting data will be presented in the EM&V reporting.

2.5 Process Evaluation Approach

ADM will complete a process evaluation of the Commercial and Industrial Program in 2022 and 2025. The process evaluation will evaluate the program implementation and design.

Table 2-3 summarizes the research topics, questions, and data sources. ADM will address these topics through:

- Interviews with program staff and participating trade allies;
- Surveys of program participants;
- Review of program documentation including any available program manuals, contractor / vendor training materials, application forms, and the program website; and
- Review and analysis of program data.

Table 2-3 Process Evaluation Topics, Research Questions, and Data Sources

Topic	Example Research Questions	Data Sources
Measure offering and incentive design	Are there any missed opportunities for additional measures to include?	Review of program materials, trade ally, participant surveys, and staff interviews.
	Are the incentive levels appropriate?	Review of program materials, trade ally, participant surveys, and staff interviews
	How do incentives compare to those offered by other utilities in the region (e.g., Dominion)? Are they competitive with these other offerings to attract trade allies?	Review of program materials, trade ally, and staff interviews
Marketing and Outreach	Is the trade ally network comprised of the right mix of expertise?	Review of contractor network and staff interviews.
	How well is the program working with key account representatives?	Staff interviews
	Is the program providing sufficient support to trade allies and what are	Trade ally interviews and staff interviews.

Topic	Example Research Questions	Data Sources
	the activities taken to keep trade allies engaged?	
	What marketing and educational activities has the program engaged in or sponsored?	Staff interviews and program materials review.
	What aspects of the program marketing influenced customer participation?	Customer surveys.
Application Processes	Does the application process balance customer burden with the need for appropriate documentation?	Review of application materials and submission procedures. Staff interviews.
	Is the application process clear to customers and trade allies?	Trade ally interviews. Participant surveys.
Quality assurance and control	What are the criteria for verification? What levels of project review are there and are these appropriate to cost efficiently mitigate risk?	Staff interviews and program materials review.
	What are the data quality and control procedures?	Staff interviews and review of program tracking data.

PART 2

3. Small Business Direct Install

3.1 Program Description

The Small Business Direct Install program will provide energy assessments, direct install measures at no cost to the customer, and incentives for additional energy efficient equipment to nonresidential customers with a peak demand 200kW or less, served at retail by the Company who have not opted out of energy efficiency programs.

3.2 Data Collection

This section summarizes sampling and data collection procedures for the evaluation of the Small Business Direct Install (SBDI) Program.

3.2.1 Onsite and Remote Site Visits and Data Collection

3.2.1.1 Sampling Approach

ADM will select a sample of SBDI Program projects for which ADM will perform measurement and verification (M&V) and calculate gross realized kWh savings and kW demand reductions.

A stratified sampling approach will be used to develop the M&V sample. A stratified sampling approach allows for a given statistical precision and confidence level target to be met with a smaller sample size than would be allowed by simple random sampling. Strata boundaries will be based on ex ante kWh energy savings. ADM will select a sample with a sufficient number of sample units to facilitate estimation of program ex post kWh energy savings with 10% statistical precision at a 90% confidence level.

Completed program projects accumulate over time as the program is implemented, and sample selection will likely occur at multiple points in time. The timing of sample selection will be contingent upon the timing of the completion of projects during the program year.

3.2.1.2 Data Collection

ADM anticipates that data collection for the SBDI Program will largely include remote verification, but may also include on-site visits. If current health conditions prevent onsite verification, ADM will only use remote verification approaches.

The approaches to on-site and remote data collection are outlined in Section 2.2.1.

3.2.2 Participant Surveys

ADM will collect data from project decision makers to support net-to-gross and the process evaluation through online and telephone surveys. Online surveying will be the primary mode for data collection and telephone surveying will be used secondarily to reach contacts not responsive to email recruitment used for the online survey.

3.2.3 Trade ally Interviews

ADM will complete interviews with program trade allies during the years that a process evaluation is planned. The interviews will use a semi-structured interview guide to focus the discussion but allow for addressing any issues raised during the interview. We will seek to complete interviews with up to 10 trade allies. We will employ a purposive sampling approach to target interviews with a trade allies who have a mix of experience with the program and who provide varying services (e.g., lighting contractors, HVAC designers). We will offer a $50 gift card to participating trade allies and expect the interviews to last approximately 20 minutes.

3.2.4 Program Staff Interviews

ADM will complete interviews with the Company's program manager and the implementation contractors program manager during years that a process evaluation is planned. Interviews may occur during years that a process evaluation is not planned as necessary to understand changes in program design or performance.

3.3 Gross Impact Evaluation Approach

2.3.2. Review Program M&V and Due Diligence Procedures

The review of program M&V and due diligence procedures approach is discussed in Section 2.3.1.

3.3.1 Estimation of Sample Project Gross Savings

The method ADM employs to determine gross savings impacts is dependent upon the types of measures being analyzed. Categories of measures include the following:

- Lighting and lighting controls
- Motors and VFDs
- Refrigeration
- Low-flow aerators, pre-rinse spray valves, and showerheads

ADM typically employs a specific set of methods to determine project gross savings that is dependent upon the type of measure being analyzed. These methods are summarized in Table 3-1.

Table 3-1 Typical Methods to Determine Savings for Prescriptive Measures

Type of Measure	Method to Determine Savings
Lighting	Reference to data on wattages of newly-installed measures, hours-of-use data obtained from field monitoring, with baseline data informed by applicable standards or pre-existing equipment characteristics. Mid-Atlantic TRM energy savings algorithm variable inputs.
Motors and VFDs	Mid-Atlantic TRM. eQUEST model using DOE-2 as its analytical engine for estimating HVAC loads and calibrated with site-level billing data to establish a benchmark.
Refrigeration	Mid-Atlantic TRM; doors, controls and operation parameters.
Low flow faucet aerators	Project specific information on verified installed quantities and values presented in the Illinois TRM.
Low flow pre-rinse spray valves	Project specific information on verified installed quantities, GPM of efficient sprayers, and values presented Mid Atlantic TRM.
Low flow showerheads	Project specific information on verified installed quantities, GPM of efficient showerheads, and values presented in the Illinois TRM.
Strip curtains	Project specific information on verified installed quantities, square footage, and values presented in the 2016 Pennsylvania TRM.

Type of Measure	Method to Determine Savings
Auto closers for walk-in cooler/freezer doors	Fully deemed values from the 2016 Pennsylvania TRM.

Activities specified in Table 3-1 produce verified gross savings calculations for each sampled project.

A kWh energy savings gross realization rate and a peak kW reduction gross realization rate is calculated for each site that is part of the M&V sample. Sites with relatively high or low gross realization rates are analyzed to determine the reasons for the discrepancy between expected and realized energy savings. The site-level gross impact analysis results for each M&V sample site will be presented in the annual program EM&V report.

3.3.2 Estimation of Program-Level kWh Energy Savings and kW Peak Reductions

The kWh gross realization rate is the ratio of sampled measure ex post gross kWh energy savings to sampled measure ex ante kWh energy savings. The kW gross realization rate is the ratio of sampled measure ex post gross kW demand savings to sampled measure ex ante kW demand savings. Since a stratified sampling approach is employed for this program, stratum-level kWh and kW gross realization rates will be developed for each sampling stratum.

Program-level gross ex post gross kWh energy savings are calculated as follows:

- The ex ante kWh energy savings of non-sampled measures are factored by the applicable stratum-level kWh gross realization rates to calculate ex post gross kWh energy savings for non-sampled measures.
- The ex post gross kWh energy savings of all sampled measures and all non-sampled measures are summed.

Program-level gross ex post gross kW demand savings are calculated as follows:

- The ex ante kW demand savings of non-sampled measures are factored by the applicable stratum-level kW gross realization rates to calculate ex post gross kW savings for non-sampled measures.
- The ex post gross kW demand savings of all sampled measures and all non-sampled measures are summed.

3.4 Net Impact Evaluation Approach

3.4.1 Estimation of Free Ridership

The free ridership approach that is discussed in Section 2.4 will also be used to assess the net impacts of the major incentivized measures installed through the SBDI program.

The approach for the no-cost direct install measures is described below.

In this methodology, respondents who indicate a lack of financial ability to pay for the free measures are deemed to not be free riders. Respondents indicate a lack of financial ability by responding "No" to the question: "Would your organization have been financially able to install the [MEASURE] at the [LOCATION] location if they were not provided for free through the program?"

For all other respondents, free ridership is determined based on the presence of prior plans to install the measures and previous experience with the measures.

Two sets of criteria – a more restrictive set and a less restrictive set – were used to determine if participants had prior plans to install the measures. The first more restrictive criteria are met if the respondent provides the following responses to each of the following questions.

- The respondent answered "yes" to the following two questions: "Did you have plans to install the [MEASURE] at the [LOCATION] location before receiving them for free through the program?" and "Would you have gone ahead with this installation even if you had not received them for free through the program?"
- The respondent answered "definitely would have installed" to the following question: "How likely is it that you would have installed the [MEASURE] at this location if you did not get them for free?"
- The respondent answered "no, program did not affect timing of purchase and installation" to the following question: "Did you install the [MEASURE] earlier than you otherwise would have without the program?"
- The respondent answered "No, program did not affect quantity" to the question "Did you install more [MEASURE] than you would have if they had not been provided for free through the program?"

The second less restrictive criteria are met if the following responses are given to the following questions:

- The respondent answered "yes" to the following two questions: "Did you have plans to install the [MEASURE] at the [LOCATION] location before receiving them for free through the program?" and "Would you have gone ahead with this installation even if you had not received them for free through the program?"
- The respondent answered either "definitely would have installed" or "probably would have installed" to the following question: "How likely is it that you would have installed the [MEASURE] at this location if you did not get them for free?"
- The respondent answered "no, program did not affect timing of purchase and installation" to the following question: "Did you install the [MEASURE] earlier than you otherwise would have without the program?" or the respondent said that while the program did affect the timing of the installation, they would have installed the same measures within two years of when they were installed.
- The respondent either answered "No, program did not affect quantity" or "Yes, would have installed some of the [Measures]" to the question "Did you install more [MEASURE] than you would have if they had not been provided for free through the program?"

Customers who demonstrate that they had previous experience with the measure by answering "Yes" to the following question may signify a higher level of free ridership.

- Did you have any [MEASURE] installed at the [LOCATION] location before you received some for free through the program?

The three sets of rules just described were used to construct three different indicator variables that address free ridership behavior. For each participant and measure, a free ridership value was assigned based on the combination of variables. The assigned free ridership based on the combination of those variables is shown in Table 3-2.

Table 3-2 Free Ridership Scoring

Indicator Variables			Free Ridership Score
Had Plans and Intentions to Install Measure without the Program? (Definition 1)	Had Plans and Intentions to Install Measure without the Program? (Definition 2)	Had Previous Experience with Measure?	
Y	N/A	Y	100%
Y	N/A	N	67%
N	Y	Y	100%
N	Y	N	33%
N	N	Y	33%
N	N	N	0%

3.4.2 Estimation of Participant Spillover

The same approach discussed for the Commercial and Industrial Program in Section 2.4.2 will be used to estimate spillover for the SBDI Program.

3.5 Process Evaluation Approach

ADM will complete a process evaluation of the Commercial and Industrial Program in 2022 and 2025. The process evaluation will evaluate the program implementation and design.

Table 2-3 summarizes the research topics, questions, and data sources. ADM will address these topics through:

- Interviews with program staff and participating trade allies;
- Surveys of program participants;
- Reviews of program documentation including any available program manuals, contractor / vendor training materials, application forms, and the program website; and
- Review and analysis of program data.

Table 3-3 Process Evaluation Topics, Research Questions, and Data Sources

Topic	Example Research Questions	Data Sources
Measure offering and incentive design	Are there any missed opportunities for additional measures to include?	Review of program materials, trade ally, participant surveys, and staff interviews.
	Are the incentive levels appropriate?	Review of program materials, trade ally, participant surveys, and staff interviews
	How do incentives compare to those offered by other utilities in the region (e.g., Dominion)? Are they competitive	Review of program materials, trade ally, and staff interviews

Topic	Example Research Questions	Data Sources
	with these other offerings to attract trade allies?	
Marketing and Outreach	Are there trade allies in the network to install non-lighting measures?	Review of contractor network and staff interviews.
	What marketing and collateral is developed for use by trade allies? Is it used and is it effective?	Staff interviews, trade ally interviews. Program materials review.
	Is the program providing sufficient support to trade allies and what are the activities taken to keep trade allies engaged?	Trade ally interviews and staff interviews.
	How do trade allies target qualified customers and qualify them for the program?	Staff interviews, trade ally interviews. Program materials review.
	What aspects of the program marketing influenced customer participation? What concerns did they have about participating?	Customer surveys.
Project implementation process	Does the application process balance customer burden with the need for appropriate documentation?	Review of application materials and submission procedures. Staff interviews.
	What is the energy audit process? Is it comprehensive in terms of systems and measure types?	Staff and document review. Trade ally interviews.
	How are multi-measure projects handled? Does the design facilitate or hinder multiple measure types?	Staff and document review. Trade ally interviews.
	Is the application process clear to customers and trade allies?	Trade ally interviews. Participant surveys.
Quality assurance and control	What are the criteria for verification? What levels of project review are there and are these appropriate to cost efficiently mitigate risk?	Staff interviews and program materials review.
	What qualifications are required for trade allies? What training are the provided?	Staff interviews and program materials review.
	What are the data quality and control procedures?	Staff interviews and review of program tracking data.

