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

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Appendix G

Residential Efficient Products Marketplace Program Impact Evaluation

DOMINION ENERGY

Date: February 28, 2023

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1 EXECUTIVE SUMMARY

1.1 Study purpose and objectives

The primary objective of this study was to conduct an impact evaluation of Dominion Energy's Residential Efficient Products Marketplace Program (Marketplace Program). The Marketplace Program offers upstream lighting incentives that result in price discounts on energy-efficient lighting products for shoppers at program-participating stores. It also offers rebates on ENERGY STAR®-rated appliances. Table 1-1 lists all the energy-efficient measures implemented under this program.

Table 1-1. Program energy-efficient measures

Lighting measures (LEDs)	ENERGY STAR appliance measures
A-Lines	Freezer
Reflectors	Refrigerator
Decorative	Clothes washer
Globes	Dehumidifier
Retrofit kit and fixtures	Air purifier
	Clothes dryer
	Dishwasher

1.2 Methods

This impact evaluation provides estimates of ex post gross energy savings and net energy savings, which account for the effects of free ridership (FR). DNV calculated net-to-gross (NTG) ratios from reported estimates and applied these to tracking data for realization rates and cost-effectiveness. The evaluation also surveyed customers and interviewed lighting and appliance market actors to better understand the markets in which the Marketplace Program operates and gather participant perspectives on the program's effectiveness.

This study satisfies the applicable requirements of the Residential Efficient Products Marketplace Program EM&V Plan (Version 1.0) for Residential Efficient Products Marketplace Program according to the EM&V Rule (20 VAC 5-318). These include calculating impacts as well as informing future Marketplace Program design and implementation through insights gained from interview and survey data.

1.3 Key findings

The following is a summary of the key findings which the report describes in more detail in later sections.

1.3.1 Adjusted gross savings

This study determined that no adjustment is needed to the Marketplace Program's gross energy savings claims because:

1. All the interviewed lighting manufacturers and retail buyers confirmed the summary of their 2021 program sales that DNV had emailed them before the interviews.

2. DNV verified that all the quantities of LED product types that appeared in the sample of lighting manufacturer invoices for March-April 2021 and October-November 2021 (which accounted for one-third of program sales during the 2021 calendar year) matched those in the program tracking data.
3. Only 2 of the 1,776 surveyed appliance participants described a situation in which the program should lose some savings—either because the appliance had not been installed or it had been installed outside the Dominion service territory.[1]

1.3.2 Net savings for lighting

As discussed in more detail later, DNV calculated adjustment factors for net savings using self-reported values from in-depth interviews. These values were applied to each supplier's sales after averaging the suppliers' NTG estimates with their partnered retail buyers' NTG estimates. Table 1-2 shows the breakdown of each bulb category's NTG estimates along with confidence intervals and standard error calculations. Note, with fixtures and retrofit kits making up a tiny portion of overall sales (1%) and having the fewest number of independent NTG estimates (5), DNV decided to use an average of the NTG ratios (49%) from the three more robust lighting categories for this fixture/retrofit kit category rather than relying on the small sample of supplier self-reported NTG ratios.

Table 1-2. Lighting NTG summary by LED product type

	A-line lamps	Specialty lamps	Reflector lamps
Adjusted program sales with NTG estimates	1,190,810	356,460	325,919
Program sales	2,296,654	898,933	593,874
NTG ratio	52%	40%	55%
Standard error	4.1%	2.1%	8.3%
Lower confidence interval	45.6%	36.4%	42.2%
Upper confidence interval	58.1%	42.9%	67.6%

1.3.3 Net savings for appliances

DNV also estimated net savings for the appliance component of the program. Figure 1-1 shows the total attributable energy savings for the appliance component of the program (the ratio between program-attributable energy savings and total program savings is the NTG ratio). The portion of savings that was attributable to the program – 38% -- was a decline from the attributable portion from the last evaluation (47%). As discussed elsewhere in this report, DNV attributes this decrease to factors such as inflation where incentive levels have not kept pace with increasing appliance costs, recently exacerbated by pandemic-induced supply chain issues. As noted below, the program-rebated appliance which had the highest ratio between incentive level and equipment cost – air purifiers – also had the highest level of program attribution. The appliance NTG ratios in the current Dominion Energy study are also similar to appliance NTG ratios recently estimated in Massachusetts, as discussed in the body of the report.

[1] As part of their standard quality control practices, the program implementation contractor CLEAResult reported auditing about 5% of applications per month. These audits would request customers to supply pictures of the installed appliances to ensure that the units did not get returned and that the rebate application forms included accurate information.

Figure 1-2 breaks down the program-attributable savings by appliance. The smaller appliances (dehumidifiers, air purifiers) had higher NTG ratios than the larger appliances. One possible reason for this, as discussed later in the report, is that the program accelerated the purchase of dehumidifiers and air purifiers more than any other appliances (timing is a key component of program attribution). This is likely because participants can delay purchasing a new dehumidifier or air purifier with less inconvenience than delaying the purchase of a new refrigerator, clothes washer, or clothes dryer, especially when these larger appliances are replacements for non-functioning equipment.

The ratio between the program rebate and the average equipment purchase prices was also much higher for air purifiers (35%) than any of the other appliances. As discussed in the body of the report, there is some evidence that this might be related to air purifiers' higher level of program attribution.

Figure 1-1. Total attributable energy savings for the appliance component of the program

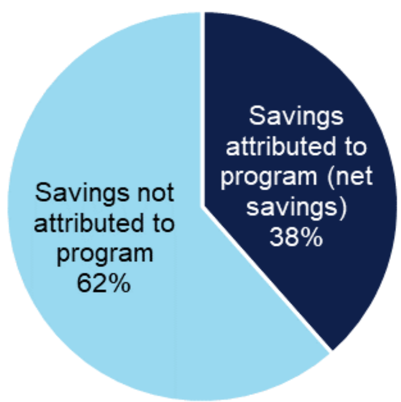


Figure 1-2. Program-attributable energy savings by ENERGY STAR appliance

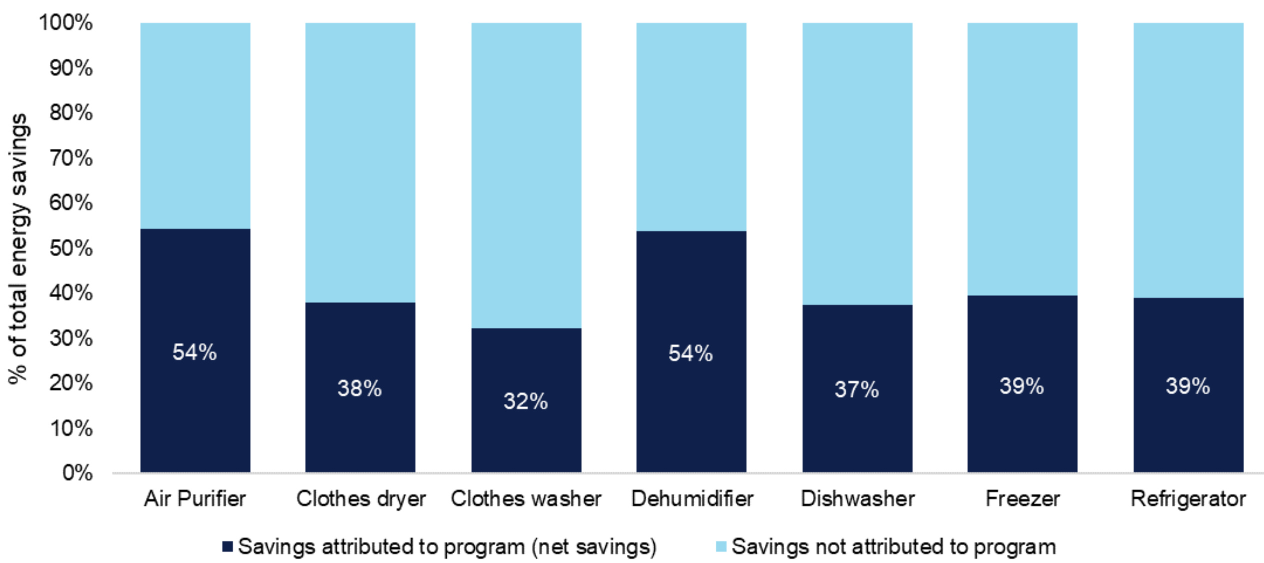


Table 1-3 shows the program attribution ratios for these appliances along with information on sample sizes, standard errors, and confidence intervals.

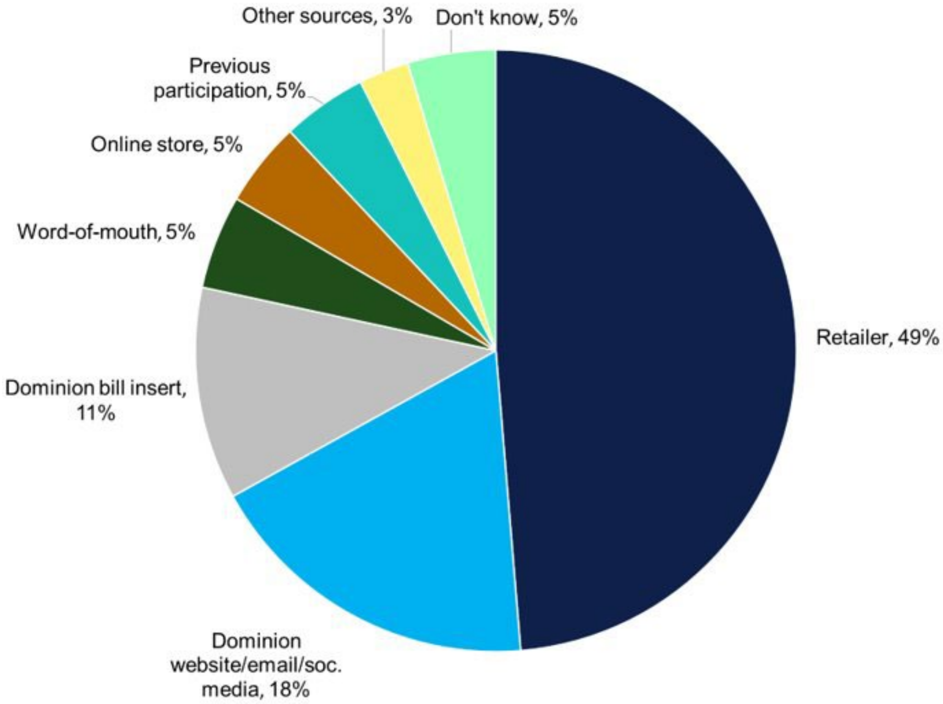
Table 1-3. Program-attributable energy savings by appliance with confidence intervals

ENERGY STAR measure	Number of respondents	Mean	Standard error	One-sided lower C.I.	One-sided upper C.I.
Air purifier	107	0.5	0.1	0.4	0.7
Clothes dryer	541	0.4	0.0	0.3	0.4
Clothes washer	655	0.4	0.0	0.3	0.4
Dehumidifier	145	0.5	0.1	0.5	0.6
Dishwasher	316	0.4	0.0	0.3	0.4
Freezer	33	0.4	0.1	0.2	0.6
Refrigerator	531	0.4	0.0	0.3	0.4

1.3.4 Program marketing and outreach

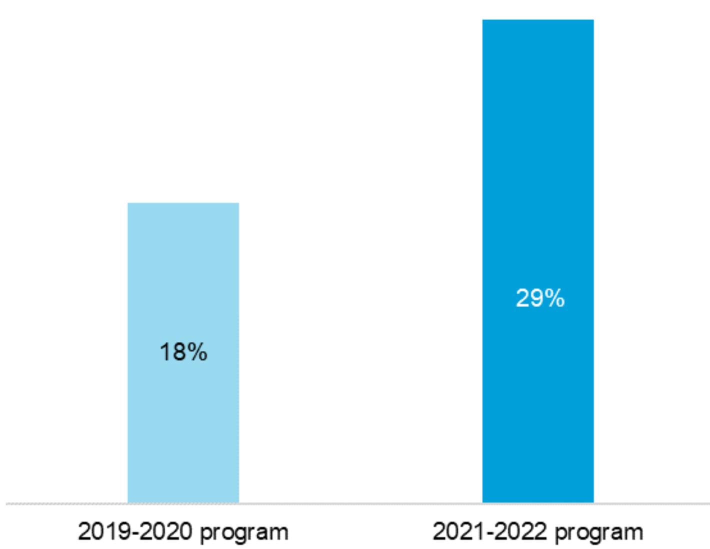
DNV asked the Marketplace Program's appliance participants how they first learned about the rebates. The most common way that appliance participants reported first hearing about the rebates was in a retail store (almost half the participants). The Dominion Energy website was a distant second, with 18% of respondents saying this is where they first heard about the rebates. Figure 1-3 shows the full range of responses.