4. Home Performance

4.1 Program Description

The Home Performance program will provide customers with a comprehensive home energy assessment, direct install measures at no cost to the customer, and rebates for additional energy efficiency measures.

4.2 Data Collection

This section summarizes sampling and data collection procedures for the evaluation of the Home Performance Program.

4.2.1 Participant Surveys

ADM will collect data from program participants using online surveys. The survey data will be used to:

- Verify the measures installed or incentivized through the program;
- Collect data on decision making to estimate program net savings; and
- Collect feedback from participants on their experience with the program.

For the surveys, ADM will attempt a census of participants with the goal of obtaining enough responses to achieve the minimum sample size for these participant surveys needed to meet 90% confidence and 10% statistical precision (90/10) for the verification rates. We estimate that the number needed to achieve this level of precision and confidence will be 68. We will use telephone surveying to complete additional surveys if online surveys are not sufficient to reach the targeted sample size.

4.2.2 Onsite Data Collection

4.2.2.1 Sampling Approach

ADM may recruit customers for on-site visits or remote data collection through the sample of survey respondents. The site visits serve multiple purposes:

- They provide a quality control check on the verification rates developed through the survey of program participants. During the site visits our staff verify the measures installed and seek to identify any discrepancies with the telephone survey results.
- They are used to verify that the measures were installed correctly, and that they were functioning properly. Photographs are taken to document measure installation.
- Data collected at each site is focused on obtaining more specific information regarding the characteristics of the home where the measures were implemented.
- They provide an opportunity to identify any missed opportunities where additional measures could have been implemented but were overlooked or refused.

To encourage customers to participate in the site visits, we will offer a $25 gift card for their participation.

4.2.3 Trade ally Interviews

ADM will complete interviews with program trade allies during the years that a process evaluation is planned. The interviews will use a semi-structured interview guide to focus the discussion but allow for addressing any issues raised during the interview. We will seek to complete interviews with up to 10 trade allies. We will employ a purposive sampling approach to target interviews with a trade allies who have a

mix of experience with the program. We will offer a $50 gift card to participating trade allies and expect the interviews to last approximately 20 minutes.

4.2.4 Program Staff Interviews

ADM will complete interviews with the Company's program manager and the implementation contractors program manager during years that a process evaluation is planned. Interviews may occur during years that a process evaluation is not planned as necessary to understand changes in program design or performance.

4.3 Gross Impact Evaluation Approach

4.3.1 Review Program M&V and Due Diligence Procedures

ADM will review the program tracking data maintained by the program implementation contractor. The first aspect of conducting measurements of program activity is to verify that the tracking data report of participants and measures is accurate. To this end, ADM will review the program data to verify that the fields required for performing the evaluation are tracked and populated (i.e., the data is not missing) and that the values are reasonable. ADM will take several steps in verifying the number of weatherproofing measures installed, which consists of the following:

- Validating program tracking data by checking for duplicate or erroneous entries;
- Performing site visits to a sample of participants' homes to confirm that measures were installed in the quantity and specifications claimed; and
- Conducting verification surveys with a sample of program participants to verify that customers listed in the program tracking database did indeed participate and that the number of measures claimed to be installed is accurate.

ADM will also perform a review of the savings estimates used to calculate ex ante energy impacts for installed measures. This evaluation activity is intended to verify that the ex ante calculations are consistent with algorithms and values used in the evaluation of program savings.

Following this review, ADM will develop recommended quality assurance/quality control (QA/QC) and due diligence procedures for program implementation contractors with the goal of minimizing the variance between ex ante and ex post energy impacts to the extent feasible and practical. Recommended QA/QC protocols may include:

- Procedures for program implementation contractors to use to document measure installation and facilitate post implementation verification;
- Recommendations for changes to data collection forms and tracking data in those cases where data necessary to estimate energy savings in accordance with the Indiana TRM is not being collected; and
- Procedures for determining baseline equipment.

As applicable, ADM will present recommendations relating to program-level QA/QC, inspection and due diligence procedures in ad hoc reports to the Company.

4.3.2 Estimation of Gross Savings and Peak Demand Reductions

The method ADM employs to determine gross savings impacts is dependent upon the types of measures being analyzed. Categories of measures include the following:

- Low-flow faucet aerators;

- Low-flow showerheads;
- Pipe insulation;
- Water heater tank wrap;
- Smart thermostats;
- Attic insulation;
- Air sealing; and
- Screw-in LEDs.

4.3.2.1 Low Flow Faucet Aerator

The methodology specified in the Faucet Aerators section of the Mid-Atlantic TRM will be used to calculate energy and peak demand impacts for the installation of a low flow faucet aerator.

The following equation will be used to calculate gross ex post annual energy savings:

$$\Delta kWh = \frac{\left((GPM_{base} \times Throttle_{base}) - (GPM_{low} \times Throttle_{low})\right) \times Time_{faucet} \times \#people \times \frac{days}{year} \times DR \times 8.3 \times (T_{ft} - T_{in})}{\eta DHW \times 3{,}412}$$

Table 4-1 summarizes the values used for the equation parameters.

Table 4-1 Low Flow Faucet Aerator Energy Savings Calculation Values

Parameter	Value or Definition
GPM_{base}	Gallons per minute of baseline faucet
$Throttle_{base}$	83%
$GPMl_{ow}$	Gallons per minute of low flow faucet; rated flow rate of unit installed or actual flow rate if baseline flow rate used
$Throttle_{low}$	95%
$Time_{faucet}$	Average minutes of faucet use per day per person
#people	Average number of people per household
Days/year	Number of days faucet used per year
DR	Percentage of water flowing down drain
8.3	Constant to convert gallons to pounds
T_{ft}	Assumed temperature of water used by faucet
T_{in}	Assumed temperature of water entering house
ηDHW	Recovery efficiency of electric domestic hot water heater
3,413	Conversion from BTU to kWh

Gross ex post peak demand reduction will be calculated using the following equation defined in the Mid-Atlantic TRM:

$$\Delta kW = \frac{\Delta kWh}{Hours} \times CF$$

Table 4-2 Low Flow Faucet Aerator Peak Demand Calculation Values

Parameter	Value or Definition
Hours	Average number of hours per year spent using faucet (#people × Timefaucet / 60 × 365)
CF	Summer peak coincidence factor for measure

4.3.2.2 Low Flow Showerhead

The methodology specified in the Low Flow Shower Head section of the Mid-Atlantic TRM will be applied to calculate energy and peak demand impacts resulting from the installation of low-flow shower heads.

The following equation will be used to calculate gross ex post annual energy savings:

$$\Delta kWh = \frac{(GPM_{base} - GPM_{low}) \times Time_{shower} \times \#people \times Showers_{person} \times \frac{days}{year} \times 8.3 \times (T_{sh} - T_{in})}{\frac{ShowerHeads}{home} \times \eta DHW \times 3{,}412}$$

Table 4-3 Low Flow Showerhead Energy Savings Calculation Values

Parameter	Value or Definition
GPM_{base}	Gallons per minute of baseline showerhead
GPM_{low}	Gallons per minute of low flow showerhead; rated flow rate o
	unit installed or actual flow rate if baseline flow rate used
Timeshower	Average minutes of showerhead use per day per person
#people	Average number of people per household
Showersperson	Average number of showers taken per person per day
Days/year	Number of days shower used per year
ShowerHeads/home	Average number of showers in the home
8.3	Constant to convert gallons to pounds
T_{sh}	Assumed temperature of water used for shower
T_{In}	Assumed temperature of water entering house
ηDHW	Recovery efficiency of electric domestic hot water heater
3,413	Conversion from BTU to kWh

Part 4

Gross ex post peak demand reduction will be calculated using the following equation defined in the Mid-Atlantic TRM:

$$\Delta kW = \frac{\Delta kWh}{Hours} \times CF$$

Table 4-4 Low Flow Showerhead Peak Demand Calculation Values

Parameter	Value or Definition
Hours	Average number of hours per year spent using faucet (#people × Timefaucet / 60 × 365)
CF	Summer peak coincidence factor for measure

4.3.2.3 Hot Water Heater Pipe Insulation

The methodology specified in the DHW Pipe Insulation section of the Mid-Atlantic TRM will be applied in calculating deemed energy and peak demand impacts from adding insulation to an un-insulated domestic hot water heater pipe.

The following equation will be used to calculate gross ex post annual energy savings:

$$\Delta kWh = \frac{\left(\frac{1}{R_{Exist}} - \frac{1}{R_{New}}\right) \times L \times C \times \Delta T \times 8{,}760}{\eta DHW \times 3{,}413}$$

Table 4-5 How Water Heater Pipe Insulation Energy Savings Calculation Values

Parameter	Value or Definition
R_{Exist}	= Assumed R-value of existing un-insulated piping
R_{New}	= R-value of existing pipe plus installed insulation
L	= Length of insulated piping (ft)
C	= Circumference of piping (ft)
ΔT	= Temperature difference between water in pipe and ambient air (°F)
8,760	= Hours per year
ηDHW	= Recovery efficiency of electric domestic hot water heater
3,413	= Conversion from BTU to kWh

Gross ex post peak demand reduction will be calculated using the following equation defined in the Mid-Atlantic TRM:

$$\Delta kW = \frac{\Delta kWh}{8760}$$

4.3.2.4 Hot Water Heater Tank Insulation

The methodology specified in the Domestic Hot Water Tank Wrap section of the Mid-Atlantic TRM will be applied in calculating deemed energy and peak demand impacts from adding insulation to the outside of an un-insulated or poorly insulated domestic hot water heater tank.

The following equation will be used to calculate gross ex post annual energy savings:

$$\Delta kWh = \frac{((U_{base} \times A_{base}) - (U_{insul} \times A_{insul})) \times \Delta T \times 8{,}760}{\eta DHW \times 3{,}413}$$

Table 4-6 Hot Water Heater Tank Insulation Energy Savings Calculation Values

Parameter	Value or Definition
U_{base}	Overall heat transfer coefficient of hot water heater tank prior to adding tank wrap (BTU/Hr-F-ft^2)
A_{base}	Surface area of storage tank prior to adding tank wrap (ft^2)
U_{insul}	Overall heat transfer coefficient of hot water heater tank after adding tank wrap (BTU/Hr-F-ft2)
A_{insul}	Surface area of storage tank after adding tank wrap (ft^2)
ΔT	Average temperature difference between water in storage tank and ambient air (°F)
8,760	Hours per year
ηDHW	Recovery efficiency of electric domestic hot water heater
3,413	Conversion from BTU to kWh

Gross ex post peak demand reduction will be calculated using the following equation defined in the Mid-Atlantic TRM:

$$\Delta kW = \frac{\Delta kWh}{8760}$$

4.3.2.5 Smart Thermostats

The methodology specified in the Smart Thermostat section of the Mid-Atlantic TRM will be used to calculate energy and peak demand impacts from smart thermostats.

The following equation will be used to calculate gross ex post annual energy savings:

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

$$\Delta kWh_{cool} = \frac{CCAP}{SEER} \; X \; EFLH_C \; X \; Cooling\_Savings\_\%$$

$$\Delta kWh_{heating} = \frac{HCAPelec}{HSPF} \; X \; EFLH_h \; X \; Elec\_Heating\_Savings\_\%$$

Table 4-7 Smart Thermostats Energy Savings Calculation Values

Parameter	Value or Definition
CCAP	Cooling capacity of existing AC unit, in kBTU/hr.
HCAPelec	Heating capacity of existing electric heat unit, in kBTU/hr.
SEER	SEER of controlled unit. If unknown use current energy code requirements for mechanical cooling efficiency.
HSPF	HSPF of controlled unit. If unknown use current energy code requirements for
EFLHcool	Full load hours for cooling equipment. Location dependent.
EFLHheat	Full load hours for heating equipment. Location dependent
Elec_Heating_Saving_%	6%
Cooling_Saving_%	7%

There are no demand savings from the smart thermostat outside of a demand response program.

4.3.2.6 Attic Insulation

The methodology specified in the Attic/ceiling/roof insulation section of the Mid-Atlantic TRM will be used to calculate energy and peak demand impacts from adding attic insulation to participant homes.

The following equation will be used to calculate gross ex post annual energy savings:

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

$$\Delta kWh_{cool} = \frac{\left(\frac{1}{R_{Exist}} - \frac{1}{R_{New}}\right) \times CDH \times DUA \times Area \times Adj_{cool}}{1{,}000 \times \eta Cool}$$

$$\Delta kWh_{heat} = \frac{\left(\frac{1}{R_{Exist}} - \frac{1}{R_{New}}\right) \times HDD \times 24 \times Area \times 293.1 \times Adj_{heat}}{1{,}000{,}000 \times \eta Heat}$$

Table 4-8 Air Insulation Energy Savings Calculation Values

Parameter	Value or Definition
RExist	R-value of roof assembly plus any existing insulation (minimum of R-5)
R_{New}	R-value of roof assembly plus any new insulation
CDH	Cooling degree hours, dependent on location
DUA	Discretionary use adjustment
Area	Square footage of area covered by new insulation
Adj_{cool}	0.8

ηCool	Efficiency in SEER of central cooling equipment (kBTU/kWH)
HDD	Heating degree days, dependent on location
293.1	Converts MMBTU to kWh
Adj_{heat}	0.6
1,000,000	Converts BTU to MMBTU
ηHeat	Efficiency in COP of heating equipment (kBTU/kWH)

Gross ex post peak demand reduction will be calculated using the following equation defined in the Mid-Atlantic TRM:

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

Table 4-9 Low Flow Showerhead Peak Demand Calculation Values

Parameter	Value or Definition
ΔkWh_{cool}	Cooling energy savings from reduction in air conditioning load
$EFLH_{cool}$	Equivalent full load cooling hours, dependent upon location
CF	Summer system peak coincidence factor for central cooling equipment

4.3.2.7 Air Sealing

The methodology specified in the Air Sealing section of the Mid-Atlantic TRM will be applied to calculate energy and peak demand impacts resulting from the installation of low-flow shower heads.

The following equations from the section was used to calculate gross ex post annual energy savings:

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

$$\Delta kWh_{cool} = \frac{(CFM50_{Exist} - CFM50_{New}) \times 60 \times CDH \times DUA \times 0.018 \times LM}{N - cool \times 1{,}000 \times \eta Cool}$$

$$\Delta kWh_{heat} = \frac{(CFM50_{Exist} - CFM50_{New}) \times 60 \times 24 \times HDD \times 0.018 \times 293.1}{N - heat \times 1{,}000{,}000 \times \eta Heat}$$

Table 4-10 Air Sealing Energy Savings Calculation Values

Parameter	Value or Definition
$CFM50_{Exist}$	Blower door result prior to air sealing

$CFM50_{New}$	Blower door result after to air sealing
N-cool	Conversion from CFM50 to CFMNatural, dependent on location and number of stories
CDH	Cooling degree hours, dependent on location
DUA	Discretionary use adjustment
ηCool	Efficiency in SEER of central cooling equipment (kBTU/kWH)
LM	Latent multiplier to account for latent cooling demand
N-heat	Conversion from CFM50 to CFMNatural, dependent on location and number of stories
HDD	Heating degree days, dependent on location
ηHeat	Efficiency in COP of heating equipment (kBTU/kWH)
293.1	Converts MMBTU to kWh

Gross ex post peak demand reduction will be calculated using the following equation defined in the Mid-Atlantic TRM:

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

Table 4-11 Low Flow Showerhead Peak Demand Calculation Values

Parameter	Value or Definition
ΔkWh_{cool}	Cooling energy savings from reduction in air conditioning load
$EFLH_{cool}$	Equivalent full load cooling hours, dependent upon location
CF	Summer system peak coincidence factor for central cooling equipment

4.3.2.8 LED Lighting

The methodology specified in the ENERGY STAR Integrated Screw Based SSL (LED) section of the Mid-Atlantic TRM will be used to calculate deemed energy and peak demand impacts from the direct installation of LED lamps.

The following equation from the section will be used to calculate gross ex post annual energy savings:

$$\Delta kWh = \frac{(WattsBase - WattsEE)}{1{,}000} \times ISR \times HOURS \times (WHFe_{heat} + (WHFe_{cool} - 1))$$

Table 4-12 LED Lighting Energy Savings Calculation Values

Parameter	Value or Definition
WattsBase	Baseline bulb wattage based on lumens of LED

WattsEE	Actual wattage of installed LED lamp
ISR	In-service rate or percentage of distributed units that are installed, as determined though analysis of customer survey response data
HOURS	Average hours of use per year
$WHFe_{heat}$	Waste heat factor for energy to account for electric heating savings from reducing waste heat from efficient lighting
$WHFe_{cool}$	Waste heat factor for energy to account for cooling savings from reducing waste heat from efficient lighting

Gross ex post peak demand reduction will be calculated using the following equation defined in the Mid-Atlantic TRM:

$$\Delta kWh = \frac{(WattsBase - WattsEE)}{1{,}000} \times ISR \times WHFd \times CF$$

Table 4-13 LED Lighting Peak Demand Calculation Values

Parameter	Value or Definition
WHFd	Waste heat factor for demand to account for cooling savings from reducing waste heat from efficient lighting
CF	Summer peak coincidence factor for measure

4.4 Net Impact Evaluation Approach

4.4.1 Free Ridership Estimation – Direct Install Measures

ADM will develop free ridership estimates for the direct install measures based on survey responses to questions about the following factors:

- Prior planning to purchase energy efficiency measures that were provided through the program;
- The likelihood of having participated the items in the absence of the program;
- The number of items the customer planned on purchasing; and
- Demonstrated behavior in purchasing similar equipment absent Program assistance.

Participant response will be used to develop a free ridership score based on the presence of prior plans to install the measure, the likelihood of installing the measure in the absence of the program, and a quantity adjustment based on the number of items the respondent expected to install in the absence of the program.

4.4.1.1 Prior Planning

The presence of prior plans to install the items will be determined from respondents stated presence of prior plans and the participants previous experience installing the items. Specifically, evidence of prior plans will be based on responses to the following questions:

- Had you purchased and installed any [MEASURE] before you received them for free through the program?

- Did you have plans to purchase and install [MEASURE] before you learned about the program?

Participants who do not have prior plans to install the measures or that they had not previously purchased them will be assigned a free ridership score of 0%. For all other respondents, a free ridership score will be developed based on their likelihood of installing the item and the number of items they expected to install.

4.4.1.2 Likelihood of Purchasing Items without the Program

Participants will be asked about the likelihood of installing the items had they not been provided for free through the program. Specifically, participants will be asked:

- If you had not received them for free through the program, how many of the [MEASURE] that you received would you have purchased and installed on your own within 12 months?

A likelihood of installing the measure in the absence of the program score will be developed by dividing the participants 0 to 10 response by 10.

4.4.1.3 Quantity Adjustment

Participants will be asked to report on the number of measures that they believe they would purchase in the next 12 months had they not been provided through the program. The response to this question will be used to calculate a quantity adjustment that was equal to the number of items the respondent believed they would purchase divided by the total number of items that they received.

4.4.1.4 Overall Free Ridership Score

The overall free ridership score will be equal to 0 for participants who did not meet the criteria for the presence of prior plans. For all other respondents, the free ridership score will be calculated as equal to the likelihood of installing the items score multiplied by the quantity adjustment.

4.4.2 Free Ridership Estimation – Major (Rebated) Measures

ADM will develop free ridership estimates for the major measures based on survey responses to questions about the following factors:

- Financial ability to install the measures;
- Prior planning to purchase energy efficiency measures provided through the program;
- The likelihood of having participated the items in the absence of the program; and
- The program impact on timing of measure installation.

4.4.2.1 Financial Ability

Participants will be asked the following question about their financial ability to pay for the rebated measure:

- Would you have been financially able to install the [MEASURE] without the financial assistance provided through the program?

Participants who indicated that they would not have been able to install the measures will be deemed to not be free riders.

4.4.2.2 Prior Planning

Two questions will be used to assess the presence of prior plans to install the measure before learning about the program:

- Prior to learning about the program, did you have plans to install the [MEASURE]?

Respondents who answer yes to this question will be determined to not be free riders and will be assigned a free ridership score of 0%.

4.4.2.3 Likelihood of Purchasing Items without the Program

Participants will be asked about the likelihood of installing the items had they not been provided for free through the program. Specifically, participants will be asked:

- On a scale of 0 to 10 where 0 represents "Not at all likely" and 10 represents "Very likely," how likely is it that you would have installed the same [MEASURE] if it was not recommended through the home energy assessment?
- On a scale of 0 to 10 where 0 represents "Not at all likely" and 10 represents "Very likely," how likely is it that you would have installed the same [MEASURE] if the financial assistance was not available?

A likelihood of installing the measure in the absence of the program score will be developed by dividing the minimum of the participants 0 to 10 response to the two questions listed above by 10.

4.4.2.4 Timing Adjustment

The following two questions will be asked to assess program impacts on the deferral of free ridership:

- Did you install the [MEASURE] sooner than you would have if the information and financial assistance from the program had not been available?
- When might you have installed the same [MEASURE] if you had not participated in the program?

Based on responses to this question, a timing adjustment score will be developed in the following manner:

Table 4-14 Timing Score

Response Option	Timing Score
Within 6 months of when you purchased it	0.75
Between 6 months and 1 year	0.25
In more than 1 year to 2 years	0
In two years or more	0
Don't know	0.5

4.4.2.5 Overall Free Ridership Score

Participants who indicated that they could not have afforded to install the efficiency measures without the financial support of the program, or who indicated that they did not have prior plans to install the measures will be assigned a free ridership score of 0. For all other respondents, a free ridership score will be developed by multiplying the likelihood of implementing the measure in the absence of the program by the timing score.

4.4.3 Spillover Estimation

ADM will use participant survey to assess participant spillover. The survey questions will be designed to gather information regarding:

- Whether program participants have purchased and installed additional, non-incentivized energy saving measures since participating in the program;
- Which additional, non-incentivized energy saving measures program participants have purchased and installed since participating in the program; and
- The extent to which the program influenced the purchase of these additional non-incentivized energy saving measures.

Survey respondents were first asked the following question:

- "Because of your experience with the program, have you bought any additional energy efficient items on your own without a financial incentive or utility rebate?"

Respondents answering "Yes" to the above question will be asked additional questions about the type of measure(s) installed and other information about the measures necessary to estimate the savings resulting from the measures.

Respondents who indicate that they have installed at least one additional energy efficient measure since participating in the program will be asked two questions to determine the level of influence that the program may have had on the decision to purchase and install the item(s).

- SO1: "On a scale of 0 to 10, where 0 represents "Not at all important" and 10 represents "Extremely important", how important was your experience with the eScore Program in your decision to purchase and install these additional items?"
- SO2: "On a scale of 0 to 10, where 0 represents "Not at all likely" and 10 represents "Extremely likely", how likely would you have been to purchase these additional non-rebated energy efficient items if you had never participated in the eScore Program?"

The Program Influence Score (PI Score) will be calculated as the average of the responses to these two questions, where the numeric scale from SO2 is reversed by subtracting the SO2 score from 10 total possible points:

$$\text{PI Score}=((\text{SO1 Score})+(10-\text{SO2 Score}))/2$$

For example, a respondent providing a rating of 9 to SO1 and a rating of 3 to SO2 would receive a PI Score as follows:

$$\text{PI Score}=(9+(10-3))/2$$

$$\text{PI Score}=8$$

Respondents whose PI Scores are above 7 are considered to have made additional energy efficiency purchases that were significantly influenced by the program and the savings of the associated measures are attributed to the program as spillover.

4.5 Process Evaluation Approach

ADM will complete a process evaluation of the Home Performance in 2022 and 2025. The process evaluation will evaluate the program implementation and design.

Table 2-3 summarizes the research topics, questions, and data sources. ADM will address these topics through:

- Interviews with program staff and participating trade allies;
- Surveys of program participants;

- Reviews of program documentation including any available program manuals, contractor / vendor training materials, application forms, and the program website; and
- Review and analysis of program data.

Table 4-15 Process Evaluation Topics, Research Questions, and Data Sources

Topic	Example Research Questions	Data Sources
Measure offering and incentive design	Are there any missed opportunities for additional measures to include?	Review of program materials, trade ally, participant surveys, and staff interviews.
	Are the incentive levels appropriate?	Review of program materials, trade ally, participant surveys, and staff interviews
	How do incentives compare to those offered by other utilities in the region (e.g., Dominion)? Are they competitive with these other offerings to attract trade allies?	Review of program materials, trade ally, and staff interviews
	At what rate to energy assessments convert to incentive projects?	Tracking data review
Marketing and outreach	What marketing and collateral is developed for use by trade allies? Is it used and is it effective?	Staff interviews, trade ally interviews. Program materials review.
	Is the program providing sufficient support to trade allies and what are the activities taken to keep trade allies engaged?	Trade ally interviews and staff interviews.
	How do trade allies target qualified customers and qualify them for the program?	Staff interviews, trade ally interviews. Program materials review.
	What aspects of the program marketing influenced customer participation? What concerns did they have about participating?	Customer surveys.
Project implementation process	Does the application process balance customer and trade ally burden with the need for appropriate documentation?	Review of application materials and submission procedures. Staff interviews.
	What is the energy audit process? Is it comprehensive in terms of systems and measure types?	Staff and document review. Trade ally interviews.
	How are multi-measure projects handled? Is the coordination among different trade ally firms necessary and if so is it effective?	Staff and document review. Trade ally interviews.
	Is the participation process clear to customers and trade allies?	Trade ally interviews. Participant surveys.
Quality assurance and control	What are the criteria for verification? What does the verification review consist of?	Staff interviews and program materials review.

Topic	Example Research Questions	Data Sources
	What qualifications are required for trade allies? What training are the provided?	Staff interviews and program materials review.
	What are the data quality and control procedures?	Staff interviews and review of program tracking data.

5. Efficient Products

5.1 Program Description

The Efficient Products Program will promote and provide incentives for energy efficient LED lighting and appliances. The program will include point of sale discounts, instant rebates, and rebates based on applications submitted after the purchase of the energy efficient appliance.