Figure 1-3. How appliance participants first heard about the program



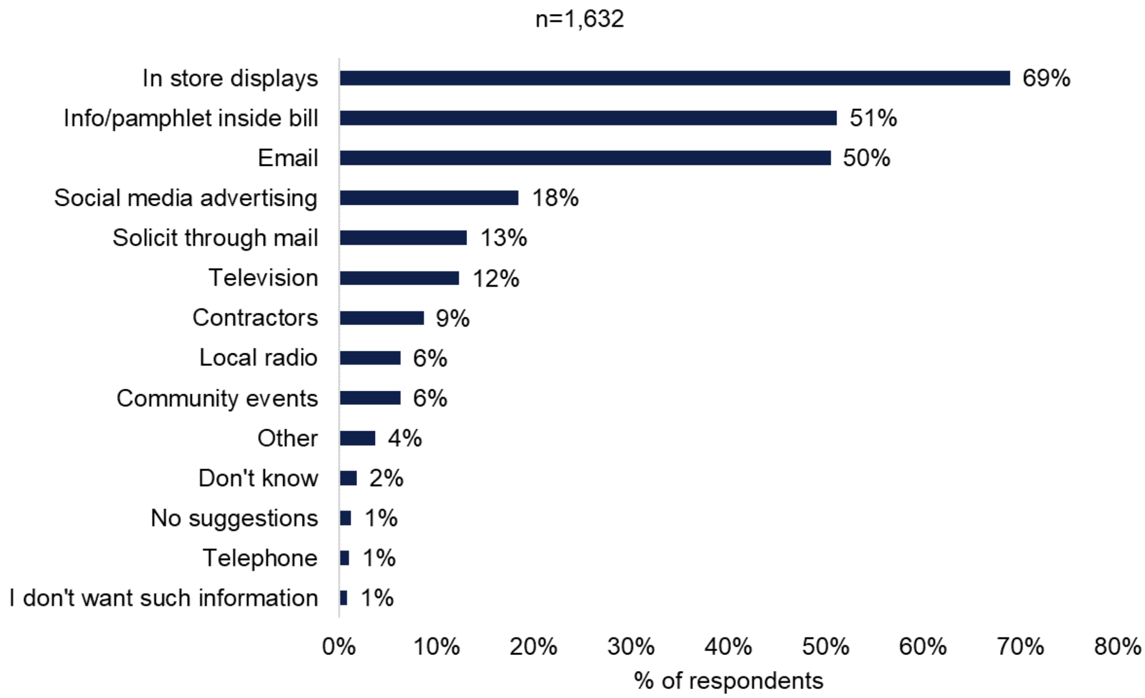
One positive trend for the program is that the 2021 appliance participants were more likely than the 2019-2020 participants to first hear about the program from Dominion Energy information sources. Figure 1-4 shows that 29% of the recent participants cited a Dominion source (website, email, social media, or bill insert) as their first source of program information compared to only 18% of the 2019-2020 participants mentioning this. However, the percentage of appliance participants who recalled seeing the program point-of-purchase marketing materials in the participating stores remained relatively flat over the two evaluation periods (54% for the 2019-2020 program and 51% for the 2021 program).

Figure 1-4. Percentage of participants who heard about rebates from Dominion Energy sources



DNV asked the appliance participants: “If Dominion wanted to inform customers like yourself about the rebates and services they offer for energy-efficient programs, what do you suggest would be the best way to do that?” In response, participants said they would most prefer hearing about energy efficiency programs and rebates from in-store point-of-purchase displays, bill stuffers, and emails. Over two-thirds of the participants recommended in-store displays, and about half suggested bill stuffers or email communications. This suggests that current outreach activities, especially, the in-store promotions, should continue. Participants cited many other recommendations as well, though less frequently, as Figure 1-5 shows.

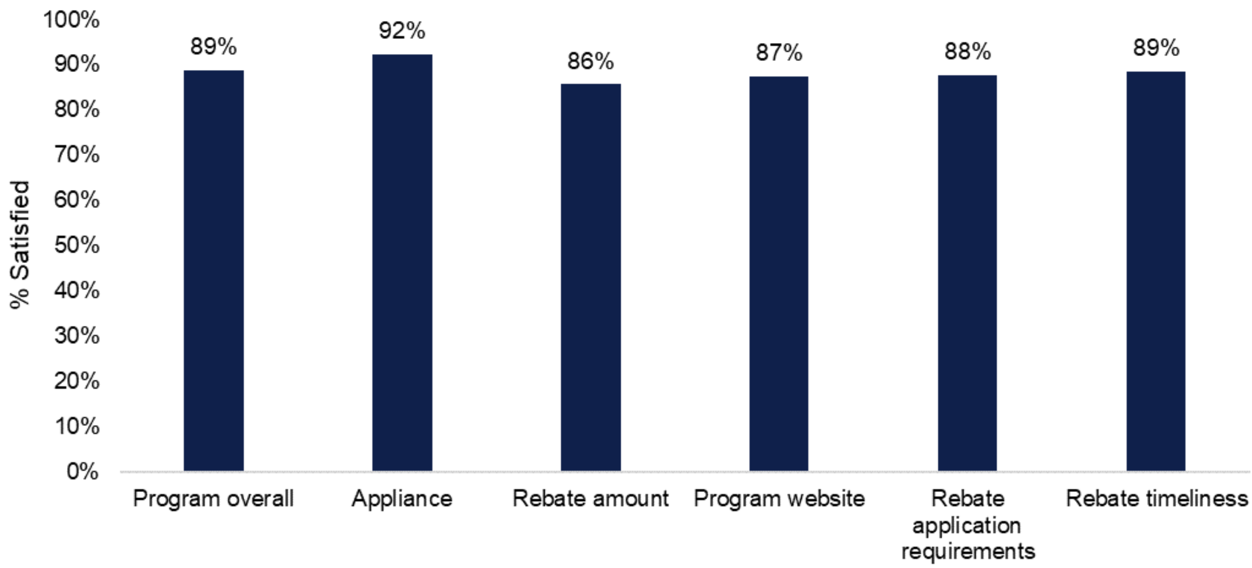
Figure 1-5. How participants would prefer to get future program information



1.3.5 Program satisfaction

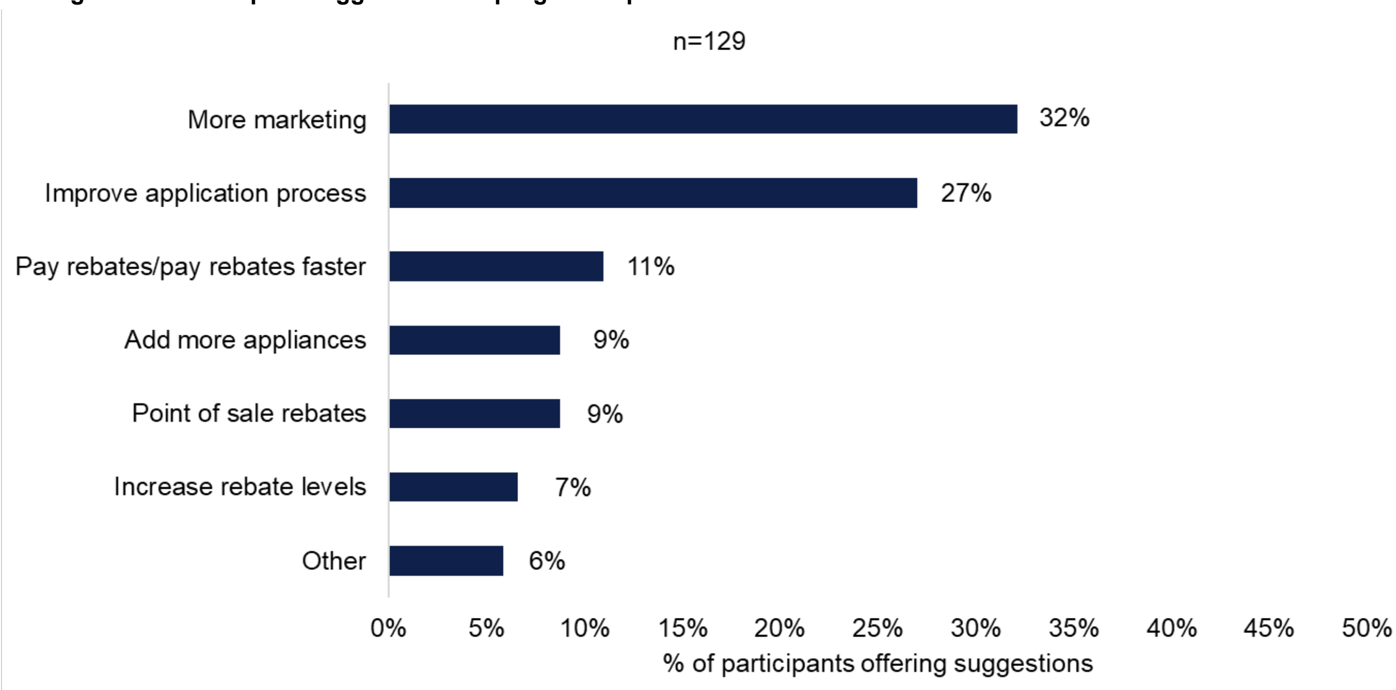
- **Program satisfaction was high.** DNV asked the participants about their satisfaction with the Marketplace Program as well as with various aspects of the program including the website, the rebate application process, the timeliness of the rebate payment, the rebate amounts, and the rebated appliances. As Figure 1-6 shows, participants were most satisfied with the rebated appliances and least satisfied with the rebate amount.

Figure 1-6. Program satisfaction



- **Few participants had suggestions for improving the program**. Only 8% of the appliance participants had suggestions for program improvements. As Figure 1-7 shows, the two most-cited suggestions were to improve the rebate application process and do more program marketing.

Figure 1-7. Participant suggestions for program improvements



Note: The percentages exceed 100% because the participants could provide multiple suggestions. *Other suggestions included allowing bill credits, offering rebates for a wider range of appliances, and supporting solar programs.

1.4 Recommendations

Based on the findings from this report, DNV makes the following recommendation for improving the future delivery of the Marketplace Program:

Promote more program small appliance sales

The NTG ratios for the smaller appliances—air purifiers (54%) and dehumidifiers (54%) were higher than those for other appliances, likely due to some of the factors mentioned above (e.g., rebates accounting for a larger proportion of the appliance purchase price, and the program having greater purchase acceleration impacts on these appliances).

2 INTRODUCTION

2.1 Study purpose and objectives

The primary objective of this study was to conduct an impact evaluation of Dominion's Residential Efficient Products Marketplace Program (Marketplace Program). The Marketplace Program offers upstream lighting incentives that result in price discounts on energy-efficient lighting products for shoppers at program-participating stores. It also offers rebates on ENERGY STAR-rated appliances. Table 2-1 lists all the energy-efficient measures implemented under this program.

Table 2-1. Program energy-efficient measures

Lighting measures (LEDs)	ENERGY STAR appliance measures
A-Lines	Freezer
Reflectors	Refrigerator
Decorative	Clothes washer
Globes	Dehumidifier
Retrofit kit and fixtures	Air purifier
	Clothes dryer
	Dishwasher

This study satisfies the applicable requirements of the Residential Efficient Products Marketplace Program EM&V Plan (Version 1.0) for Residential Efficient Products Marketplace Program according to the EM&V Rule (20 VAC 5-318). These include calculating impacts as well as informing future Marketplace Program design and implementation through insights gained from interview and survey data.

2.2 Organization of report

The remainder of this report is organized as follows:

Section 3 – Methodology

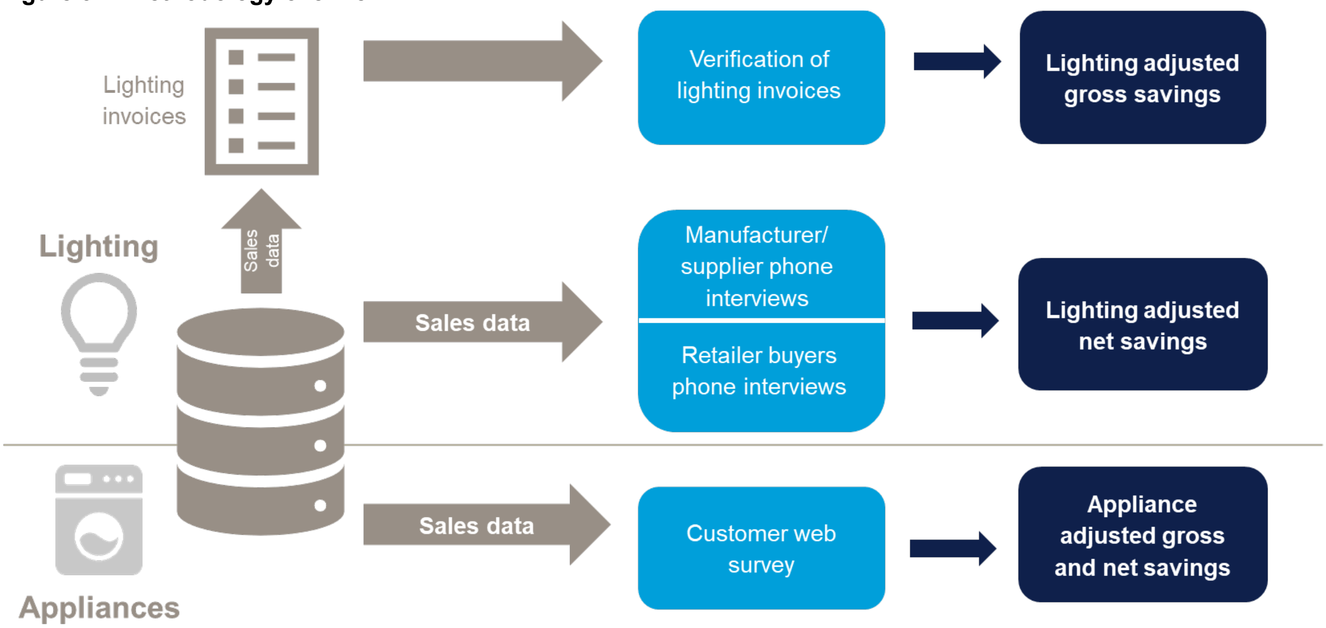
Section 4 – Findings

- Section 4.1 – Adjusted gross savings
- Section 4.2 – Adjusted net findings
- Section 4.3 – Participant perspectives on program marketing
- Section 4.4 – Program satisfaction
- Section 4.5 – Other findings

3 METHODOLOGY

This section describes how DNV calculated the adjusted gross savings factors and adjusted NTG ratios. Figure 3-1 provides a high-level overview of our methodology.