5.2 Data Collection

This section summarizes sampling and data collection procedures for the evaluation of the Efficient Products Program.

5.2.1 Participant Surveys

ADM will collect data from program participants using online surveys. The survey data will be used to:

- Verify the measures installed or incentivized through the program;
- Collect data on decision making to estimate program net savings; and
- Collect feedback from participants on their experience with the program.

For the surveys, ADM will attempt a census of participants with the goal of obtaining enough responses to achieve the minimum sample size for these participant surveys needed to meet 90% confidence and 10% statistical precision (90/10) for the verification rates. We estimate that the number needed to achieve this level of precision and confidence will be 68. We will use telephone surveying to complete additional surveys if online surveys are not sufficient to reach the targeted sample size.

5.2.2 Program Staff Interviews

ADM will complete interviews with the Company's program manager and the implementation contractors program manager during years that a process evaluation is planned. Interviews may occur during years that a process evaluation is not planned as necessary to understand changes in program design or performance.

5.3 Gross Impact Evaluation Approach

5.3.1 Review Program M&V and Due Diligence Procedures

ADM will review the program tracking data maintained by the program implementation contractor. The first aspect of conducting measurements of program activity is to verify that the tracking data report of participants and measures is accurate. To this end, ADM will review the program data to verify that the fields required for performing the evaluation are tracked and populated (i.e., the data is not missing) and that the values are reasonable. ADM will take several steps in verifying the number of weatherproofing measures installed, which consists of the following:

- Validating program tracking data by checking for duplicate or erroneous entries;
- Performing site visits to a sample of participants' homes to confirm that measures were installed in the quantity and specifications claimed; and
- Conducting verification surveys with a sample of program participants to verify that customers listed in the program tracking database did indeed participate and that the number of measures claimed to be installed is accurate.

ADM will also perform a review of the savings estimates used to calculate ex ante energy impacts for installed measures. This evaluation activity is intended to verify that the ex ante calculations are consistent with algorithms and values used in the evaluation of program savings.

Following this review, ADM will develop recommended quality assurance/quality control (QA/QC) and due diligence procedures for program implementation contractors with the goal of minimizing the variance between ex ante and ex post energy impacts to the extent feasible and practical. Recommended QA/QC protocols may include:

- Procedures for program implementation contractors to use to document measure installation and facilitate post implementation verification;
- Recommendations for changes to data collection forms and tracking data in those cases where data necessary to estimate energy savings in accordance with the Indiana TRM is not being collected; and
- Procedures for determining baseline equipment.

As applicable, ADM will present recommendations relating to program-level QA/QC, inspection and due diligence procedures in ad hoc reports to the Company.

5.3.2 Estimation of Gross Savings and Peak Demand Reductions

The method ADM employs to determine gross savings impacts is dependent upon the types of measures being analyzed. Categories of measures include the following:

- Advanced Power Strips;
- Air filters;
- ENERGY STAR air purifiers;
- ENERGY STAR dehumidifiers;
- LED lighting;
- LED nightlights;
- ENERGY STAR pool pumps – variable speed;
- ENERGY STAR refrigerators;
- Smart thermostats; and
- Spray foam insulation.

5.3.2.1 Advanced Power Strips

The methodology specified in the Advanced Power Strips section of the Mid-Atlantic TRM will be used to calculate energy and peak demand impacts resulting from the measure.

The following equation will be used to calculate gross ex post annual energy savings:

$$\Delta kWh = \left(kWh_{Office} * Weighting_{Office} + kWh_{Ent} * Weighting_{Ent}\right) * ISR$$

The table below summarizes the values used for the equation parameters.

Table 5-1 Advanced Power Strips Energy Savings Calculation Values

Parameter	Value or Definition
kWh_{Office}	Estimated energy savings from using an APS in a home office, 31.0 kWh
$Weighting_{Office}$	Relative penetration of computers, 41%
kWh_{Ent}	Estimated energy savings from using an APS in a home entertainment system, 75.1 kWh
$Weighting_{Ent}$	59%
ISR	In service rate, 89%

Gross ex post peak demand reduction will be calculated using the following equation defined in the Mid-Atlantic TRM:

$$\Delta kW = \frac{\Delta kWh}{Hours} \times CF$$

Table 5-2 Advanced Power Strips Peak Demand Calculation Values

Parameter	Value or Definition
Hours	Annual hours when controlled standby loads are turned off, 6,351
CF	Summer peak coincidence factor for measure, 0.8

5.3.2.2 Air Filters

The methodology specified in the Furnace Whistle section of the Pennsylvania TRM will be used to calculate energy and peak demand impacts resulting from the measure. This section characterizes savings from changing out an air filter.

The following equations will be used to calculate gross ex post annual energy savings:

$$\Delta kWh = \frac{\Delta kWh}{yr_{heat}} + \frac{\Delta kWh}{yr_{cool}}$$

$$\frac{\Delta kWh}{yr_{heat}} = kW_{motor}\ X\ EFLH_{heat}\ X\ EI\ X\ ISR$$

$$\frac{\Delta kWh}{yr_{cool}} = kW_{motor}\ X\ EFLH_{cool}\ X\ EI\ X\ ISR$$

The table below summarizes the values used for the equation parameters.

Table 5-3 Air Filter Energy Savings Calculation Values

Parameter	Value or Definition
kW_{motor}	Average motor full load electric demand, 0.5
$EFLH_{Heat}$	Estimated full load heating hours, dependent on location
$EFLH_{Cool}$	Estimated full load cooling hours, dependent on location
EI	Efficiency improvement, 15%
ISR	In service rate, 47.4%

Gross ex post peak demand reduction will be calculated using the following equation defined in the Pennsylvania TRM:

$$\Delta kW = \frac{\Delta kWh/_{yr_{cool}}}{EFLH_{cool}} \times CF$$

Table 5-4 Air Filter Peak Demand Calculation Values

Parameter	Value or Definition
$EFLH_{Cool}$	Estimated full load cooling hours, dependent on location
CF	Summer peak coincidence factor for measure, .647

5.3.2.3 ENERGY STAR Air Purifiers

The methodology specified in the Air Purifier/Cleaner section of the Mid-Atlantic TRM will be used to calculate energy and peak demand impacts resulting from the measure.

The following equation will be used to calculate gross ex post annual energy savings:

$$\Delta kWh = kWh_{Base} - kWh_{ESTAR}$$

The table below summarizes the values used for the equation parameters.

Table 5-5 Air Purifier Energy Savings Calculation Values

Parameter	Value or Definition
kWh_{Base}	Baseline Consumption per year, see Table below
kWh_{ESTAR}	ENERGY STAR kWh consumption per year, see Tableb elow
3,413	Conversion from BTU to kWh

Table 5-6 Air Purifier Energy Baseline and ENERGY STAR Consumption

Clean Air Delivery Rate (CADR)	CADR used in calculation	Baseline Unit Energy Consumption (kWh/year)	ENERGY STAR Unit Energy Consumption (kWh/year)	ΔkWH
CADR 51-100	75	441	148	293
CADR 101-150	125	733	245	488
CADR 151-200	175	1025	342	683
CADR 201-250	225	1317	440	877
CADR Over 250	275	1609	537	1072

Gross ex post peak demand reduction will be calculated using the following equation defined in the Mid-Atlantic TRM:

$$\Delta kW = \frac{\Delta kWh}{Hours} \times CF$$

Table 5-7 Air Purifiers Peak Demand Calculation Values

Parameter	Value or Definition
Hours	Average number of hours of use per year, 5,840
CF	Summer peak coincidence factor for measure

5.3.2.4 ENERGY STAR Dehumidifiers

The methodology specified in the dehumidifiers section of the Mid-Atlantic TRM will be used to calculate energy and peak demand impacts resulting from the measure.

The following equation will be used to calculate gross ex post annual energy savings:

$$\Delta kWh = Capacity * {}^{0.473}/_{24} * Hours * {}^{1}/\left({}^{L}/_{kWh_{Base}}\right) - \left({}^{1}/\left({}^{L}/_{kWh_{Eff}}\right)\right)$$

The table below summarizes the values used for the equation parameters.

Table 5-8 Dehumidifier Energy Savings Calculation Values

Parameter	Value or Definition
Capacity	Capacity of the unit (pints/day)
0.473	Constant to convert Pints to Liters
24	Constant to convert Liters/day to Liters/hour
Hours	Run hours per year, 1632
L/kWh	Liters of water per kWh consumed, as provided in tales above

Gross ex post peak demand reduction will be calculated using the following equation defined in the Mid-Atlantic TRM:

$$\Delta kW = \frac{\Delta kWh}{Hours} \times CF$$

Table 5-9 Dehumidifier Peak Demand Calculation Values

Parameter	Value or Definition
Hours	Annual operating hours, 1632
CF	Summer peak coincidence factor for measure, .37

5.3.2.5 LED Lighting

The methodology specified in the ENERGY STAR Integrated Screw Based SSL (LED) section of the Mid-Atlantic TRM will be used to calculate deemed energy and peak demand impacts from the direct installation of LED lamps.

The following equation will be used to calculate gross ex post annual energy savings:

$$\Delta kWh = \frac{(WattsBase - WattsEE)}{1{,}000} \times ISR \times HOURS \times (WHFe_{heat} + (WHFe_{cool} - 1))$$

Table 5-10 LED Lighting Energy Savings Calculation Values

Parameter	Value or Definition
WattsBase	Baseline bulb wattage based on lumens of LED
WattsEE	Actual wattage of installed LED lamp
ISR	In-service rate or percentage of distributed units that are installed, as determined though analysis of customer survey response data
HOURS	Average hours of use per year
$WHFe_{heat}$	Waste heat factor for energy to account for electric heating savings from reducing waste heat from efficient lighting
$WHFe_{cool}$	Waste heat factor for energy to account for cooling savings from reducing waste heat from efficient lighting

Gross ex post peak demand reduction will be calculated using the following equation defined in the Mid-Atlantic TRM:

$$\Delta kWh = \frac{(WattsBase - WattsEE)}{1{,}000} \times ISR \times WHFd \times CF$$

Table 5-11 LED Lighting Peak Demand Calculation Values

Parameter	Value or Definition
WHFd	Waste heat factor for demand to account for cooling savings from reducing waste heat from efficient lighting
CF	Summer peak coincidence factor for measure

5.3.2.6 LED Nightlights

The methodology specified in the LED nightlight section of the Pennsylvania TRM will be used to calculate energy and peak demand impacts resulting from the measure.

The following equation will be used to calculate gross ex post annual energy savings:

$$\left[(W_{base} - W_{NL})X\left(\frac{HOU\ X\ 365\ \frac{days}{yr}}{1000\ \frac{W}{kW}}\right)\right]\ X\ ISR$$

The table below summarizes the values used for the equation parameters.

Table 5-12 LED Nightlights Energy Savings Calculation Values

Parameter	Value or Definition
W_{base}	Watts per baseline, 7
W_{NL}	Watts per LED nightlight, 1
HOU	Hours of use per day, 12
ISR	97%

5.3.2.7 ENERGY STAR Pool Pumps

The methodology specified in the pool pump – variable speed section of the Mid-Atlantic TRM will be used to calculate energy and peak demand impacts resulting from the measure.

The following equation will be used to calculate gross ex post annual energy savings:

$$\Delta kWh = kWh_{Base} - kWh_{Variable\ Speed}$$

The table below summarizes the values used for the equation parameters.

Table 5-13 ENERGY STAR Pool Pumps Energy Savings Calculation Values

Parameter	Value or Definition
kWh_{Base}	Typical consumption of a single speed motor, 707 kWh
$kWh_{Variable\ Speed}$	Typical consumption of an efficient variable speed pump, 113 kWh

Gross ex post peak demand reduction will be calculated using the following equation defined in the Mid-Atlantic TRM:

$$\Delta kW = kW_{Base} - kW_{Variable\ Speed} * CF$$

Table 5-14 ENERGY STAR Pool Pumps Peak Demand Calculation Values

Parameter	Value or Definition
kW_{Base}	Connected load of baseline motor, 1.3 kW
$kW_{Variable\ Speed}$	Connected load of variable speed motor, 0.087 kW
CF	Summer peak coincidence factor for measure, 0.27

5.3.2.8 ENERGY STAR Refrigerators

The methodology specified in the Refrigerator section of the Mid-Atlantic TRM will be used to calculate energy and peak demand impacts resulting from the measure.

The following equation will be used to calculate gross ex post annual energy savings:

$$\Delta kWh = kWh_{Base} * ES$$

The table below summarizes the values used for the equation parameters.

Table 5-15 ENERGY STAR Refrigerators Energy Savings Calculation Values

Parameter	Value or Definition
kWh_{base}	Annual energy consumption of the baseline unit, depends on unit size and configuration.
ES	Annual energy savings of energy efficient unit. ES is 10% for ENERGY STAR units, 15% for CEE Tier 2 units, and 20% for CEE Tier 3 units.

Gross ex post peak demand reduction will be calculated using the following equation defined in the Mid-Atlantic TRM:

$$\Delta kW = \frac{\Delta kWh}{8760} \times TAF\ X\ LSAF$$

Table 5-16 ENERGY STAR Refrigerators Peak Demand Calculation Values

Parameter	Value or Definition
TAF	Temperature adjustment factor, 1.23
LSAF	Load shape adjustment factor, 1.15

5.3.2.9 Smart Thermostats

The methodology specified in the Smart Thermostat section of the Mid-Atlantic TRM will be used to calculate energy and peak demand impacts from smart thermostats.

The following equation will be used to calculate gross ex post annual energy savings:

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

$$\Delta kWh_{cool} = \frac{CCAP}{SEER} \; X \; EFLH_C \; X \; Cooling\_Savings\_\%$$

$$\Delta kWh_{heating} = \frac{HCAPelec}{HSPF} \; X \; EFLH_h \; X \; Elec\_Heating\_Savings\_\%$$

Table 5-17 Smart Thermostats Energy Savings Calculation Values

Parameter	Value or Definition
CCAP	Cooling capacity of existing AC unit, in kBTU/hr.
HCAPelec	Heating capacity of existing electric heat unit, in kBTU/hr.
SEER	SEER of controlled unit. If unknown use current energy code requirements for mechanical cooling efficiency.
HSPF	HSPF of controlled unit. If unknown use current energy code requirements for
EFLHcool	Full load hours for cooling equipment. Location dependent.
EFLHheat	Full load hours for heating equipment. Location dependent
Elec_Heating_Saving_%	6%
Cooling_Saving_%	7%

There are no demand savings from the smart thermostat outside of a demand response program.

5.3.2.10 Spray Foam Insulation

The methodology specified in the Weather Stripping, Caulking, and Outlet Gaskets section of the Pennsylvania TRM will be used to calculate energy and peak demand impacts resulting from the measure.

The following equation will be used to calculate gross ex post annual energy savings:

$$\Delta kWh_{cool} = \frac{1.08 \; X \; \Delta CFM_{50} X \; CDD \; X \; 24 \frac{hr}{day} \; X \; ISR}{N \; X \; SEER \; X \; 1{,}000 \; \frac{W}{kW}} \; X \; LM \; X \; DUA$$

$$\Delta kWh_{heat} = \frac{1.08\ X\ \Delta CFM_{50} X\ HDD\ X\ 24\frac{hr}{day}\ X\ ISR}{N\ X\ HSPF\ X\ 1{,}000\ \frac{W}{kW}}\ X\ LM\ X\ DUA$$

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

The table below summarizes the values used for the equation parameters.

Table 5-18 Spray Foam Insulation Energy Savings Calculation Values

Parameter	Value or Definition
1.08	Conversion factor that converts CFM air (at 70°F) to Btu/hr-°F
ΔCFM_{50}	Reduction in air leakage at a test pressure of 50 Pascals, .689 CFM/lf of crack
CDD	Cooling degree-days, varies by location
HDD	Heating degree-days, varies by location
ISR	In-service rate
LM	Latent multiplier to convert the calculated sensible load to the total (sensible and latent) load, varies by location
DUA	Discretionary use adjustment to account for uncertainty in predicting cooling system usage patterns of occupants, 0.75
N	Correlation factor. This factor accounts for four environmental characteristics that may influence infiltration, which include climate, building height, wind shielding and building leakiness., varies by exposure and number of stories
SEER	Cooling system seasonal efficiency, ASHP = 13.5, CAC = 12.1, GSHP = 15.0
HSPF	Heating system seasonal efficiency, ASHP = 8.2, GSHP, 10.9, Elec baseboard – 3.4121, Elec. Furnace = 3.241, Space Heaters = 3.412

Gross ex post peak demand reduction will be calculated using the following equation defined in the Pennsylvania TRM.

$$\Delta kW = \Delta kWh_{cool}\ X\ PCF$$

Table 5-19 Spray Foam Insulation Peak Demand Calculation Values

Parameter	Value or Definition
PCF	Peak demand savings conversion factor, 0.000017 (1.7×10^{-5})

5.4 Net Impact Evaluation Approach

The following sections discuss the planned approach to estimating net impacts of the upstream lighting and downstream appliance rebate components of the Efficient Products Program.

5.4.1 Retail Lighting Markdowns

Free ridership will be estimated using a price response model to predict sales levels in the absence of the program for retail lighting purchases only. The analysis uses program tracking data of sales that included package and bulb sales for each retailer by model number and week of purchase. ADM will use a negative binomial model to account for the right-skewed relationship between prices and quantities. The dependent variable is number of packages per day sold by the program. Independent variables used to predict sales include month, promotion dummy (e.g. presence of a promotional event on the sales date), program price, and a dummy variable for each model type. Model types are defined as a combination of bulb type (i.e. specialty LED vs. standard LED), bulb shape (i.e. A19 vs BR40), lumens range (i.e. 0-500, 500-1000, etc....), and the number of bulbs per package.

The model the Evaluation Team will use is based on the assumption that three broad factors affect bulb sales: prices, the presence of promotional events and seasonal trends. The final model used dummy variables to control for seasonal effects (month dummies) and bulb type (model number dummies). The basic equation of the price response model was estimated as follows (for bulb model i, in period t):

$$\ln(Q_{it}) = \beta_1 + \beta_2 * \ln(P_{it}) + \beta_3 EventDummy_{it} + \Sigma_\pi \beta_\pi ModelNumberDummy_i + \Sigma_\gamma \beta_\gamma ModelNumberDummy_t + \varepsilon_{it}$$

Where:

ln = natural logarithm

Q = quantity of bulb packs, *i*, sold during week *t*

P = retail price (after markdown) for package of bulbs, *i*, during week *t*

EventDummy = a binary variable equaling 1 if a promotional event occurred at the retailer selling bulb pack, *i*, during week *t*; 0 otherwise

ModelNumberDummy = a binary variable equaling 1 for each unique model number; 0 otherwise

MonthDummy = a binary variable equaling 1 in a given month; otherwise

The β2 coefficient in the model represents average price elasticity of demand holding the effects of all other independent variables constant. The β3 coefficient captures the impact of promotional events on bulb sales. Under the counterfactual scenario where no program exists, the EventDummy variable is always zero, indicating the absence of program sponsored promotional events.

Free ridership ratios will be calculated for the program as follows. First, the price response model will be used to estimate bulb package sales under program and non-program pricing scenarios. The non-program scenario represents pricing at original retail levels along with the absence of any program sponsored promotional events. Bulb package sales under both scenarios will be multiplied by the number of bulbs per package to arrive at total bulb sales under the program and non-program scenarios. Finally, savings values (gross kWh) will be applied to the estimated number of bulbs sold under both scenarios. The final price response model will be used to estimate free ridership as described in the equation below:

$$Free\ ridership\ ratio = \frac{\Sigma_i^n E[Bulbs_{NoProgram_i}] * kWh_i}{\Sigma_i^n E[Bulbs_{Program_i}] * kWh_i}$$

Where:

$E[Bulbs_{NoProgram_i}]$ = the expected number of bulbs of type, i, purchased given original retail pricing (as predicted by the model).

$E[Bulbs_{Program_i}]$ = the expected number of bulbs of type, i, given program discounted pricing (as predicted by the model).

kWh_i = the average gross kWh savings for bulb type, i.

The free ridership ratio is subtracted from one to calculate the net-to-gross ratio.

5.4.2 Retail Markdowns for Low-Flow Devices, Appliances, and DIY Weatherization

ADM will perform a literature review to estimate the net savings resulting from low-flow devices, appliances, and DIY weatherization materials discounted by the program through retail markdowns. These types of measure are typically low volume and contribute a relatively small share of total program savings. Moreover, they are difficult to assess net savings for because 1) they are infrequent purchases which makes it difficult to study purchasers decision making through a general population survey and 2) the low sales volume constrains the ability to develop a reliable price-response model using program sales data.

In the event that the retail markdowns for these measures have a significant impact on sales, ADM may complete a general population study of respondent willingness to pay for the various measures installed through the program to estimate the net savings impacts.

5.4.3 Instant Rebates and Online or Mail-in Rebates

ADM will use a self-report methodology to assess the program free ridership for the appliances rebated through the program. The objective of the approach is to use response to questions on how the program may have influenced the decision to determine the share of program savings that would have occurred in the absence of the program. ADM will assess four factors to determine the net savings of the Efficient Product program appliances:

- The participants financial ability to purchase the measure without the program incentive;
- The presence of plans to install the measure before learning of the rebate; and
- The program influence on the timing of the purchase.

A score ranging between 0 and 1, with 1 indicating full free ridership and 0 indicating an absence of free ridership, will be developed for each factor using the following approaches.

5.4.3.1 Financial Ability

Respondents will be assigned a financial ability score of 1 (indicating full free ridership) if they stated that they were financially able to purchase the measure and if they confirmed that they would have paid the additional cost of the efficient measure if the rebate was not available.

5.4.3.2 Likelihood of Purchasing in the Absence of the Program

A score for the likelihood of purchasing the product will be developed based on responses to the following questions:

- Which of the following best describes when you learned about the availability of the rebate for the [MEASURE]?

- On a scale of 0 to 10 where 0 represents "Not at all likely" and 10 represents "Very likely", how likely is it that you would have purchased the same [MEASURE] if you had not received rebate or informational assistance through the program?

Respondents who state that they learned of the rebate before deciding to purchase the measure and rate the likelihood of purchasing the measure if the rebate was not available as four or less will be assigned likelihood score of 0. All other respondents will be assigned a likelihood score of 1.

5.4.3.3 Prior Plans

The influence of prior plans to install the measure will be assessed with the following two questions.

- Were you planning to purchase [MEASURE] before you learned that a rebate was available from the program?
- Just to be clear, did you have plans to specifically purchase an efficient [MEASURE] instead of a standard [MEASURE]?

Respondents who state that they planned to purchase the efficient measure and confirmed that their plan were to specifically purchase an efficient measure will be assigned a prior plans score of 1. All other respondents will be assigned a free ridership value of 0 on this factor.

5.4.3.4 Influence on Timing

Respondents will be asked if they purchased and installed the measure sooner then they would have if the program had not been available. Based on their responses, a timing score will be assigned as shown in Table 5-20 assigned as follows:

Table 5-20 Timing Score

Response Option	Timing Score
Within 6 months of when you purchased it	0.75
Between 6 months and 1 year	0.25
In more than 1 year to 2 years	0
In two years or more	0
Don't know	0.5

5.4.3.5 Overall Free Ridership Score

Respondents who are assigned a score of 0 (absence of free ridership) on the financial ability, prior plans, or likelihood of purchasing the measure in the absence of the program factors are assigned a free ridership value of 0. For all other respondents the final free ridership score will be based on the program's influence on timing.

5.4.4 Spillover Estimation

ADM will use participant survey to assess participant spillover. The survey questions will be designed to gather information regarding:

- Whether program participants have purchased and installed additional, non-incentivized energy saving measures since participating in the program;

- Which additional, non-incentivized energy saving measures program participants have purchased and installed since participating in the program; and
- The extent to which the program influenced the purchase of these additional non-incentivized energy saving measures.

We will ask survey respondents the following question:

- "Because of your experience with the program, have you bought any additional energy efficient items on your own without a financial incentive or utility rebate?"

Respondents answering "Yes" to the above question will be asked additional questions about the type of measure(s) installed and other information about the measures necessary to estimate the savings resulting from the measures.

Respondents who indicate that they have installed at least one additional energy efficient measure since participating in the program will be asked two questions to determine the level of influence that the program may have had on the decision to purchase and install the item(s).

- SO1: "On a scale of 0 to 10, where 0 represents "Not at all important" and 10 represents "Extremely important", how important was your experience with the eScore Program in your decision to purchase and install these additional items?"
- SO2: "On a scale of 0 to 10, where 0 represents "Not at all likely" and 10 represents "Extremely likely", how likely would you have been to purchase these additional non-rebated energy efficient items if you had never participated in the eScore Program?"

The Program Influence Score (PI Score) will be calculated as the average of the responses to these two questions, where the numeric scale from SO2 is reversed by subtracting the SO2 score from 10 total possible points:

$$\text{PI Score}=((\text{SO1 Score})+(10-\text{SO2 Score}))/2$$

For example, a respondent providing a rating of 9 to SO1 and a rating of 3 to SO2 would receive a PI Score as follows:

$$\text{PI Score}=(9+(10-3))/2$$

$$\text{PI Score}=8$$

Respondents whose PI Scores are above 7 are considered to have made additional energy efficiency purchases that were significantly influenced by the program and the savings of the associated measures are attributed to the program as spillover.

5.5 Process Evaluation Approach

ADM will complete a process evaluation of the Efficient Products Program in 2023 and 2026. The process evaluation will evaluate the program implementation and design.

Table 5-21 summarizes the research topics, questions, and data sources. ADM will address these topics through:

- Surveys of program appliance rebate participants;
- Reviews of program documentation including any available program manuals, application forms, and the program website; and
- Review and analysis of program data.