Figure 3-1. Methodology overview



The study followed the Residential Efficient Products Marketplace Program EM&V Plan (Version 1.0) and national protocols for designing survey and survey samples and measuring net savings such as the Uniform Methods Project (UMP).[2] The evaluation used well-established survey methodologies to estimate program impacts. First, DNV interviewed the Dominion Energy program manager to gain greater insights and background knowledge of the program. These interviews helped DNV write informed questions for the impact, marketing, and satisfaction sections of the survey instruments.

For the lighting portion of the study, DNV conducted in-depth interviews with lighting manufacturers who participated in the program and the retailers who sold bulbs. The interviewers first asked them to confirm their sales through the program as stated in the program tracking data, which they were given before the interview took place. They then asked the manufacturers and retailers to estimate the impact on their sales if the Marketplace Program, with its price discounts and point-of-purchase promotional materials, had not been available. DNV asked this series of program attribution (NTG) questions for each of the four different classes of LED lighting products: 1) A-line lamps, 2) reflectors, 3) specialty lamps, and 4) fixtures and retrofit kits.

DNV then asked the manufacturers and retailers questions about market trends, including possible barriers to LED product demand and the future direction of LED product pricing. Finally, it asked the manufacturers and retailers to rate their satisfaction with the Marketplace Program. The survey instruments for the suppliers and retailers can be found in Appendix C and D, respectively.

[2] Daniel M. Violette and Pamela Rathbun, (2017) *Chapter 21: Estimating Net Savings – Common Practices, The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68578; Robert Baumgartner. (2017). *Chapter 12: Survey Design and Implementation for Estimating Gross Savings Cross-Cutting Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures.* Golden, CO; National Renewable Energy Laboratory. NREL/ SR-7A40-68568.

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3.1 Sample design

This section describes the sample designs for each component of the Marketplace Program.

3.1.1 Lighting sample design

For the lighting part of the evaluation, DNV reviewed the 2021 Marketplace Program tracking data and identified 21 participating lighting manufacturers and 13 participating large retailers. These small populations allowed for a census approach to the data collection where DNV attempted to complete interviews with all participating manufacturers and large retailers. Therefore, no formal sample design was needed.

3.1.2 Appliance sample design

For the appliance part of the evaluation, DNV sent out web survey invitations to all Marketplace Program participants in the 2021 tracking data. To reduce respondent fatigue, if participants had received more than two appliances through the program, they were only asked about two of them.

After the survey was out of the field, DNV checked the representativeness of the sample by comparing the characteristics of the respondents to those of the full program population. Table 3-1 presents this comparison. As the table shows, the sample compares well to the population, with the possible exception of the average purchase price of the air purifiers (7% higher for the sample than for the population).

Table 3-1. Appliance characteristics: program participants vs study participants

ENERGY STAR appliance	Percent number of units	Percent savings	Average savings (kWh/year)	Percent of sum of price	Average purchase price ($)	Percent of rebates	Average rebate ($)
Program participants							
Air purifier	6%	11%	222	1%	144	5%	50
Clothes dryer	23%	30%	175	22%	906	38%	100
Clothes washer	28%	41%	191	26%	877	24%	50
Dehumidifier	5%	4%	103	1%	219	2%	25
Dishwasher	14%	4%	36	10%	711	11%	50
Freezer	1%	0%	44	1%	663	1%	50
Refrigerator	22%	11%	63	38%	1,626	18%	50
Total	**100%**	**100%**	*	**100%**	*	100%	*
Study participants							
Air purifier	6%	11%	238	1%	155	5%	50
Clothes dryer	22%	29%	174	21%	910	37%	100
Clothes washer	27%	39%	190	25%	878	22%	50
Dehumidifier	7%	5%	102	2%	221	3%	25
Dishwasher	14%	4%	36	11%	723	12%	50
Freezer	1%	0%	43	1%	639	1%	50
Refrigerator	23%	11%	64	40%	1,604	20%	50
Total	**100%**	**100%**	*	**100%**	*	**100%**	*

* Not applicable

Because the program provides rebates for so many different types of ENERGY STAR appliances, it is useful to know which of these appliances are more important than others as measured either by energy savings or incentive amounts. Figure 3-2 and Figure 3-3 illustrate the savings and rebates for each of the ENERGY STAR program appliances. For example, clothes washers account for 41% of the program savings but only 27% of the program rebates. In contrast, clothes dryers account for 30% of savings and 40% of rebates.

Figure 3-2. ENERGY STAR appliance program savings

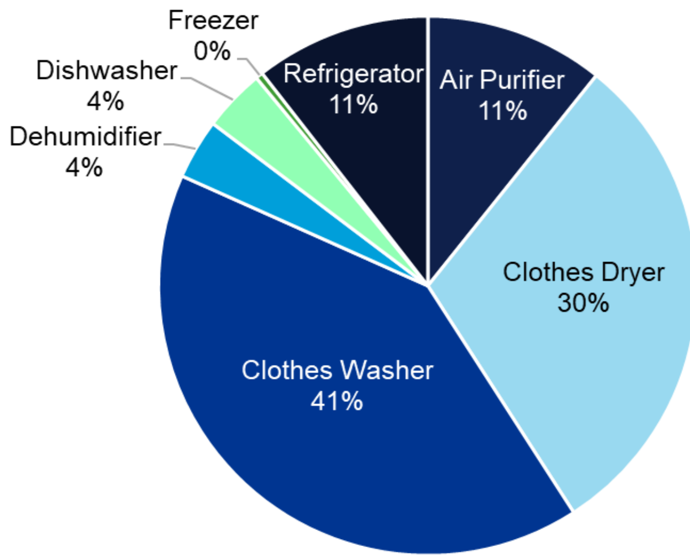
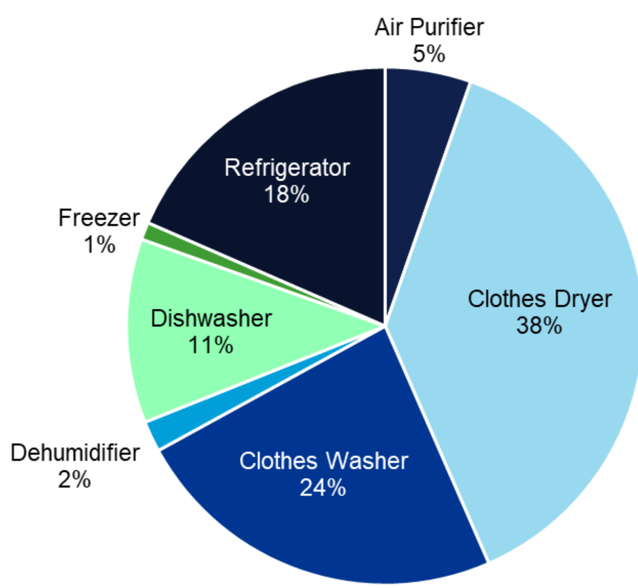


Figure 3-3. ENERGY STAR appliance program rebates



DNV also compared the reasons for purchase stated in the rebate form for all program participants to those of the sample. Table 3-2 shows that in this respect, the sample is a good representation of the population.

Table 3-2. Reasons for purchase stated in rebate form

Reason for purchase stated in rebate form	All program participants (population no. of units)	% of program participants	Study participants (sample no. of units)	% of study participants
Replace broken	10,857	44%	1,097	44%
Replace working unit (upgrade) / Remodel	7,270	29%	793	32%
Purchase for new move into existing home	3,114	13%	252	10%
Purchase additional unit(s) in existing home	2,297	9%	239	10%
Purchase for newly built home (new construction)	1,217	5%	103	4%
No answer	65	0%	10	0%
Totals	**24,820**	**100%**	**2,494**	**100%**

3.2 Data sources

DNV obtained program tracking data from the program implementer from 2021 for the lighting and appliance components of the program. For the lighting component, DNV also acquired invoices from participating lighting manufacturers from March-April 2021 and October-November 2021 and contact information for all the participating manufacturers. Since the contact information that Dominion Energy's implementation contractor provided was incomplete, DNV supplemented it via web searches and contact information we had compiled from previous evaluations of upstream lighting programs in other jurisdictions.

DNV attempted a census of all lighting manufacturers and retailers for the data collection interviews, focusing on the manufacturers/distributors and retail buyers who accounted for the largest volume of programs. DNV enlisted the help of Dominion Energy and the program implementer to encourage cooperation from those manufacturers.

To collect the data needed for the evaluation, DNV reached out to each manufacturer contact first by email and then with a follow-up phone call. Data collection occurred between October and December 2022. Multiple emails and phone calls were attempted until a contact was considered exhausted or non-responsive. For retailer contacts, DNV followed a similar process. A contact list was unavailable from the program implementer, so DNV accessed past contact information from the previous evaluation and cross-referenced it with publicly available information. This resulted in contact information for only 7 of the 12 retailers and likely contributed to the lower response rate for retailers compared to manufacturers. An additional reason for the lower response rate is that retailers do not partner directly with the program and benefit only indirectly through the incentives given to manufacturers.

Ultimately, DNV was successful in interviewing some of the largest program actors. We completed interviews with 12 lighting manufacturers or distributors including interviews with 9 out of 10 of the largest manufacturers. DNV also completed an interview with the largest retail buyer within the program. This compares to completed interviews with 9 manufacturers and 4 retail buyers in the previous evaluation. Table 3-3 shows that the interviewed manufacturers accounted for 83% of program sales; Table 3-4 shows that the interviewed retail buyers represented 32% of program sales. The tables also show that these sale percentages varied with the LED product type.

Table 3-3. Program sales accounted for by interviewed lighting manufacturers

Sales volume	A-Lines	Specialty	Fixtures and retrofit kits	Reflectors	Total
Program sales of interviewed manufacturers (January–December 2021)	2,296,654	898,933	14,764	593,874	3,804,225
Total program sales (January–December 2021)	2,718,022	1,178,108	21,089	644,398	4,561,617
% of program sales accounted for by interviewees	85%	76%	70%	92%	83%

Table 3-4. Program sales accounted for by interviewed lighting retailers

Sales category	A-Lines	Specialty	Fixtures and retrofit kits	Reflectors	Total
Program sales of interviewed retailers (January–December 2021)	810,268	439,472	13,632	207,666	1,471,038
Total program sales (January–December 2021)	2,718,022	1,178,108	21,089	644,398	4,561,617
% of program sales accounted for by interviewees	30%	37%	65%	32%	32%

3.3 Adjusted gross savings

DNV verified gross savings for the Marketplace Program in three different ways:

1. **DNV asked participating lighting manufacturers and retail buyers to verify the volume of their LED product sales through the Marketplace Program.** Before the interviews with the participating lighting manufacturers and retail buyers, DNV emailed a table summarizing their sales through the Marketplace Program for 2021 broken out by LED product type. During the interviews, DNV asked them to verify the quantities in the summary tables.
2. **DNV compared a sample of invoices from lighting suppliers to the program tracking data used to estimate gross savings.** DNV selected a sample of invoices from March-April 2021 and October-November 2021, which accounted for 37,318,181 kWh/year of the program's ex ante savings. We selected this sample because it included invoices from both the first and second half of the year. Table 3-5 shows there was not much variation in program activity throughout the year, so a random sample of 2-month batches would not cause an unrepresentative low volume of sales.

Table 3-5. Upstream 2021 kWh bulb savings by month

Reporting month	Sum of kWh savings	Percentage of total by month
Jan	10,369,745	9%
Feb	9,379,324	8%
Mar	8,196,282	7%
Apr	7,248,383	7%
May	10,669,956	10%
Jun	7,234,081	7%
Jul	8,167,656	7%
Aug	9,695,897	9%
Sept	7,605,313	7%
Oct	11,575,033	10%
Nov	10,298,483	9%
Dec	10,243,472	9%
Total	**110,683,624**	100%

a. DNV reviewed total as well as average LED shipments by distribution channel (e.g., discount, drug store, etc.) as well as by product type (A-line, globe, PAR, candelabra base, etc.). For each invoice/application selected for verification, we compared the program tracking data to what was provided in the invoice form. In addition to the quantity of utility-discounted products shipped, we attempted to verify the following key metrics:

   - Manufacturer name
   - Measure name
   - Product type
   - Retailer name and location
   - Invoice completion date
   - Total bulb quantity
   - Total units

3. **DNV asked participants who received a program-rebated appliance to confirm that the appliance had been installed in the Dominion Energy service territory**, and if not, what the participant had done with the appliance.

3.4 Adjusted net savings

3.4.1 Lighting estimates

To estimate net energy savings for the upstream lighting component of the program, DNV used the supplier self-report methodology.[3] This methodology is one of the few available for estimating NTG ratios for upstream lighting programs that do not collect contact information from participating customers. Self-report methodology was first used to estimate NTG ratios for California's upstream lighting program in 2007[4] and has since been used to calculate NTG ratios for some of the nation's

[3] Daniel M. Violette and Pamela Rathbun, (2017) *Chapter 21: Estimating Net Savings – Common Practices, The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68578;

[4] *2004/2005 Statewide Residential Retrofit Single-Family Family Energy Efficiency Rebate Evaluation*, Final Report, Prepared for California's Investor-Owned Utilities, October 2, 2007, CPUC-ID#:1115-04.

largest upstream lighting programs, including in California, Massachusetts, Illinois, and the service territory of the Tennessee Valley Authority (TVA).

The supplier self-report methodology bases NTG estimates on what the participating lighting manufacturers and retail buyers believe would have been the impact on their sales of the program-rebated LED products if the program's price discounts and point-of-purchase promotional materials had not been available. Table 3-6 shows generic and condensed versions of the actual interview questions (which can be found in Appendices B and C).

Evaluations of upstream lighting programs in other jurisdictions have found that certain discount retailers, such as dollar stores and thrift stores, are only able to offer lighting products when the program discounts are available. Question Q1 in Table 3-6 is designed to identify these situations in the lighting manufacturer interviews. Question Q2 is designed to cover most situations, where the lighting manufacturers and retail buyers estimate that they would continue to sell the discounted LED products without the program, but at lower sales volumes.

Table 3-6. Example NTG questions from manufacturer/retail buyer interviews

Question scope	Question language
Sales impact questions asked only of lighting manufacturers	**Q1.** The Dominion Energy Program paid average buydown or markdown discounts of $<average_buydown> per <lamp type>. Are there any retailers or retailer categories that you worked with through the program that you think would not have been selling any <lamp type> if these discounts had not been available? As a reminder, you worked with <retailers >. **Q1a.** [IF YES] Which retailers or retailer categories? **Q1b.** [IF YES] Why do you say this?
Sales impact questions asked of both lighting manufacturers and retail buyers[5]	**Q2.** Dominion Energy Program paid average buydown or markdown discounts of $<average_buydown> per <lamp type>. If these program buydown/markdown discounts and program promotional materials had not been available during 2019 and early 2020 (before the COVID pandemic), do you think your sales of these types of bulbs through <retailers_string> in Virginia and North Carolina would have been about the same, lower, or higher? **Q2a.** [IF THE SAME OR HIGHER] Why do you say this? **Q2b.** [IF LOWER] By what percentage do you estimate your sales of <lamp type> through <retailers string> would be lower during 2019 if these program buydowns/ markdowns and program promotional materials had not been available? [RECORD % DECREASE] **Q2c.**I want to make sure I understand you correctly. You estimate that your sales would have been [PERCENTAGE FROM Q2b] % lower without the program support. So, if you actually sold <lamp type> in a given week, you think you'd have sold only about [100 – (PERCENTAGE FROM Q2b) * 100)] in that period if the buydowns/markdowns hadn't been available?

[5] The example question Q2 here is the one used for the lighting manufacturer interviews. The question for the retail buyers is shorter because there is no need to break out the question by retail channel.

For any responses to question Q2 that indicated a decline in sales absent the program, the team assigned an NTG ratio equivalent to the estimated drop in sales. For example, if a lighting manufacturer representative or a retail buyer estimated that their sales of a given LED product would decline 60% absent the program, the NTG ratio would be 60%.

DNV collected separate NTG ratios for each of four LED product types: 1) A-lines, 2) reflectors, 3) specialty lamps, and 4) fixtures/retrofit kits. The specialty lamps category included globes, candelabra base lamps, candles, and other specialty lamps. However, DNV only asked the manufacturer representatives or retail buyers about a particular LED product type if they sold that product type through the program.

DNV asked the manufacturer representatives to also provide NTG estimates that were specific to the retailers their company used to sell their products through the program. To reduce respondent fatigue, if manufacturers sold program-discounted through many retailers, DNV only asked the manufacturer representatives to provide NTG estimates for the retailers that accounted for the largest percentage of their sales through the program.

The final step was to combine the NTG estimates provided by the 10 manufacturer representatives and one retail buyer to produce separate NTG estimates for each LED product type. DNV weighted each NTG estimate by the volume of program sales represented by the interviews. For example, if we had obtained two NTG estimates for the same sales "stream" (e.g., Manufacturer A sold 10,000 A-line lamps through Retailer B), then we averaged the NTG estimates from Manufacturer A and Retailer B for those 10,000 A-line lamps.

3.4.1.1 Methodology advantages and disadvantages

As with all NTG methodologies, the supplier self-report methodology has its advantage and disadvantages. The advantages include:

- *Market knowledge:* Lighting manufacturers and retail buyers are knowledgeable about lighting market trends. When bidding into upstream lighting programs, it is in the manufacturers' best interests to reliably estimate how many LED products they can expect to sell given a certain price level. Understanding the dynamics between price and sales volume is key to making good NTG estimates.
- *Evaluation efficiency:* Since a few lighting manufacturers and retailers account for a large percentage of program sales, it is possible to get NTG estimates for a significant portion of program activity with only a few estimates. In this evaluation, DNV was able to account for 83% of program sales with less than a dozen lighting manufacturer interviews.

The disadvantages include:

- *Gaming biases:* Since lighting manufacturers directly benefit from the price discounts offered by upstream lighting programs, it is in their best interest to overestimate the sales impacts of the program price discounts to ensure these programs continue.
- *Other biases:* Some retailers may exaggerate their capacity to sell “green” products and therefore underestimate the importance of price discounts provided by upstream lighting programs.[6]

These biases tend to work in opposite directions with the gaming biases tending to increase NTG ratios and the “green retailer” biases tending to decrease them.

3.4.2 Appliance estimates

DNV estimated net savings for the appliance component of the program by applying an adjustment factor that reflects program influence. The adjustment factor is expressed as the percentage of savings that are attributed to the program, and net program savings are the fraction of deemed savings that were caused by the program.

Net Program Savings = Deemed Program Savings x Attribution Factor

DNV calculated attribution factors for each appliance in the Marketplace Program with respect to the influence of the program on (1) the timing of the purchase, and (2) the efficiency level of the chosen appliances.

[6] See for example “Multistage Lighting Net‐to‐Gross Assessment: Overall Report,” Prepared for The Electric and Gas Program Administrators of Massachusetts, Part of the Residential Evaluation Program Area, August 2015.

4 FINDINGS

4.1 Adjusted gross savings

4.1.1 Lighting manufacturer/retail buyer sales verification

When asked to verify the quantities in the summary tables DNV had created, all the lighting manufacturers and the one retail buyer reported that the summary table quantities appeared to be accurate for the sales period in question.

4.1.2 Lighting supplier invoice verification

DNV also verified gross energy savings claims for the Marketplace Program by reviewing a sample of invoices from participating lighting suppliers and matching them with LED shipment data from the program tracking data. We were able to verify 100% of the sample invoices against the tracking data.

4.1.3 Appliance participant installation verification

DNV asked the customers who had participated in the appliance component of the program to verify that their rebated appliance had been installed at the address indicated in the program tracking data.[7] Only 17 of the 1,776 surveyed participants (<1%) said that this was not the case.[8]

DNV then asked these 17 participants what they did with the appliance. Eleven of the 17 responded to this follow-up question:

- Seven responded they had installed the appliance at a different address within the Dominion Energy service territory.
- Two responded they had installed their rebated appliance at a different address but did not specify whether it was outside the Dominion Energy territory.
- Two chose the “Other” response option on the web survey without specifying details.

Since only two of the 1,776 surveyed appliance participants described a situation where savings would be discounted and the associated savings were less than 1%—either because the appliance had not been installed or it had been installed outside the Dominion Energy service territory—DNV determined that there was effectively no reduction to the gross savings for the appliance component of the program.

4.1.4 Summary

This study determined that no adjustment to gross energy savings claims was needed because:

1. All the interviewed lighting manufacturers and retail buyers confirmed the summary of their 2021 program sales from the tracking data, which DNV had emailed them before the interviews.
2. DNV verified that all the quantities of LED product types that appeared in the sample of lighting manufacturer invoices for March-April and October-November 2021 (which accounted for one-third of program sales during the 2021 calendar year) matched those in the program tracking data.
3. Only two of the 1,776 surveyed appliance participants (accounting for <1% of gross savings) described a situation where the program would be discounted savings—either because the appliance had not been installed or because it had been installed outside the Dominion Energy service territory.

[7] DNV assumed that the program implementation contractor had checked to make sure the addresses in the program tracking data were within the Dominion Energy service territory before approving the rebates. For appliance rebates, customer validation occurs via the online portal that customers use to submit rebate applications. In this portal customers must provide their Dominion Account Number and name on the account along with contact information which includes an address. Once a rebate is submitted, customer information is verified with an API connection (web service) that the program implementation contractor set up with Dominion Energy. The implementation contractor’s processing team verifies all these required validations during the processing as well to further confirm customer eligibility.

[8] These 17 participants represented 20 appliances because three of them had not installed two of the rebated appliances.

4.2 Adjusted net savings

This section summarizes the findings concerning net savings estimates for both the lighting and appliance components of the Marketplace Program

As discussed earlier, DNV calculated adjustment factors for net savings using self-reported values from in-depth interviews. These values were applied to each supplier's sales after averaging the suppliers' NTG estimates with their partnered retail buyer's NTG estimates. The breakdown of each bulb category's NTG estimates is shown in Table 4-1. Note, with fixtures and retrofit kits making up a tiny portion of overall sales (1%) and having the fewest number of independent NTG estimates (5), DNV decided to use an average of the NTG ratios (49%) from the three more robust lighting categories for this fixture/retrofit kit category rather than relying on the small sample of supplier self-reported NTG ratios.

Table 4-1. Lighting NTG summary by LED product type

	A-line lamps	Specialty lamps	Reflector lamps
Adjusted program sales with NTG estimates	1,190,810	356,460	325,919
Program sales	2,296,654	898,933	593,874
NTG ratio	52%	40%	55%
Standard error	4.1%	2.1%	8.3%
Lower confidence interval	45.6%	36.4%	42.2%
Upper confidence interval	58.1%	42.9%	67.6%

This research showed lower NTG values for the lighting program compared to the evaluation the team conducted two years ago using the same methodology (Figure 4-1). This decline is likely due to the increasing market adoption of LEDs and the reduced availability of non-LED alternatives. The Consortium for Retail Energy Efficiency Data (CREED), which collects national retail lighting sales data, estimates that the LED market share increased from 60% to 76% from 2019-2021.[9] States such as California, Illinois, and Massachusetts have discontinued their upstream lighting programs due to these kinds of market trends.

[9] https://www.creedlighttracker.com/wp-content/uploads/2022/06/graph-1.png

Figure 4-1. Lighting NTG ratios – 2019 vs. 2021

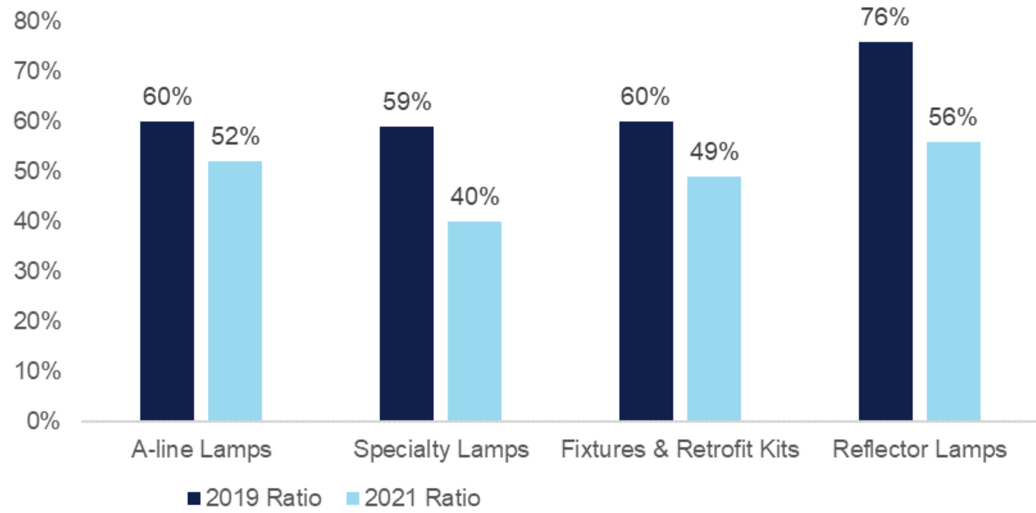
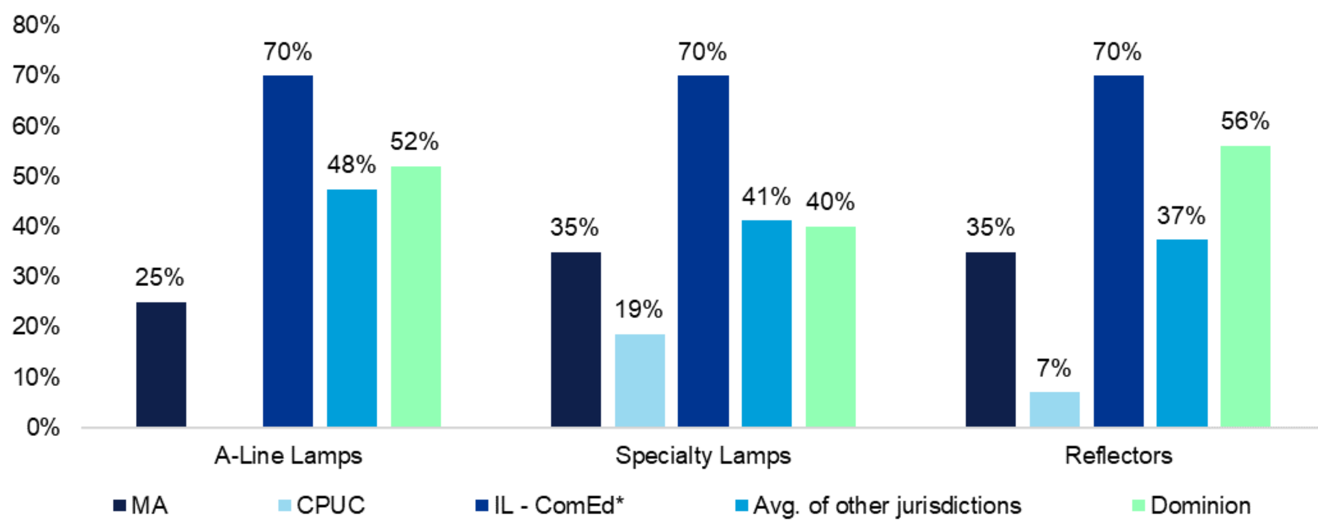