Table 5-21 Process Evaluation Topics, Research Questions, and Data Sources

Topic	Example Research Questions	Data Sources
Measure offering and incentive design	Are the incentive delivery approaches appropriate for the measure type?	Review of program materials, tracking data, and staff interviews.
	How have the instant rebates performed? Does that channel reach a different customer segment than the online/mail in rebate channel?	Staff interviews and participant surveys.
	Do incentive levels or other factors explain the activity of lower volume measures? Would it be reasonable to raise incentives to increase sales?	Staff interviews, incentive benchmarking, review of program materials and tracking data.
Marketing and outreach	What is the marketing approach for the measures? What channels and messaging are used?	Staff interviews, trade ally interviews. Program materials review.
	What is the process for recruiting retailers and store locations? Are there are other potential retailers not participating?	Staff interviews.
	What is the in-store marketing strategy? How are products placed in stores and what signage is used to inform customers?	Staff interviews.
	How do customers learn about the instant appliance rebates? Did it influence them to participate?	Participant surveys.
Project implementation process	How is the funding of instant rebate incentive dollars to retailers accomplished?	Staff interviews.
	What is the process for direct shipment of smart thermostats?	Staff interviews.
Quality assurance and control	What is the process for reviewing applications?	Staff interviews.
	What training and education is provided to retailers?	Staff interviews.
	What is the process for reviewing retailer store locations? How often does this happen?	Staff interviews.

6. Energy Efficiency Kits

6.1 Program Description

The energy efficiency kits program provides customers with an online energy audit and a no-cost kit mailed to their residence. The kit will contain:

- 9w LED lamp;
- 1.5 gpm kitchen faucet aerator;
- 1.0 gpm bathroom faucet aerator;
- 1.5 hpm showerhead;
- Water temperature card; and
- LED nightlight.

6.2 Data Collection

This section summarizes sampling and data collection procedures for the evaluation of the Energy Efficiency Kits Program.

6.2.1 Participant Surveys

ADM will collect data from program participants using online surveys. The survey data will be used to:

- Verify the measures installed or incentivized through the program;
- Collect data on decision making to estimate program net savings; and
- Collect feedback from participants on their experience with the program.

For the surveys, ADM will attempt a census of participants with the goal of obtaining enough responses to achieve the minimum sample size for these participant surveys needed to meet 90% confidence and 10% statistical precision (90/10) for the verification rates. We estimate that the number needed to achieve this level of precision and confidence will be 68 (per kit type).

6.2.2 Program Staff Interviews

ADM will complete interviews with the Company's program manager and the implementation contractors program manager during years that a process evaluation is planned. Interviews may occur during years that a process evaluation is not planned as necessary to understand changes in program design or performance.

6.3 Gross Impact Evaluation Approach

6.3.1 Review Program M&V and Due Diligence Procedures

ADM will review the program tracking data maintained by the program implementation contractor. The first aspect of conducting measurements of program activity is to verify that the tracking data report of participants and measures is accurate. To this end, ADM will review the program data to verify that the fields required for performing the evaluation are tracked and populated (i.e., the data is not missing) and that the values are reasonable. ADM will take several steps in verifying the number of weatherproofing measures installed, which consists of the following:

- Validating program tracking data by checking for duplicate or erroneous entries;

- Performing site visits to a sample of participants' homes to confirm that measures were installed in the quantity and specifications claimed; and
- Conducting verification surveys with a sample of program participants to verify that customers listed in the program tracking database did indeed participate and that the number of measures claimed to be installed is accurate.

ADM will also perform a review of the savings estimates used to calculate ex ante energy impacts for installed measures. This evaluation activity is intended to verify that the ex ante calculations are consistent with algorithms and values used in the evaluation of program savings.

Following this review, ADM will develop recommended quality assurance/quality control (QA/QC) and due diligence procedures for program implementation contractors with the goal of minimizing the variance between ex ante and ex post energy impacts to the extent feasible and practical. Recommended QA/QC protocols may include:

- Procedures for program implementation contractors to use to document measure installation and facilitate post implementation verification;
- Recommendations for changes to data collection forms and tracking data in those cases where data necessary to estimate energy savings is not being collected; and
- Procedures for determining baseline equipment.

As applicable, ADM will present recommendations relating to program-level QA/QC, inspection and due diligence procedures in ad hoc reports to the Company.

6.3.2 Estimation of Gross Savings and Peak Demand Reductions

The method ADM employs to determine gross savings impacts is dependent upon the types of measures being analyzed. Categories of measures include the following:

- 9w LED lamp;
- LED nightlight;
- 1.5 gpm kitchen faucet aerator;
- 1.0 gpm bathroom faucet aerator;
- 1.5 gpm showerhead; and
- Water temperature card.

6.3.2.1 LED Lighting

The methodology specified in the ENERGY STAR Integrated Screw Based SSL (LED) section of the Mid-Atlantic TRM will be used to calculate deemed energy and peak demand impacts from the direct installation of LED lamps.

The following equation will be used to calculate gross ex post annual energy savings:

$$\Delta kWh = \frac{(WattsBase - WattsEE)}{1{,}000} \times ISR \times HOURS \times (WHFe_{heat} + (WHFe_{cool} - 1))$$

Table 6-1 LED Lighting Energy Savings Calculation Values

Parameter	Value or Definition
WattsBase	Baseline bulb wattage based on lumens of LED
WattsEE	Actual wattage of installed LED lamp
ISR	In-service rate or percentage of distributed units that are installed, as determined though analysis of customer survey response data
HOURS	Average hours of use per year
$WHFe_{heat}$	Waste heat factor for energy to account for electric heating savings from reducing waste heat from efficient lighting
$WHFe_{cool}$	Waste heat factor for energy to account for cooling savings from reducing waste heat from efficient lighting

Gross ex post peak demand reduction will be calculated using the following equation defined in the Mid-Atlantic TRM:

$$\Delta kWh = \frac{(WattsBase - WattsEE)}{1{,}000} \times ISR \times WHFd \times CF$$

Table 6-2 LED Lighting Peak Demand Calculation Values

Parameter	Value or Definition
WHFd	Waste heat factor for demand to account for cooling savings from reducing waste heat from efficient lighting
CF	Summer peak coincidence factor for measure

6.3.2.2 LED Nightlights

The methodology specified in the LED nightlight section of the Pennsylvania TRM will be used to calculate energy and peak demand impacts resulting from the measure.

The following equation will be used to calculate gross ex post annual energy savings:

$$\left[(W_{base} - W_{NL})X\left(\frac{HOU\ X\ 365\ \frac{days}{yr}}{1000\ \frac{W}{kW}}\right)\right] X\ ISR$$

The table below summarizes the values used for the equation parameters.

Table 6-3 LED Nightlights Energy Savings Calculation Values

Parameter	Value or Definition
W_{base}	Watts per baseline, 7
W_{NL}	Watts per LED nightlight, 1
HOU	Hours of use per day, 12
ISR	97%

6.3.2.3 Low Flow Faucet Aerator

The methodology specified in the Faucet Aerators section of the Mid-Atlantic TRM will be used to calculate energy and peak demand impacts for the installation of a low flow faucet aerator.

The following equation from the section was used to calculate gross ex post annual energy savings:

$$\Delta kWh = \frac{((GPM_{base} \times Throttle_{base}) - (GPM_{low} \times Throttle_{low})) \times Time_{faucet} \times \#people \times \frac{days}{year} \times DR \times 8.3 \times (T_{ft} - T_{ln})}{\eta DHW \times 3{,}412}$$

The table below summarizes the values used for the equation parameters.

Table 6-4 Low Flow Faucet Aerator Energy Savings Calculation Values

Parameter	Value or Definition
GPM_{base}	Gallons per minute of baseline faucet
$Throttle_{base}$	83%
$GPMl_{ow}$	Gallons per minute of low flow faucet; rated flow rate of unit installed or actual flow rate if baseline flow rate used
$Throttle_{low}$	95%
$Time_{faucet}$	Average minutes of faucet use per day per person
#people	Average number of people per household
Days/year	Number of days faucet used per year
DR	Percentage of water flowing down drain
8.3	Constant to convert gallons to pounds
T_{ft}	Assumed temperature of water used by faucet
T_{in}	Assumed temperature of water entering house
ηDHW	Recovery efficiency of electric domestic hot water heater
3,413	Conversion from BTU to kWh

Gross ex post peak demand reduction will be calculated using the following equation defined in the Mid-Atlantic TRM:

$$\Delta kW = \frac{\Delta kWh}{Hours} \times CF$$

Table 6-5 Low Flow Faucet Aerator Peak Demand Calculation Values

Parameter	Value or Definition
Hours	Average number of hours per year spent using faucet (#people × Timefaucet / 60 × 365)
CF	Summer peak coincidence factor for measure

6.3.2.4 Low Flow Showerhead

The methodology specified in the Low Flow Shower Head section of the Mid-Atlantic TRM will be applied to calculate energy and peak demand impacts resulting from the installation of low-flow shower heads.

The following equation will be used to calculate gross ex post annual energy savings:

$$\Delta kWh = \frac{(GPM_{base} - GPM_{low}) \times Time_{shower} \times \#people \times Showers_{person} \times \frac{days}{year} \times 8.3 \times (T_{sh} - T_{in})}{\frac{ShowerHeads}{home} \times \eta DHW \times 3{,}412}$$

Table 6-6 Low Flow Showerhead Energy Savings Calculation Values

Parameter	Value or Definition
GPM_{base}	Gallons per minute of baseline showerhead
GPM_{low}	Gallons per minute of low flow showerhead; rated flow rate o
	unit installed or actual flow rate if baseline flow rate used
Timeshower	Average minutes of showerhead use per day per person
#people	Average number of people per household
Showersperson	Average number of showers taken per person per day
Days/year	Number of days shower used per year
ShowerHeads/home	Average number of showers in the home
8.3	Constant to convert gallons to pounds
T_{sh}	Assumed temperature of water used for shower
T_{In}	Assumed temperature of water entering house
ηDHW	Recovery efficiency of electric domestic hot water heater
3,413	Conversion from BTU to kWh

Gross ex post peak demand reduction will be calculated using the following equation defined in the Mid-Atlantic TRM:

$$\Delta kW = \frac{\Delta kWh}{Hours} \times CF$$

Table 6-7 Low Flow Showerhead Peak Demand Calculation Values

Parameter	Value or Definition
Hours	Average number of hours per year spent using faucet (#people × Timefaucet / 60 × 365)
CF	Summer peak coincidence factor for measure

6.3.2.5 Water Temperature Card

The methodology specified in the Water Heater Temperature Setback section of the Mid-Atlantic TRM will be used to calculate energy and peak demand impacts resulting from the measure.

The following equation from the section was used to calculate gross ex post annual energy savings:

$$\Delta kWh = \frac{(UA * (Tpre - Tpost) * Hours)}{(3412 * RE\_electric)} * ISR$$

The table below summarizes the values used for the equation parameters.

Table 6-8 Water Temperature Card Savings Calculation Values

Parameter	Value or Definition
U	Overall heat transfer coefficient of tank (BTU/Hr-°F-ft2), 0.083
A	Surface area of storage tank (square feet), Actual or assume 24.99 ft^2
Tpre	Hot water temperature prior to setback, 135 degrees
Tpost	Hot water temperature after setback, 120 degrees
Hours	Hours in a year, 8760
RE_electric	Recovery efficiency of electric hot water heater, 0.98
ISR	In service rate, based on survey responses on adjustments made to water heater temperature.

6.4 Net Impact Evaluation Approach

The following sections discuss the planned approach to estimating net impacts of the upstream lighting and downstream appliance rebate components of the Efficient Products Program.

6.4.1 Estimation of Free Ridership

The calculation of a free ridership is based on the responses to questions on the following topics:

- Prior experience with similar energy saving equipment;
- Prior planning to purchase energy efficiency measures that were provided through the program; and

- Likelihood of installing similar equipment without the program.

6.4.1.1 Prior Experience

The program is designed to encourage customers to try efficiency measures that they previously did not have experience with by providing them at no cost to the customer. As such, a primary indicator of the likelihood that a participant is a free rider, is whether he or she has previously purchased a similar measure. Previous experience is used as an indicator of whether the customer would have coincidently purchased a similar measure on their own.

Prior experience is assessed through the following question:

- FR1: Thinking back to before you completed the online energy checkup, had you purchased and installed any of the following items in your home in the last three years?

Respondents indicating that they had not purchased a given measure in the past three years are considered to have minimal to no prior experience with that measure, meaning that the intervention of the program is likely significantly influential in the energy savings resulting from the measure. These respondents receive an overall free ridership score of 0 for this measure. Otherwise, free ridership is assessed using the following three factors.

6.4.1.2 Prior Plans and Intentions

Customers were asked as to any plans they had to purchase any of the measures. This is addressed in the following question:

- FR2: Before you heard of the program, did you have specific plans to purchase any of these kit items that were sent to you? If so, which items did you plan to purchase?

For LEDs, night lights, shower heads, and bathroom faucet aerators, customers that respond that they planned to install the measures are asked the following question:

- FR3: Of the [MEASURE COUNT] [MEAUSRE] provided in the kit, how many did you plan to purchase on your own?

Respondents who indicate that they had plans to purchase the measure on FR2, are given a plans score of 1. The response to FR3 is used to adjust the plans score to reflect the number of items the respondent planned to purchase. For example, if the respondent planned to purchase one of the two items received, the plans score is adjusted to .5.