Figure 4-2 compares the NTG ratios for the 2021 Dominion program with the most recent NTG ratios for upstream lighting programs from other jurisdictions. It shows that the Dominion NTG ratios for A-line and specialty lamps are very similar to those of the jurisdictional average. For reflectors, the Dominion NTG ratio is higher than the jurisdictional average.

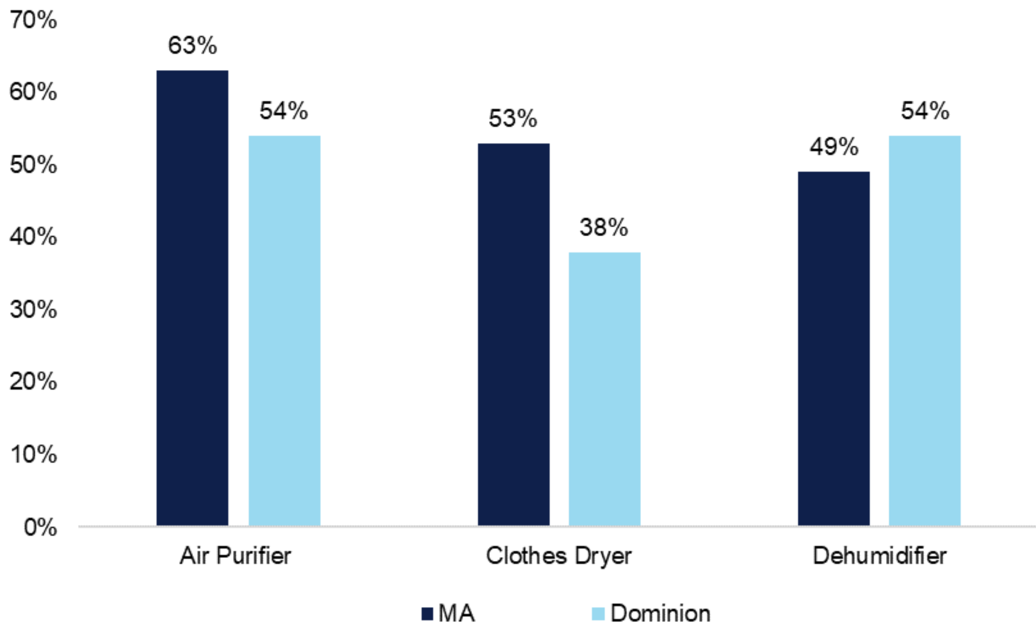
Figure 4-2. Similar lighting program NTG Ratios



*Illinois ComEd did not differentiate between lamp types in their NTG ratios.

Figure 4-3 compares the NTG ratios from the current study with NTG ratios from a recent Massachusetts study. It shows that the Dominion NTG ratios were lower than the Massachusetts ratios for air purifiers and clothes dryers, but higher for dehumidifiers.

Figure 4-3. Similar appliance program NTG ratios[10]



4.2.1.1 Timing

Table 4-2 shows the program's influence on *when* the equipment was purchased. The acceleration period corresponds to the number of months between the time of equipment purchase and the time it would have been purchased in the absence of the program. The program had the most significant influence on the timing of air purifier purchases.

[11] The Spearman's rank correlation coefficient is a non-parametric test. This was used instead of the more common Pearson's rho because the SPA does not meet the assumptions necessary for the Pearson's rho. The SPA for each survey respondent is a whole number score from 0 to 2 and is not continuous

Table 4-2. Summary of acceleration by measure

ENERGY STAR measure	Number of respondents	Program acceleration (mean number of months)	Standard error	One-sided 90% confidence interval lower bound	One-sided 90% confidence interval upper bound
Air purifier	107	5.9	0.8	4.5	7.2
Clothes dryer	541	2.9	0.3	2.5	3.3
Clothes washer	655	2.4	0.2	2.0	2.7
Dehumidifier	145	3.0	0.5	2.3	3.8
Dishwasher	316	2.5	0.3	2.0	3.0
Freezer	33	2.5	1.2	0.6	4.5
Refrigerator	531	2.8	0.2	2.4	3.2

* Confidence intervals represent the range of the mean. If the range includes zero, the mean is deemed to not be statistically different from zero. In other words, the timing was not conclusively affected for these appliances.

To calculate timing attribution, DNV assigned a score to each survey participant's response that reflects the program's acceleration of the purchase of the equipment above compared to when it would have been purchased otherwise (Table 4-3). Table 4-4 shows timing attribution.

Table 4-3. Attribution scores by response type

Response Type	Attribution Score
Missing	-1
No Effect	0
Effect	1
Don't Know	2

Table 4-4. Summary of timing attribution by appliance

ENERGY STAR measure	Number of respondents	Mean score	Standard error	One-sided lower C.I.	One-sided upper C.I.
Air purifier	107	0.3	0.1	0.2	0.4
Clothes dryer	541	0.3	0.0	0.2	0.3
Clothes washer	655	0.2	0.0	0.2	0.3
Dehumidifier	145	0.4	0.1	0.3	0.5
Dishwasher	316	0.2	0.0	0.2	0.3
Freezer	33	0.2	0.1	0.0	0.3
Refrigerator	531	0.3	0.0	0.2	0.3

* Confidence intervals represent the range of the mean. If the range includes zero, the mean is deemed to not be statistically different from zero. In other words, the program did not conclusively affect the timing of the purchase of these appliances.

4.2.1.2 Efficiency

Table 4-5 shows efficiency attribution. To calculate efficiency attribution, DNV assigned a score to each survey participant's response that reflects the program's influence on the efficiency of the equipment purchased compared to the efficiency level of the equipment that would have been purchased otherwise in the absence of the program (see Table 4-3 above for attribution scores).

Table 4-5. Summary of efficiency attribution by appliance

ENERGY STAR measure	Number of respondents	Mean	Standard error	One-sided lower C.I.	One-sided upper C.I.
Air purifier	107	0.3	0.0	0.3	0.4
Clothes dryer	541	0.2	0.0	0.2	0.2
Clothes washer	655	0.1	0.0	0.1	0.2
Dehumidifier	145	0.3	0.0	0.2	0.3
Dishwasher	316	0.2	0.0	0.1	0.2
Freezer	33	0.2	0.1	0.1	0.3
Refrigerator	531	0.2	0.0	0.1	0.2

* Confidence intervals represent the range of the mean. If the range includes zero, the mean is deemed to not be statistically different from zero. The program's impact on appliance efficiency is statistically significant for all appliances.

4.2.1.3 Program attribution

Table 4-6 shows simple program attribution. To calculate simple program attribution, DNV used the timing and efficiency attribution scores assigned to each survey participant's response. The fraction of deemed savings that would have occurred without the program is the product of the timing attribution score, f_T, and the efficiency attribution score, f_E.

$$f_{QE} = f_T\, f_E$$

The simple program attribution (SPA) is the complement of this FR portion.

$$SPA = 1 - (1-f_E)(1- f_T)$$

Table 4-6. Summary of simple program attribution (SPA) by appliance

ENERGY STAR measure	Number of respondents	Mean	Standard error	One-sided lower C.I.	One-sided upper C.I.
Air purifier	107	0.5	0.1	0.4	0.7
Clothes dryer	541	0.4	0.0	0.3	0.4
Clothes washer	655	0.3	0.0	0.3	0.4
Dehumidifier	145	0.5	0.1	0.5	0.6
Dishwasher	316	0.4	0.0	0.3	0.4
Freezer	33	0.4	0.1	0.2	0.6
Refrigerator	531	0.4	0.0	0.3	0.4

* Confidence intervals represent the range of the mean. If the range includes zero, the mean is deemed to not be statistically different from zero. Simple program attribution is deemed to be statistically significant for all appliances.

DNV used the product of SPA and deemed gross savings for each participant and measure.

$$\text{Net kWh Savings} = \text{Deemed Gross kWh Savings} \times \text{SPA}$$

Table 4-7. NTG summary by measure

ENERGY STAR measure	Number of respondents	Sum of weights	Mean timing attribution	Mean efficiency attribution	Mean SPA	Gross kWh/yr. savings	Net kWh/yr. savings
Air purifier	107	1,603	0.3	0.3	0.5	472,831	256,301
Clothes dryer	541	5,699	0.3	0.2	0.4	1,072,710	408,463
Clothes washer	655	7,060	0.2	0.1	0.3	1,460,235	470,396
Dehumidifier	145	1,155	0.4	0.3	0.5	138,095	74,286
Dishwasher	316	3,436	0.2	0.2	0.4	135,297	50,522
Freezer	33	326	0.2	0.2	0.4	16,267	6,408
Refrigerator	531	5,527	0.3	0.2	0.4	379,302	147,864

Figure 4-4 shows the total attributable energy savings for the appliance component of the program. Figure 4-5 breaks down the program-attributable savings by appliance. Figure 4-6 compares the 2019 appliance NTGRs with those from 2021.

The smaller appliances (dehumidifiers, air purifiers) had higher NTG ratios than the larger appliances. One possible reason for this is that the program rebates accounted for a larger share of the purchase prices of the smaller appliances than all the larger appliances except the ENERGY STAR air dryers. Table 4-8 also shows that the program accelerated the purchase of dehumidifiers and air purifiers more than any other appliances. This is likely because participants could delay purchasing a new dehumidifier or air purifier with less inconvenience than delaying the purchase of a new refrigerator, clothes washer, or clothes dryer, especially when these larger appliances were replacing non-functioning equipment.