6.4.1.3 Likelihood of Purchasing Measure

Once customers learn of the program, it is possible that this knowledge will sway their decision-making process to install these energy efficient measures in their homes. Additionally, the information and measures provided through the program may help to overcome existing barriers to energy efficiency improvements. To address this, participants are asked the following questions:

- FR4: Using a scale where 0 means "not at all likely" and 10 means "very likely", if you had not completed the online energy checkup or received the energy conservation kit, how likely would you have been to purchase any of the following items on your own within 12 months of when you received them?
- FR5: [IF FR4 > 0] Based on your response, there is some likelihood that you would have purchased some of the kit items in the next 12 months. Given that, we would like to know why you had not already purchased the items on your own. Had you not already purchased [MEASURE] because 1) you

didn't want to spend the money, 2) you had not gotten around to it, 3) you didn't know where to purchase [MEASURE], 4) you didn't know enough about [MEASURE], or 6) another reason?

Respondents who indicate in FR4 that they had not already purchased a given measure because they did not want to spend the money, did not know where to purchase the measure, or did not know enough about the measure are considered to have had significant barriers to implementing these energy efficiency improvements and receive a score of 0% free ridership for the measure under this component. Otherwise, the likelihood of purchasing is scored as:

Likelihood of Purchasing = FR4/10

6.4.1.4 Free Ridership Scoring

For respondents who demonstrated prior experience with a measure, the scores for the prior plans and likelihood of purchasing the measures are averaged to assign a measure-level free ridership score to each respondent.

6.4.2 Spillover Estimation

ADM will use participant survey to assess participant spillover. The survey questions will be designed to gather information regarding:

- Whether program participants have purchased and installed additional, non-incentivized energy saving measures since participating in the program;
- Which additional, non-incentivized energy saving measures program participants have purchased and installed since participating in the program; and
- The extent to which the program influenced the purchase of these additional non-incentivized energy saving measures.

We will ask survey respondents the following question:

- "Because of your experience with the program, have you bought any additional energy efficient items on your own without a financial incentive or utility rebate?"

Respondents answering "Yes" to the above question will be asked additional questions about the type of measure(s) installed and other information about the measures necessary to estimate the savings resulting from the measures.

Respondents who indicate that they have installed at least one additional energy efficient measure since participating in the program will be asked two questions to determine the level of influence that the program may have had on the decision to purchase and install the item(s).

- SO1: "On a scale of 0 to 10, where 0 represents "Not at all important" and 10 represents "Extremely important", how important was your experience with the eScore Program in your decision to purchase and install these additional items?"
- SO2: "On a scale of 0 to 10, where 0 represents "Not at all likely" and 10 represents "Extremely likely", how likely would you have been to purchase these additional non-rebated energy efficient items if you had never participated in the eScore Program?"

The Program Influence Score (PI Score) will be calculated as the average of the responses to these two questions, where the numeric scale from SO2 is reversed by subtracting the SO2 score from 10 total possible points:

$$PI\ Score=((SO1\ Score)+(10-SO2\ Score))/2$$

For example, a respondent providing a rating of 9 to SO1 and a rating of 3 to SO2 would receive a PI Score as follows:

$$PI\ Score=(9+(10-3))/2$$

$$PI\ Score=8$$

Respondents whose PI Scores are above 7 are considered to have made additional energy efficiency purchases that were significantly influenced by the program and the savings of the associated measures are attributed to the program as spillover.

6.5 Process Evaluation Approach

ADM will complete a process evaluation of the Efficient Products Program in 2023 and 2026. The process evaluation will evaluate the program implementation and design.

Table 6-9 summarizes the research topics, questions, and data sources. ADM will address these topics through:

- Surveys of program participants;
- Reviews of online energy assessment and database of recommendations; and
- Review and analysis of program data.

Table 6-9 Process Evaluation Topics, Research Questions, and Data Sources

Topic	Example Research Questions	Data Sources
Measure offering	What are the measure in service rates? What barriers are there to installation that the program can address?	Participant surveys and program documents.
	How well does the online energy assessment work for customers? Is it easy to access and use?	Participant survey.
	What are customer perceptions of the recommendations provided through the online assessment?	Participant survey.
	Does the online assessment increase participation in other programs? Are there changes that could increase participation in other programs?	Participant survey and analysis of participant tracking data in this and other residential programs.
Marketing and outreach	How are customers informed of the online assessment and energy saving kits?	Staff interviews and participant survey.
	What drives their decision to participate in the program?	Participant survey.
	Are there channels that are underutilized that could increase participation?	Staff interviews. ADM experience evaluating similar programs.
Project implementation process	How is data on customers who take the assessment shared to allow for the mailing of kits? Is the coordination between the online assessment and kit delivery process working well?	Staff interviews.
	What is the process for adding or modifying content on the online assessments or in the energy efficiency kits?	Staff interviews.
Quality assurance and control	How are customer records verified and screened for prior participation?	Staff interviews.
	What is the process for tracking shipments and handling undeliverable kits?	Staff interviews.
	How do customers report a damaged kit item and what is the process for handling damage claims?	Staff interviews.

7. Home Energy Reports

7.1 Program Description

The Home Energy Report program will provide residential customers with an online report on their household energy consumption and tips for reducing their use. The program uses random assignment of customers to treatment and control group for use in the annual energy impacts of the program.

7.2 Data Collection

This section summarizes sampling and data collection procedures for the evaluation of the Home Energy Report Program.

7.2.1 Utility Consumption Data and Participation Records

To carry out the evaluation described in this plan, program implementation and Company staff will need to provide ADM with the following data:

- Billing data which covers at least one year prior to the first home energy report (for a given Wave), as well as all of 2019.
- Participant lists for each Home Energy Report participant, listing whether a customer is in the treatment or control group, when the first home energy report was received, and whether the customer opted out or stopped electrical service.

7.2.2 Participant Survey

ADM will complete an online survey of treatment group customers to obtain feedback on their experience with the HER. Because of the large population and low marginal costs of obtaining additional survey responses with an online survey, ADM will seek to complete a survey with 200 treatment group customers. To do this, we will sample 2,500 treatment group customers at random to receive the survey invitation.

7.3 Net Impact Evaluation Approach

7.3.1 Review Program M&V and Due Diligence Procedures

As a first step, ADM will review data tracking systems associated with the program to ensure that the data provides sufficient information to identify unique customers for surveying and to calculate energy and demand impacts. In particular, data screening procedures will include:

- Removing duplicate records;
- Removing customers with incomplete (less than two years of data) billing records; and
- Screening for outliers (>10,000 kWh per month).

7.3.2 Calculation of Net Energy Impacts

A free rider in the program would be a customer who would have reduced energy consumption regardless of the program's influence. The experimental design for this study excludes customers who are known to be enrolled in other energy-efficiency programs, and controls for attributes that may correlate with energy conservation via the randomization. A free rider then would have been equally likely to have been in the treatment or control groups, and hence Net-to-Gross is 1. There are no assumed free riders.

ADM's approach will closely follow the guidelines laid out in a document authored by the Department of Energy's State & Local Energy Efficiency Action (DOE SEE) Network that provides general

recommendations on how behavioral energy-efficiency programs like the Home Energy Reports Program should be evaluated.

ADM will conduct a regression analysis using a census of program participant billing data and control group. The billing data for participants will include two years of monthly observations for each customer. The regression analysis will only be applied to those customers with a Pre and Post Period. For each account with treatment, ADM will define the "pre" period as one year prior to treatment start and the "post" period as the evaluation year (i.e., 2022, 2023, 2024, 2025, or 2026). At least 10 months of monthly billing must be available for both the pre and post periods for a customer to be included in the regression.

To serve as a baseline, ADM will use data from a control group of randomly selected customers. This group will also be screened for duplicate entries.

The mixed effects panel regression model to be used is specified as follows:

$$kWh_{i,t} = \beta_1 HDD65_{i,t} + \beta_2 CDD75_{i,t} + \beta_3 Post_{i,t} + \beta_4 (Post_{i,t} * HDD65_t) + \beta_5 (Post_{i,t} * CDD75_t)$$

Where T(i) represents the number of bills available for i. The model is defined as "mixed effects" because the model decomposes its parameters into fixed-effects (i.e. HDD65, CDD75, Post, Treat, and its various interactions) and random effects (i.e. the individual customer's base usage). Put simply, a fixed effect is assumed to be constant and independent of the sample, while random effects are assumed to be sources of variation (other than natural measurement error) that are uncorrelated with the fixed effects. The approach is similar to others that treat the individual customer as a fixed-effect, but is more computationally efficient as the number of individuals in the sample becomes very large.

While the results of this model are expected to be consistent with a pooled regression (which ignores the individual customer effect), controlling for the individual effect will achieve some improvement in the model's fit to the data. The variables included in the regression models are specified in Table 7-1 below.

Table 7-1 Description of Variables Used in the Regression Model

Variable	Description
Customer random intercept	Unique identifier for each customer to control for any customer specific differences.
Heating Degree Days (HDD)	Average Heating Degree Days per day within each billing period. This will be calculated by summing up the number of heating degree hours per day, and then averaging over the number of days in the billing period.
Cooling Degree Days (CDD)	Average Cooling Degree Days per day within each billing period. This will be calculated by summing up the number of cooling degree hours per day, and then averaging over the number of days in the billing period.
Post	Indicator if an observation is post audit (=1 if post, =0 otherwise).
kWh	The average daily kWh usage for account i during billing period t.
Post * Treatment	Indicator that adjusts for the interactive effect between whether customer i's monthly billing data in period t is in the pre or post period and whether customer i is in the treatment or control group during period t.

7.3.2.1 Double Counting / Uplift Analysis

The HER program billing analysis of savings estimates may include savings generated by increased rates of program participation among the treatment group as compared to the control group. The first step to account for this impact, is to cross-reference the account IDs for each treatment and control group customer with all other program participation in the study period. This results in a total "other program kWh" per-group. What is important in this analysis is to normalize the effects to the number of households in the group. The treatment and control groups are not precisely matched in customer count. As such, if one were to directly compare the other-program-kWh of the treatment and control group, it would overestimate the double count (a treatment group of 30,000 customers is most assuredly going to show higher savings than a matched control group of 10,000 customers). By comparing this on a per-household basis, we normalize to the reality of mismatched treatment and control group population sizes.

7.4 Process Evaluation Approach

ADM will complete a process evaluation of the Home Energy Reports Program in 2023 and 2026. The process evaluation will evaluate the program implementation and design.

Table 7-2 summarizes the research topics, questions, and data sources. ADM will address these topics through:

- Surveys of customers in the treatment group;
- Review of the home energy report and other materials; and
- Interviews with program staff.

Table 7-2 Process Evaluation Topics, Research Questions, and Data Sources

Topic	Example Research Questions	Data Sources
HER Design	How is the HER well is the HER laid out? Is the report design clear and easy to understand?	Review of report.
	What are the key messaging strategies used to motivate change? Are there additional tactics that could be used?	Review of report and staff interviews.
	How is the HER integrated with promotion of incentives available through other programs?	Review of report and staff interviews.
Customer experience	What is the open rate for the eHER? What strategies has the program taken to increase the open rate?	Review of materials and staff interviews.
	What is the opt-out rate?	Review of materials and staff interviews.
	Do treatment customers find the report informational and the recommendations appropriate?	Treatment group survey.
	Do treatment customers share the report with other members of their household?	Treatment group survey.
	How did customers energy consumption compare to their expectation? Do they think that their energy consumption data presented was accurate?	Treatment group survey.
Quality assurance and control	What is the review process of the report before report delivery?	Staff interviews.
	What was the process for identifying treatment and control group customers?	Staff interviews.

8. Bring Your Own Thermostat

8.1 Program Description

The Bring Your Own Thermostat (BYOT) program is a demand response program that provides incentives for allowing adjustments to their thermostat to reduce air conditioner usage during peak event periods. Participating customers can earn the incentive for each of the five months during the peak season (May through September).

8.2 Data Collection

8.2.1 Run Time Data

ADM will require the runtime data from the smart thermostats to estimate the peak demand impacts. The runtime data will be obtained from either a census of units or from a sample of units of sufficient size to meet +/- 10% statistical precision at the 90% confidence level. ADM will also obtain regional weather data and participant equipment characteristics.

8.3 Gross Impact Evaluation Approach

8.3.1 Baseline Runtime Calculation

The baseline runtime will be estimated for each participant by hour using a regression model of runtime vs a construct known as the weighted temperature humidity index (WTHI). This method, which was originally proposed by PJM, is often used in M&V efforts to estimate residential direct load control.

Temperature and humidity measurements from the closest weather station to each participant (Roanoke or Lynchburg weather stations) will be used. WTHI is calculated as shown in Equation 8.1 from the temperature humidity index (THI) from the current and previous days. THI, as shown in Equation 8.2, is calculated from the temperature and humidity. The maximum daily WTHI was used in the analysis.

Equation 8.1

$$WTHI = \frac{4 * THI_{CurrentDay} + THI_{PreviousDay}}{5}$$

Equation 8.2

$$THI = Temperature_{°F} - .55 * \left(1 - \frac{\%Relative\ Humidity}{100}\right) * (Temperature_{°F} - 58.0)$$

Regression models (Equation 8.3) will be generated for each participant for each hour using hourly ending runtime data for non-event days from May through September. The estimated runtime can then be calculated using the slope, intercept, and WTHI for event days to generate baseline runtimes on event days by day and hour for each participant. Regression models will only be generated for participants that had greater than 50 days of runtime data, to increase the stability of the models.

Equation 8.3

$$Runtime = Slope * WTHI + Intercept$$

8.3.2 kW and kWh Savings Calculation

Because the Evaluation Team will use runtime data, an engineering conversion factor of kW per ton for each unit was calculated, to convert to kW and kWh savings. For the BYOT Program, HVAC unit efficiency and capacity data were not available.

The average baseline and actual runtimes by hour will be calculated over all the participants with runtime data for each event day. A normalization constant, which is calculated as the ratio of the average actual and baseline runtimes two hours before the event, will be applied to the baseline runtimes to account for any differences between the groups.

The runtime reduction for each event hour on event days will be calculated by taking the difference between the normalized-baseline run time and actual run time, as shown in Equation 8.4.

Equation 8.4

$$runtime\ reduction = runtime_{baseline} - runtime_{actual}$$

Hourly kW reduction per unit will be calculated for each unit by factoring the runtime reduction by the average unit kW per unit (Equation 22). The hourly kW reduction will be calculated by multiplying the mean hourly kW reduction per participant by the number in the entire participant population (Equation 23).

$$Hourly\ kW\ reduction\ per\ participant = \frac{1}{n}\sum_{i=1}^{n} runtime\ reduction_{i,hour} * aerage\ kW\ per\ unit$$

Where,

n = Number of event participants with runtime data

Equation 8.5

$$kW\ Reduction = kW\ reduction\ per\ participant * N$$

Where,

N = Total number of event participants

The kWh savings per participant for each event will be calculated by summing the average runtime reduction across all event hours and one hour pre-cooling periods and one hour snapback periods and multiplying by the average kW per unit for the entire population (Equation 8.6). The kWh savings will be calculated for each event by multiplying the kWh saving per participant by number in the entire participant population, according to Equation 8.7.

Equation 8.6

$$kWh\ per\ participant = \sum_{hour=1}^{m}\left(\sum_{i=1}^{n} runtime\ reduction_{i,hour}\right) * average\ kW\ per\ unit$$

Equation 8.7

$$kWh\ savings = kWh\ savings\ per\ participant * N$$

8.4 Net Impact Evaluation Approach

Because the occurrence and timing of the load reducing events are under the direct control of the Company and are implemented within the context of the program, the estimates developed through the approach characterized in Section 8.3.

8.5 Process Evaluation Approach

ADM will complete a process evaluation of the Home Energy Reports Program in 2023 and 2026. The process evaluation will evaluate the program implementation and design.

Table 8-1 summarizes the research topics, questions, and data sources. ADM will address these topics through:

- Surveys of program participants; and
- Reviews of online energy assessment and database of recommendations.

Table 8-1 Process Evaluation Topics, Research Questions, and Data Sources

Topic	Example Research Questions	Data Sources
Incentive design and qualifications,	How does the participation incentive compare to other similar programs?	Review of similar programs and review of program materials.
	What types of thermostats qualify for the program? Are there any types with significant market share that do not qualify?	Review of program materials.
Marketing and outreach	What are the channels used to market the offering and what messaging is used?	Staff interviews and program materials review.
	Is the program cross-promoted though other programs that incentivize smart thermostats?	Staff interviews and program materials review.
	How did participants learn of the program and what motivated the decision to participate?	Participant survey.
Customer experience	Do participants have an accurate understanding of how their thermostat is controlled?	Participant survey.
	What concerns do customers report having about participation?	Participant survey.
	What impacts, if any, did their participation have on their home comfort?	Participant survey.
	How likely are participants to remain enrolled in the following year? What drives participants' likelihood of continuing their participation?	Participant survey.
	How many events did participants expect and was this consistent with the information provided through the program?	Participant survey.
Quality assurance and control	What checks are there in the process to verify that the event control software is communicating with thermostats and that the thermostats are responsive?	Staff interviews.
	What is the process for verifying that a customers thermostat qualifies for the program?	Staff interviews.

9. VoltVar Voltage Control

9.1 Program Description

The VoltVar Voltage Control Program (VoltVar) achieves energy conservation through automated monitoring and control of voltage levels provided on distribution circuits. End use customers realize lower energy and demand consumption when VoltVar is applied to the distribution circuit from which they are served.

A distribution circuit facilitates electric power transfer from an electric substation to utility meters located at electric customer premises. Electric power customers employ end-use electric devices (loads) that consume electrical power. At any point along a single distribution circuit, voltage levels vary based upon several parameters, mainly including, but not exclusive of, the actual electrical conductors that comprise the distribution circuit, the size and location of electric loads along the circuit, the type of end-use loads being served, the distance of loads from the power source, and losses incurred inherent to the distribution circuit itself.

All end-use loads require certain voltage levels to operate and standards exist to regulate the levels of voltage delivered by utilities. The Company is required to maintain a steady state +/- 5% of the respective baseline level (120-volt baseline yields acceptable voltage range of 114 volts to 126 volts).

Because most devices operated by electricity (especially motors) are designed to operate most efficiently at 115 volts, any "excess" voltage is typically wasted, usually in the form of heat. Tighter voltage regulation allows end-use devices to operate more efficiently without any action on the part of consumers. Consumers receive a lower but still acceptable voltage and use less energy to accomplish the same tasks.

9.2 Data Collection

The Company and its vendor will use an "On/Off" procedure for voltage reductions during various parts of the year. This procedure will provide data sets with measurements of voltages and energy use that include both regular voltages (measured on "Off" 'days) and reduced voltages (measured on "On" days).

Data for the following elements will be collected and stored during the year.

- Regulated source voltages by phase,
- Total feeder current by phase,
- kW by phase,
- kvar by phase,
- Primary voltages at or near the end of the distribution feeders by phase, and
- Temperature data.

The data to be collected are of high time granularity. The system can make continuous changes in voltage levels; voltage readings were made continuously, not dichotomously (i.e., off / on). The power and voltage elements will be measured and the data collected and stored at 10-second intervals. Data will be collected and stored six times per minute, 360 times per hour. Because of this frequency of recording, there could be over 3 million data points for each station / circuit / phase. (If no gaps in recording, there would be 3,153,600 data points, for 365 days at 24 hours per day and 360 data points per hour.)

9.3 Net Impact Evaluation Approach

For this program, a net-to-gross (NTG) ratio of 1.0 will be applied in the calculation of net realized energy impacts.

As shown by Equation 9.1 the kWh energy savings that result from voltage reduction can be quantified as the difference between a baseline energy use value (when voltage is not reduced) and actual energy use when voltage is reduced.

Equation 9.1

$$kWh\ savings = kWh_{Baseline} - kWh_{Actual\ when\ VVO\ is\ "On"}$$

The energy use when VVO is "On" can be measured. However, baseline energy use is essentially a "counterfactual" estimate: what would energy use have been during a given hour when VVO was on had VVO been "Off" instead. This counterfactual analysis requires that the relationship between kWh and voltage be specified and empirically estimated. This will be done using a regression modeling approach.

9.3.1 Protocols for CVR Analysis

Methods for using circuit-level data on voltages and power usage to measure and verify savings from voltage reductions are set out in several existing protocols. Because much of the early work on voltage reduction was performed in the Pacific Northwest, the Northwest Regional Technical Forum (RTF) managed a process to prepare a protocol for estimating savings from automated CVR. This protocol (Automated CVR Protocol No. 1) was approved by the RTF in 2004. The RTF approved a second protocol (Simplified Voltage Optimization Protocol) in 2010.

With the RTF protocols, savings resulting from voltage reduction are estimated by multiplying a change in voltage level by a CVR factor that reflects the estimated relationship between voltage reduction and energy reduction. For application of the protocols in the Pacific Northwest, load research data were used to develop a series of lookup tables with CVR values for participating utilities. However, these CVR values depend on load and weather conditions and end-use equipment saturations (e.g., air conditioning use) that are specific to the Pacific Northwest.

An enhanced version of the RTF protocols has been developed by a CVR working group in Pennsylvania. Using data collected for utility distribution circuits in Pennsylvania, the working group developed a Conservation Voltage Reduction (CVR) Custom Measurement Protocol for Demand Reduction. (Revised version was published September 21, 2011.)

9.3.2 Method for Determining kWh Savings

As shown by Equation 9.2, the kWh savings that result from voltage reduction can be quantified as the difference between a baseline energy use (when voltage is not reduced) and actual energy use when voltage is reduced.

Equation 9.2

$$kWh\ savings = kWh_{Baseline} - kWh_{Actual\ when\ VVO\ is\ "On"}$$

Determining Baseline Voltages

Baseline voltages for hours when VVO was "on" will be imputed using mean values of voltages when VVO was "off". These mean values will be calculated for each circuit for cells defined by season (i.e., heating, cooling) and hour of day. For each hour that VVO was "on", the baseline voltage will be imputed to be the "off" voltage from the cell similarly defined by season and hour of day. For example, the baseline voltage for 1 PM during the heating season when VVO is "on" will be imputed to be the mean voltage calculated from voltage readings for the 1 PM hour in the heating season when VVO is "off".

9.3.2.1 Determining Baseline Power

Power for a circuit is not completely independent from voltage changes because not all loads react in the same way to a voltage change. Various studies have shown that the energy savings that result from voltage reduction depend on the characteristics and loads of a feeder.

- Some loads are characterized by constant impedance, where power consumed is proportional to voltage squared. Examples of such loads include resistive water heaters, stovetop and oven cooking loads, for instance.
- Other loads are constant power, where demand is constant regardless of voltage. Examples of constant power loads include electric motors and regulated power supplies.
- A relatively small percentage of loads are constant current, where demand is proportional to voltage. Examples of constant current loads include welding units, smelting, and electroplating processes.

The overall load on a feeder will be a mix of the different load types. Rules of thumb for the split between constant power and constant impedance loads are as follows:

- For summer peak loads, 60% constant power and 40% constant impedance
- For winter peak loads, 40% constant power and 60% constant impedance
- For industrial loads, 80% constant power and 20% constant impedance
- For summer peaking residential loads, 70% constant power and 30% constant impedance
- For winter peaking residential loads, 30% constant power and 70% constant impedance
- For commercial loads, the split between constant power and constant impedance is generally 50%/50% or 60%/40%

Regression analysis will be used to relate circuit power data to month of year, VoltVar operating state and weather. The regression model used is given in Equation 9.3 below.

Equation 9.3

$$Power_i = \alpha + \beta_{1,j} CVR_k + \beta_2 CDD\_Lag2_i + \beta_4 CDD\_Lag4_i + \beta_5 HDD_i + \beta_6 Hour_i + \beta_7 Day\_Type_i + \beta_8 Month_i + e_j$$

Key model variables are identified in Table 9-1.

Table 9-1 Analysis Model Variables

Variable Name	Variable Description
Power	Dependent variable; hourly power (kW).
CVR	1 if VoltVar is on; otherwise 0.
CDH	MAX (Outdoor Temperature - 65°F, 0)
CDD_Lag2	Average CDD for preceding two hours.
CDD_Lag4	Average CDD for preceding four hours.
HDD	MAX (65°F - Outdoor Temperature, 0)
Hour	Group of dummy variables for hour of the day.
Day_Type	1 if weekday; otherwise 0.
Month	Group of dummy variables for month.

Based on the evidence from the heating and cooling degree day data and the power-temperature correlations, two seasons will be defined for the analysis. The heating season includes the months of January through May and October through December. The cooling season includes the months of June through September.

For each circuit, regression models using the specification in Equation 9.3 will be estimated. Separate models will be estimated for two seasons (heating and cooling). Regression models will be developed using a randomly selected subset of data meeting the requirement of balance between weekday and weekend observations and minimizing weather differences between "on" and "off" observations.

The value for β_1 estimated through the regression analysis shows how power on a circuit changes in response to EECO being operated, controlling for month of year, weather, day type, and hour of day.

9.3.2.2 Determining Energy Savings

The results from studies of voltage reduction are often summarized in terms of a conservation voltage reduction factor (CVFf). A CVRf measures the relationship between changes in energy in response to changes in voltage effected under the CVR program. Mathematically, CVRf is calculated as the ratio between the percentage change in energy and the percentage change in voltage, as shown below in Equation 9.4.

Equation 9.4

$$CVR_f = \frac{\%\Delta\ in\ energy}{\%\Delta\ in\ voltage}$$

Where,

$\%\Delta\ in\ energy = \Delta kWh/kWh_{Base}$, and

$\%\Delta\ in\ voltage = \Delta Volts/Volts_{Base}$

9.3.3 Method to Calculate Aggregate Annual kWh Savings

The method described in section 9.3.2 provides hourly circuit/phase/season-level estimates of the day of the average kWh savings that result from VVO voltage reduction. Multiplying an hour-of-the-day estimate of savings by the number of hours voltage was reduced during that hour of the day during the season

provides an aggregate estimate of kWh savings. Summing the hourly kWh savings across hours of the day and type of day provides kWh savings for the whole season. These savings are those that occurred on the days when VVO was "on".

9.4 Process Evaluation Approach

A process evaluation of the VoltVar Voltage Control Program is not planned.