Figure 4-4. Total attributable energy savings for the appliance component of the program

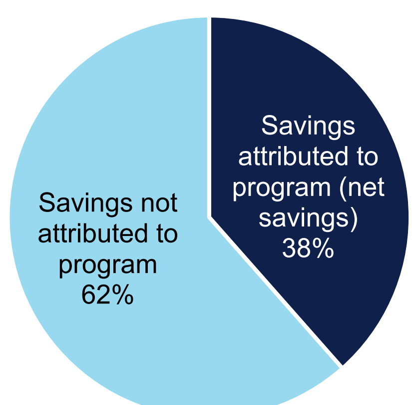


Figure 4-5. Program-attributable energy savings by ENERGY STAR appliance

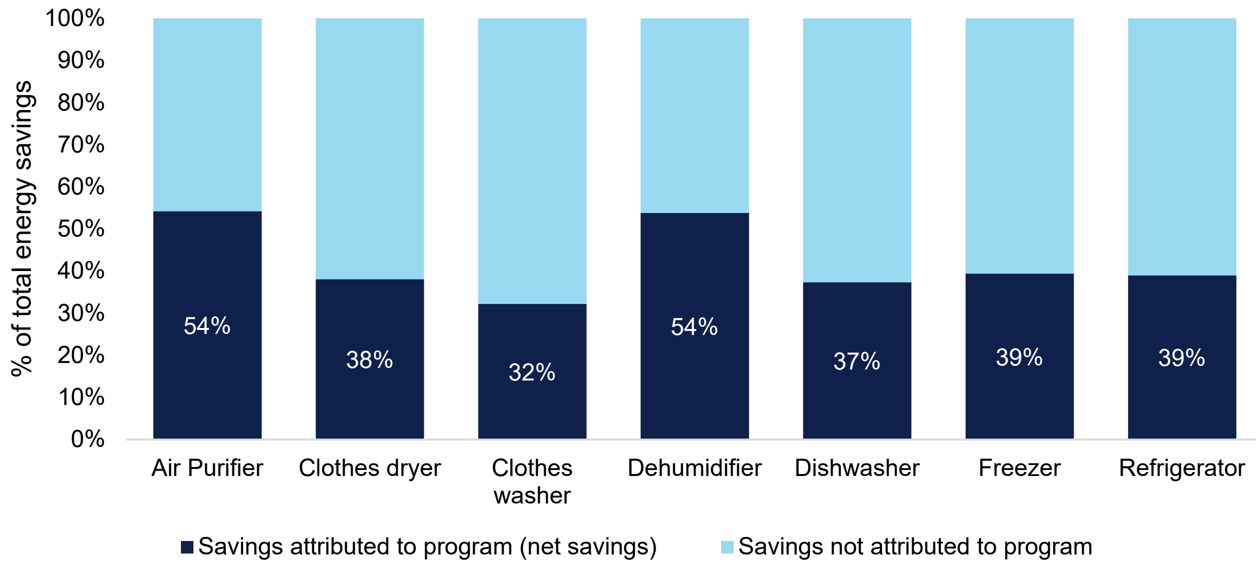
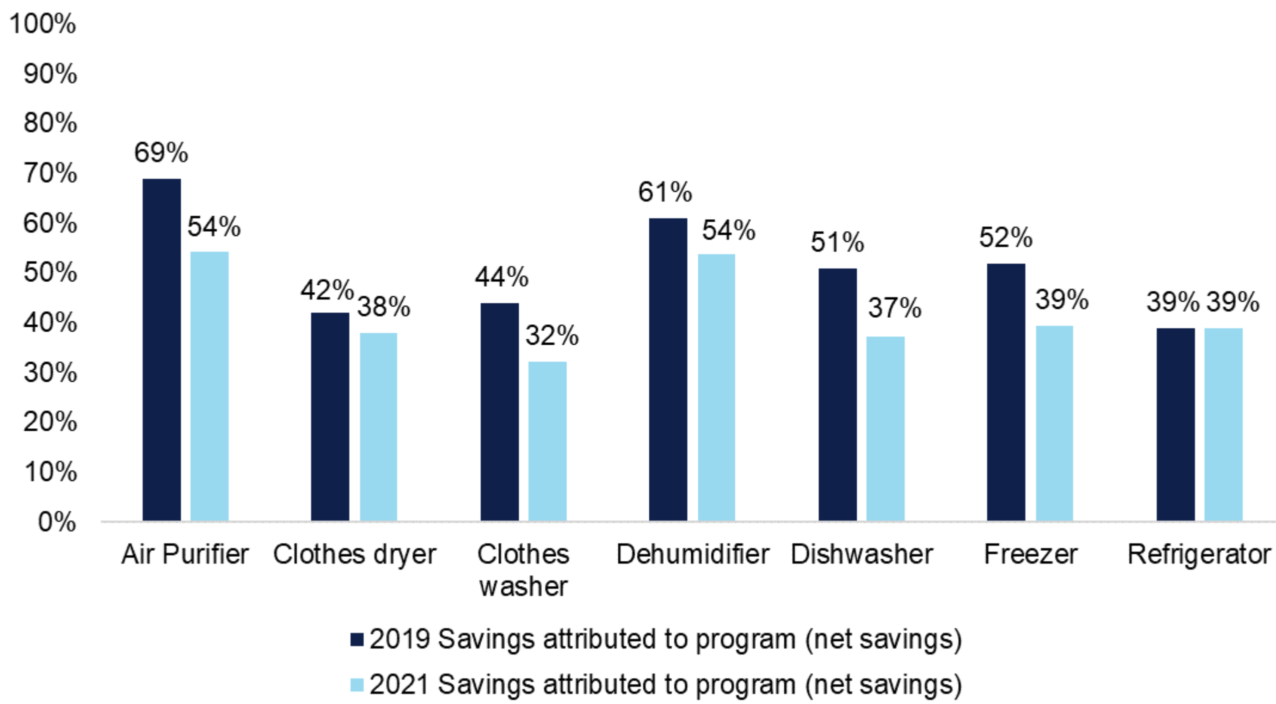


Figure 4-6. Appliance NTG Ratios: 2019 vs. 2021



DNV examined whether there was a relationship between how early customers participated in the appliance component of the program and their program attribution scores.

For each appliance type, DNV first calculated the average amount of time that had elapsed between when the program participants received the rebates and when they completed the evaluation's web survey. Table 4-8 shows that the dehumidifier participants had the shortest average time interval between the rebate and survey and the freezer participants had the longest.

Table 4-8. The timing of program participation by appliance

ENERGY STAR measure	Sample size	Mean simple program attribution	Mean days*
Air purifier	107	0.5	499.2
Clothes dryer	541	0.4	492.7
Clothes washer	655	0.3	496.0
Dehumidifier	145	0.5	450.2
Dishwasher	316	0.4	502.1
Freezer	33	0.4	503.0
Refrigerator	531	0.4	479.2

*Mean days are the average number of days between participants' receipt of the program rebate and their completion of the evaluation web survey

To further investigate the effect of the time between rebates and survey submission, DNV calculated Spearman's rank correlation coefficients by looking at the relationship between participants' simple program attribution (SPA) scores and the days lapsed between rebate and survey submission.[11] This was done across the program and by measure.

Table 4-9 shows the measure-level calculations. A correlation coefficient between ±0.1 – ±0.3 is a weak correlation, a correlation between ±0.3 - ±0.6 is a moderate correlation, and a correlation between ±0.6 - ±1.0 is a strong correlation. Correlation coefficients range between -1.0 and +1.0.

There was a weak correlation between SPA scores and the mean number of days between rebate and survey for the air purifiers and freezers, and no correlations for the other appliances. It should be noted that the freezer sample size was small (n=33) which can increase the variability of results. The overall correlation between participants' simple program attribution scores and days lapsed between rebate and survey submission for the program was -0.03 (p=0.11).

Table 4-9. Correlations between program attribution and days between rebate and survey submission by measure

ENERGY STAR measure	R_S	P-value
Air purifier	-0.11	0.19
Clothes dryer	0.04	0.37
Clothes washer	0.01	0.81
Dehumidifier	-0.07	0.34
Dishwasher	-0.04	0.49
Freezer	-0.2	0.27
Refrigerator	-0.06	0.15

[11] The Spearman's rank correlation coefficient is a non-parametric test. This was used instead of the more common Pearson's rho because the SPA does not meet the assumptions necessary for the Pearson's rho. The SPA for each survey respondent is a whole number score from 0 to 2 and is not continuous

DNV also examined possible relationships between program attribution and the ratio between the program rebates and the purchase prices of the appliances. Table 4-10 shows that the ratio between rebate level and appliance purchase cost was highest for air purifiers and lowest for clothes washers.

Table 4-10. The ratio of program rebates to appliance purchase costs

ENERGY STAR measure	Sample size	Mean simple program attribution	Mean % of cost*
Air purifier	107	0.5	38.8%
Clothes dryer	541	0.4	11.6%
Clothes washer	655	0.3	6.6%
Dehumidifier	145	0.5	14.2%
Dishwasher	316	0.4	10.5%
Freezer	33	0.4	10.3%
Refrigerator	531	0.4	7.9%

*% of Cost = (rebate amount/appliance purchase price) x 100

DNV also calculated Spearman's rank correlation coefficients by looking at the relationship between participants' simple program attribution scores and the ratio between the program rebates and the purchase prices of the appliances. This was done across the program and by measure. As noted, a correlation coefficient between ±0.1 – ±0.3 is a weak correlation, a correlation between ±0.3 - ±0.6 is a moderate correlation, and a correlation between ±0.6 - ±1.0 is a strong correlation.

Table 4-11 shows that there were weak correlations between program attribution and the ratio between rebates and purchase price for air purifiers, dishwashers, and freezers. As previously mentioned, the sample size for freezers was small. The overall correlation between participants' simple program attribution scores and the percentage of rebate to purchase price for the program was 0.08 ($p<0.001$).

Table 4-11. Correlations between program attribution and the ratio between rebates and purchase price

ENERGY STAR measure	R_S	P-value
Air purifier	-0.2	<0.05
Clothes dryer	0.00	0.95
Clothes washer	-0.01	0.70
Dehumidifier	0.07	0.35
Dishwasher	0.13	<0.05
Freezer	0.14	0.44
Refrigerator	0.06	0.15

4.3 Participant perspectives on program marketing

This section describes how the program was marketed, how participating customers heard about the rebates, and how they would prefer to receive program information in the future.

4.3.1 How the program was marketed

An interview with Dominion Energy's project manager confirmed that point-of-purchase (POP) marketing materials in retail stores are the primary means of promoting the Marketplace Program. For the energy-efficient lighting products, this includes signage next to the rebate-eligible products as well as additional signage in the aisles. For the ENERGY STAR appliances, this includes signage on the program-eligible models. Figure 4-7 and Figure 4-8 provide examples of this POP signage. The program also utilized bill inserts, direct mail campaigns, and display ads to promote participation.

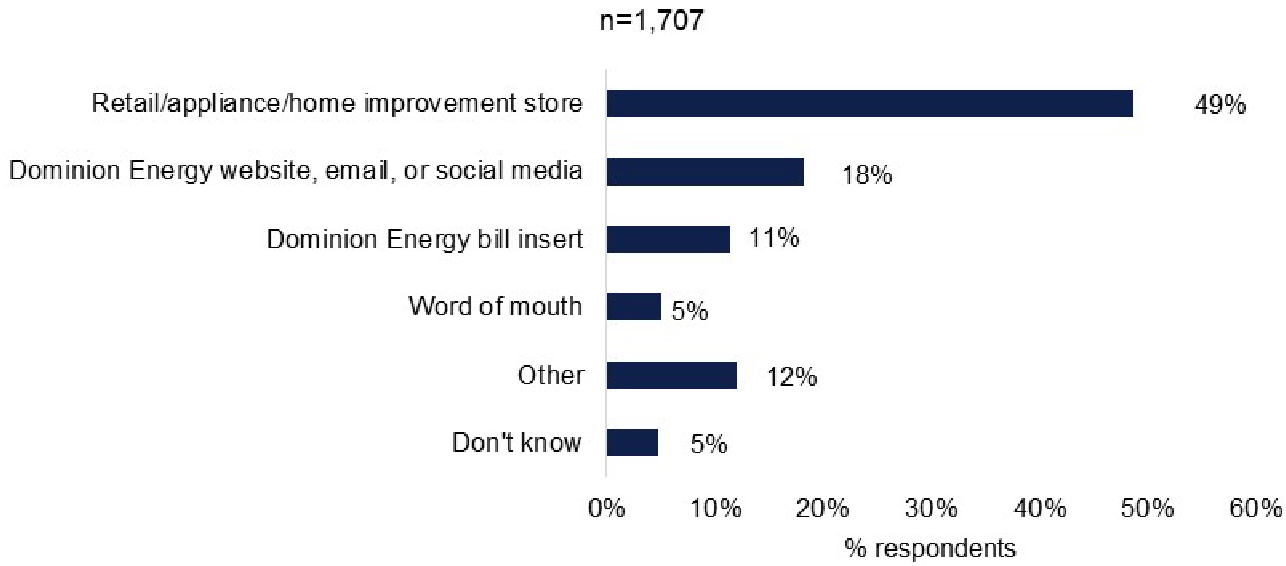
Figure 4-7. Sample Marketplace Program lighting signage

Figure 4-8. Sample Marketplace Program appliance signage

4.3.2 How participants heard about the rebates

DNV asked the appliance participants how they first learned about the Marketplace Program rebates available to them. Figure 4-9 shows their responses. Almost half said they first heard about the rebates in the retail store. The Dominion Energy website was a distant second (18% of respondents) as the first information source for the rebates.

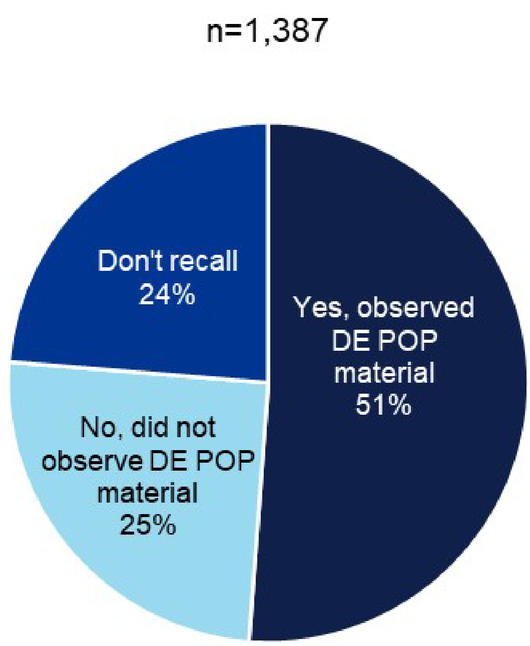
Figure 4-9. How participants heard about the Marketplace Program rebates



*Other information sources included previous EE program participation, retailer websites, own internet research, and manufacturer's websites.

DNV asked the participants who reported buying their appliances in a retail store whether, when they were in the store, they recalled: “any Dominion Energy promotional rebate/discount materials such has stickers on merchandise, clings, or signs in the aisle or the store.” Figure 4-10 shows that about half (51%) of these participants recall observing these POP materials.

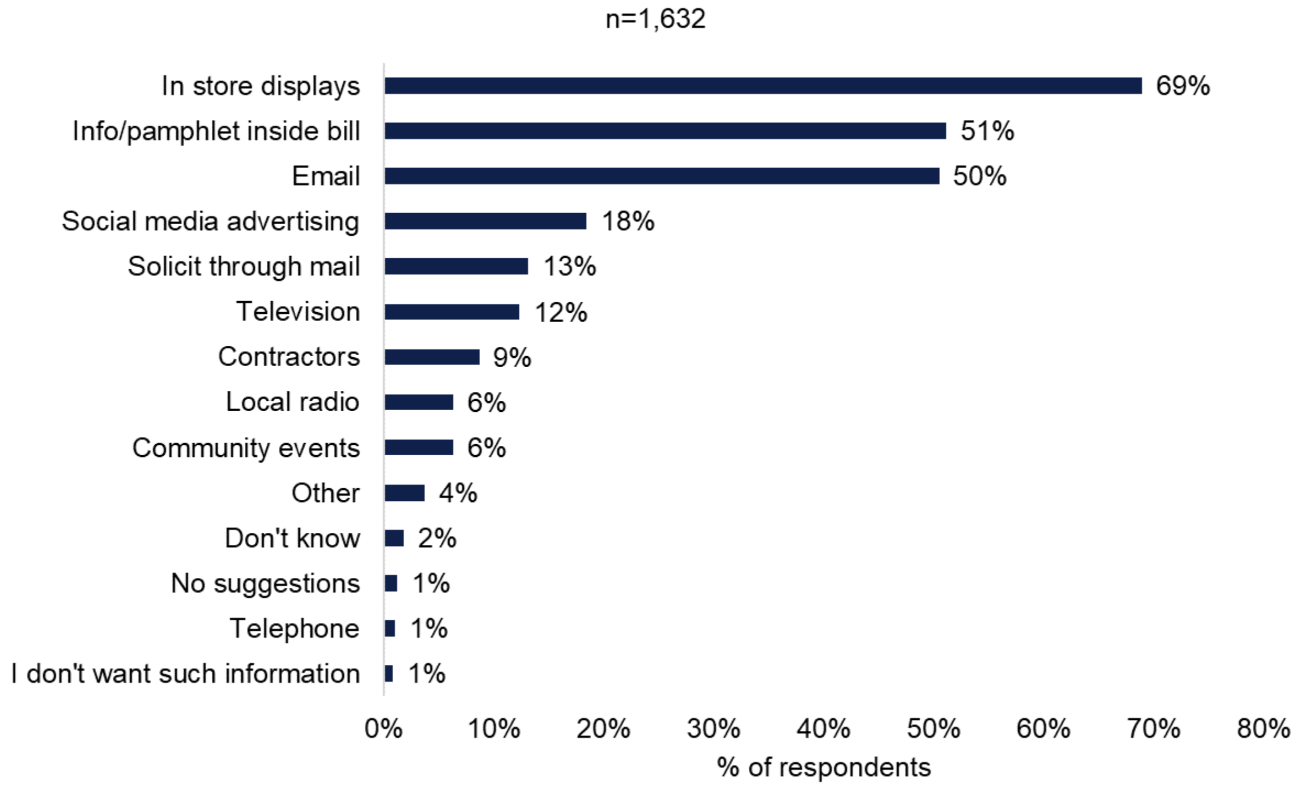
Figure 4-10. Participant recall of in-store Dominion Energy promotional material



4.3.3 How participants prefer to get future program information

DNV asked the participants, “If Dominion Energy wanted to inform customers like yourself about the rebates and services they offer for energy-efficient programs, what do you suggest would be the best way to do that?” Figure 4-11 shows that over two-thirds of the participants recommended in-store displays and about half suggested bill stuffers or email communications.

Figure 4-11. How participants prefer to get future program information

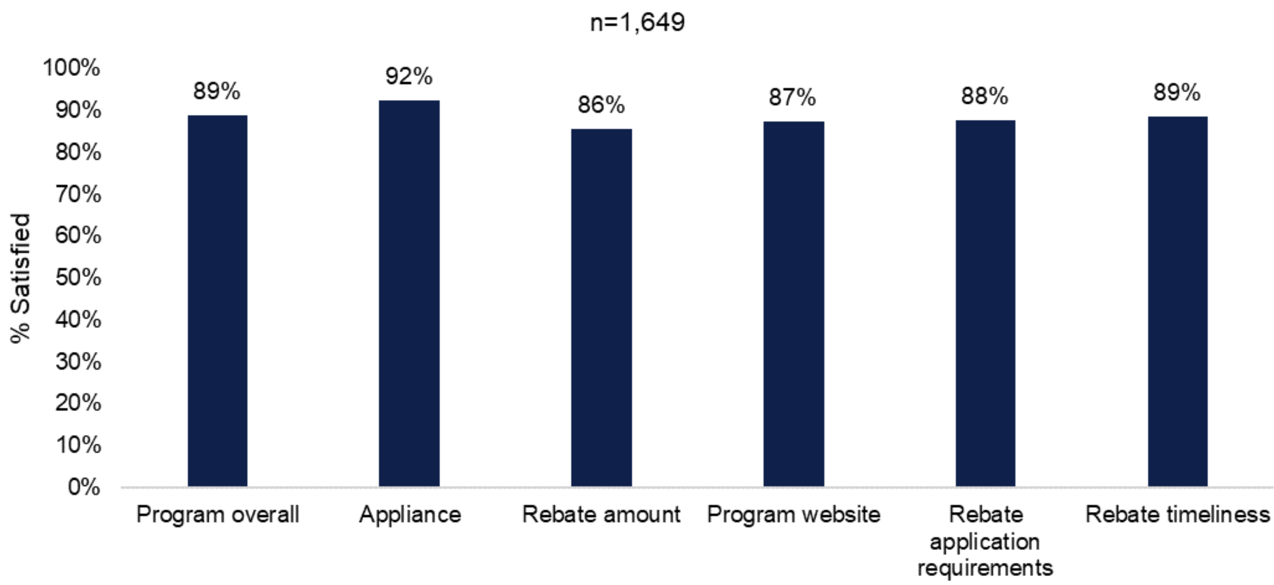


4.4 Program satisfaction

DNV asked the participants about their satisfaction with the Marketplace Program and with various aspects of the program including the website, the rebate application process, the timeliness of the rebate payment, the rebate amounts, and the rebated appliances. DNV asked the participants to use a five-point satisfaction scale where five indicated “very satisfied” and one indicated “very dissatisfied.” Figure 4-12 shows the percentage of participants who were satisfied (4 or 5 satisfaction ratings) with the overall program as well as with the program components.[12] The participants were most satisfied with the rebated appliances and least satisfied with the rebate amount.

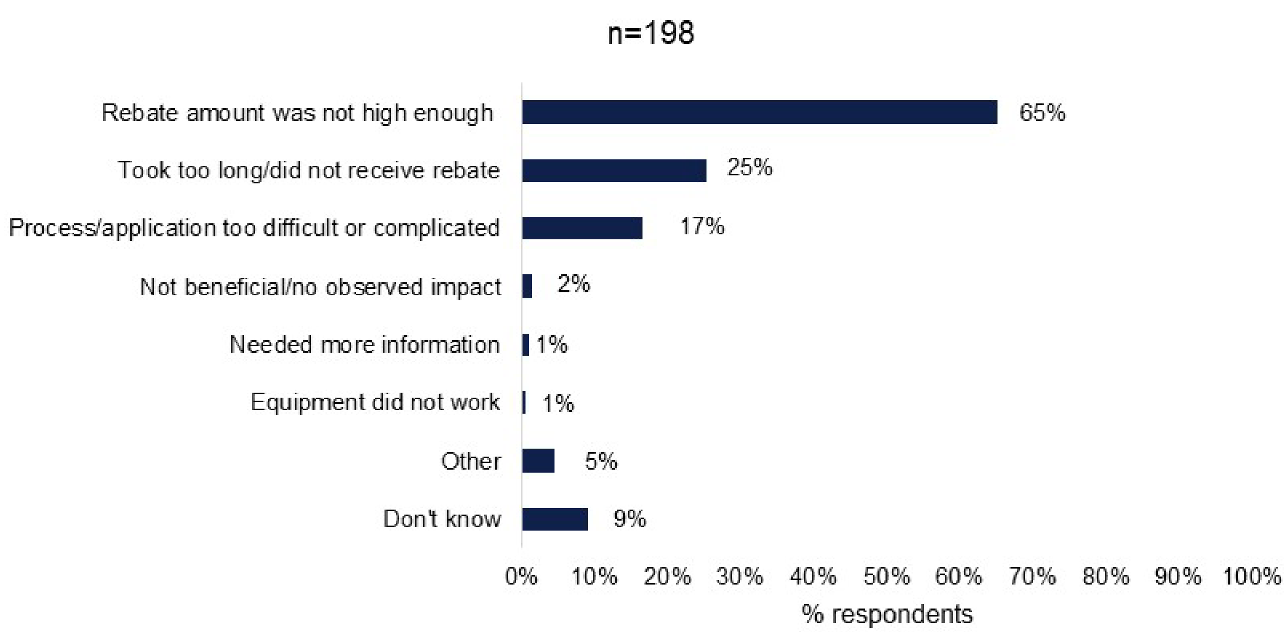
[12] While the program has little control over the quality of the appliances, it is still useful to measure participant satisfaction with their appliances since dissatisfaction with an appliance can sometimes influence their satisfaction with other aspects of the program.

Figure 4-12. Program satisfaction



DNV also asked the participants who were less than satisfied with the rebate amounts (satisfaction ratings of 3, 2, or 1 on the five-point satisfaction scale) what the program could do better. Figure 4-13 shows that while increasing the rebate amount was the most common recommendation, some dissatisfaction with the rebate amount was tied to dissatisfaction with other aspects of the program such as the rebate application process and the timeliness of the rebate payment.

Figure 4-13. Reasons for being less than satisfied with rebate amounts



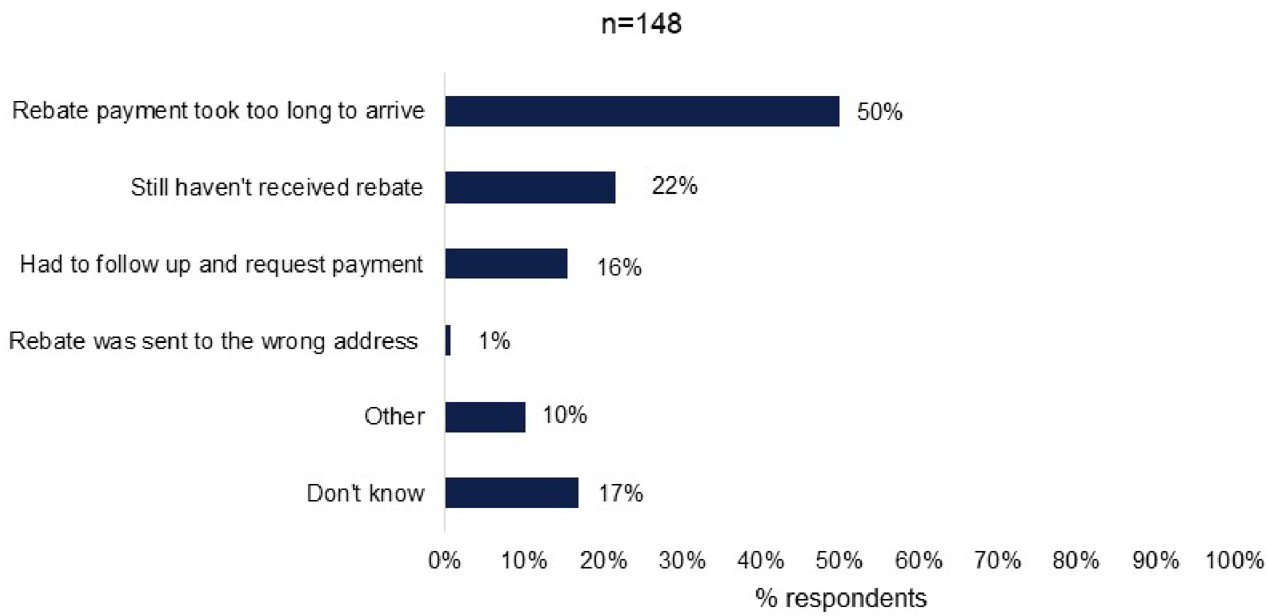
Note: The percentages exceed 100% because the participants could provide multiple reasons.

4.4.1 Timeliness of the rebate payments

Eighty-nine percent of the participants were satisfied with the timeliness of the program rebates, with 56% of the participants being "very satisfied."

DNV also asked the participants who were less than satisfied with the timelines of the rebate payments (satisfaction ratings of 3, 2, or 1 on the five-point satisfaction scale) what the program could do better. Figure 4-14 shows that apart from being dissatisfied with the late arrival of rebates, 22% of the less-than-satisfied participants claimed that they had never received the rebates (about 2% of total participants). Considering that the survey was fielded in November 2022 and covered participation no later than December 2021, it is unclear why these participants would still be waiting for rebates. The program implementation contractor reported having practices to minimize the occurrence of missed rebate payments. These practices included calling program participants who have not cashed their rebate payments within a certain period to notify them of options for voiding and reissuing the payments. The program implementation contractor said that in 2021 1% of the rebates issued were not cashed, but it was not clear whether these uncashed rebates were due to the program participants not receiving them, receiving them but not noticing them, or some other reason.

Figure 4-14. Reasons for being less than satisfied with timeliness of rebate payment



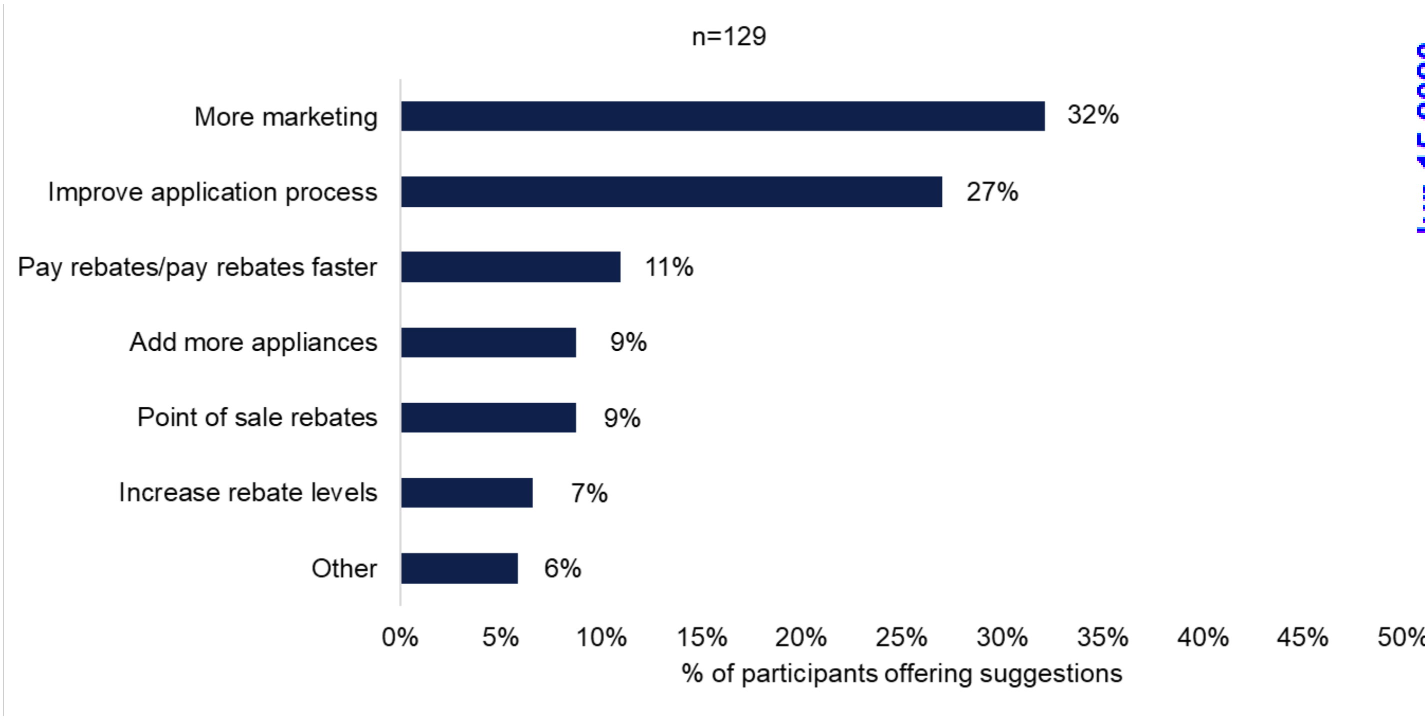
Note: The percentages exceed 100% because the participants could provide multiple reasons.

- *Satisfaction with appliances was high:* Ninety-two percent of the participants were satisfied with their rebated appliance with 61% of the participants being very satisfied.
- *Overall program satisfaction:* Eighty-nine percent of the participants were satisfied with the overall program, with 54% of the participants being very satisfied.

4.4.2 Participant suggestions for program improvements

DNV asked the participants: "Do you have any suggestions to improve the delivery of this program for customers like yourself?" Only 8% of them had suggestions for program improvements. Figure 4-15 shows that the two most-cited suggestions were to improve the rebate application process and do more program marketing.

Figure 4-15. Participant suggestions for program improvements



Note: The percentages exceed 100% because the participants could provide multiple suggestions. *Other suggestions included allowing bill credits, offering rebates for a wider range of appliances, and supporting solar programs.

4.4.2.1 Improving the rebate application process

Table 4-12 shows the most frequent suggestions that participants made for improving the rebate application process. The two most common suggestions were to make the rebate application requirements clearer for the program and to be less strict about the criteria for approving applications. The program requirements the participants most frequently mentioned as not clear or prominent enough included what appliances are eligible for the rebate and the requirements that participants provide information such as serial numbers for the appliances that were removed.[13] The suggestions for the program to be less strict about approving applications usually originated from participants who suggested more options for submitting the rebate instead of the website and participants who asked for a longer timeline due to supply chain issues.

[13] The program implementation contractor observed that there is a customer-facing Qualified Products List on the portal that can be viewed before the appliance application/ purchase occurs and that the serial number of the removed appliance is requested but not required information.

Table 4-12. Most frequent suggestions for improving the rebate application process

Suggestion	# of participants making suggestion
Make rebate application requirements clearer	10
Be less strict about criteria for approving applications	7
Streamline the rebate application process	6
Better follow-up communication	6
Provide way to check status of rebate applications	4
Allow applications for multiple appliances	1

4.4.2.2 Improving program marketing

Table 4-13 shows the most frequent suggestions for doing more program marketing. Increasing in-store promotions and advertising the program in the monthly utility bills were the two most common suggestions.

Table 4-13. Most frequent suggestions for doing more program marketing

Suggestion	# of participants making suggestion
More in-store promotions	12
Advertise program in monthly bill (online or paper)	10
Advertise the program through emails	8
Get more retailers to advertise program on their websites	7
Advertise the program by direct mail	4
Advertise the program online/through social media	3

4.5 Other findings

In addition to NTG estimates, DNV asked participating lighting suppliers and retail buyers about LED market trends and program satisfaction. This feedback can help inform program design or implementation since many suppliers and retail buyers interact with similar programs in different utility service territories and can offer insights and comparisons to similar upstream lighting programs.

4.5.1 Market trends

The first set of interview questions asked market actors to share their understanding of the current LED market conditions in Virginia, North Carolina, and the United States. Suppliers and retail buyers were asked to provide any demand barriers that are limiting customer demand for LED products. Some respondents continued to cite price points and suggested the ongoing need for price discounts, especially to attract low-income customers. Other respondents suggested lingering impacts of supply chain issues affecting the availability of products and diminishing purchasing power brought on by inflation. Most respondents reported that these barriers do not vary by bulb type. Some suggested that specialty bulbs such as candelabras could be targeted for increased incentives. Respondents cited the fact that customers may have replaced all the A-line bulbs at their residence but have yet to replace less common bulbs such as candelabras as the reasoning behind this suggestion. While there was no clear trend as to whether suppliers and retail buyers thought LED prices would increase, decrease, or stay the same in the coming year, all but one respondent thought prices would either increase or stay the same, with only one respondent saying prices would decrease.

4.5.2 Lighting manufacturer/retail buyer satisfaction

Respondents were asked to rate their satisfaction with the program implementor, CLEAResult, on a scale of 1 to 5 where 5 is “very satisfied” and 1 is “very dissatisfied.” Nine of the 10 lighting suppliers and the one retail buyer were satisfied with the program implementer. Two respondents reported issues with processing invoices through the online portal used by CLEAResult citing the potential influence of PI staff turnover.

Despite this feedback, most interviewees reported having a good working relationship with the program implementer. When asked to use the same scale to rate the program overall, all respondents were satisfied with the program.

4.5.2.1 Improving the program process

Respondents were asked what could be done to improve the program process. Likely due to the higher satisfaction, there were few suggestions for program process improvements. A few respondents requested higher incentives, which is a common suggestion in evaluations. One respondent emphasized the importance of communication between the PI and manufacturers about incentives and program budgets to ensure accurate inventory stocking by partnering stores. When asked about additional bulb types to include in the program that were not currently included, participants suggested connected or WIFI-enabled bulbs, hardwired LEDs, and night light bulbs. Overall, these results suggest a strong ongoing program with a few opportunities for improvement in future program design and implementation.

DNV

APPENDIX A. STUDY WORK PLAN

Residential Efficient Products Marketplace – Impact and Net-to-Gross Evaluation Plan

Program Year 2021

Prepared by DNV, Inc.

August 4, 2022

Introduction

This is the detailed work plan for the evaluation of the Residential Efficient Products Marketplace program (REEC) implemented by CLEAResult and administered by the Virginia Electric and Power Company, hereafter Dominion. This impact evaluation will provide estimates of both *ex post* gross energy savings and net energy savings, which account for the effect of free ridership (FR). Net-to-Gross (NTG) ratios will be calculated from reported estimates and applied to tracking data for realization rates and cost-effectiveness.

The program's evaluation year will cover the 2021 calendar year period. This evaluation plan is designed to maximize the available funding while providing an analysis that is tailored to lighting and appliance measures. This evaluation will be conducted in accordance with the REEC EM&V Plan to calculate impacts and inform future program design and implementation through insights gained from interviews and survey data.

Overview of implemented programs and measures

The Dominion program offers upstream lighting incentives which result in price discounts on energy-efficient lighting products for shoppers at program-participating stores. It also offers rebates on Energy Star® rated appliances. Table 4-14 lists all the energy-efficient measures implemented under this program.

Table 4-14. Program energy-efficient measures

Lighting measures (LEDs)	Appliance measures ENERGY STAR
▪ A-Lines	▪ Freezer
▪ Reflectors	▪ Refrigeration
▪ Decorative	▪ Clothes Washer
▪ Globes	▪ Dehumidifier
▪ Retrofit Kit and Fixture	▪ Air Purifier
	▪ Clothes Dryer
	▪ Dishwasher
	▪ Freezer

Evaluation plan

This section provides an overview of our EM&V approach. The following sections describe the impact evaluation approach for the upstream lighting (UL) measures and detail the evaluation approach for the appliance rebate (AR) measures.

The first step in the evaluation will be for DNV to complete in-depth interviews with both the Dominion program manager and the program manager from the program's implementation contractor. The purpose of these interviews will be to ensure that DNV has a deep understanding of the design and delivery of the program before the survey instruments and analysis plan are finalized.

Table 4-15 summarizes the data collection activities for the impact evaluation. Because customer contact information is not tracked for the upstream lighting program, the evaluation will rely on program invoices and the Dominion Energy Technical Reference Manual to estimate gross savings. DNV will rely on in-depth interviews with

The interviews will derive NTG estimates by asking the suppliers and retail buyers to estimate what their level of sales of led lamps would have been without the price discounts provided by the dominion program (the counterfactual scenario).

participating lighting manufacturers and retailers to estimate net savings for upstream lighting.

The program tracking data includes customer contact information for the AR participants and will use customer surveys to estimate both gross and net energy savings.

Table 4-15. Data collection summary

Program	Target market actor or program staff	Population size	Target number of completed interviews or surveys	Mode of data collection
Upstream Lighting & Appliance Rebates	Dominion PM (Ryan Burruss)	1	1	In-depth interview
	CLEAResult Program Manager	1	1	In-depth interview
Upstream Lighting	Participating lighting manufacturers	21	21	In-depth interview
	Participating large retailers	13	13	In-depth interview
Appliance Rebates	Participating customers with email addresses	17,529	300	Web surveys

The sample design will aim for a representative sample of program participants based on characteristics such as the type of appliance purchased and the participant's geographical location. The design will attempt to achieve 85/15 precision (15% relative precision with 85% confidence intervals) at the program level and will explore the feasibility of achieving similar levels of precision for individual appliances. In the 2020 study, the team achieved many more completed appliance web participant surveys (n=1,519) than it had originally targeted (n=300). However, it is unclear whether this higher response rate might have been influenced by so many people being home in 2020 due to COVID-19 pandemic lockdowns.

Impact evaluation approach – upstream lighting

Estimating net and gross savings

The impact evaluation verifies program savings by verifying the installation of tracked measures if customer contact information data is available. The evaluation of the Dominion upstream lighting program, as with most upstream lighting programs, will rely on alternative methods to estimate gross and net energy savings since it cannot rely on customer self-reporting.

For estimating gross energy savings for the upstream lighting program, DNV will use two methods.

- Review the program tracking data to verify that the lighting deemed savings values in the Dominion Energy Technical Reference Manual are being properly applied to program participants.
- Review invoices from participating suppliers to ensure the lamp quantities in the tracking databases match those in the program tracking data and note any discrepancies (a sample invoice request is included at the end of this plan).

For estimating net energy savings for the upstream lighting program, DNV will conduct in-depth interviews with participating lighting suppliers and retailers. DNV will attempt to interview the census of 21 lighting suppliers, also referred to as manufacturers. In addition, it will attempt to complete interviews with representatives of the largest participants who are responsible for purchasing lighting products for their stores, also referred to as "retail buyers."

Before the interviews, DNV will send the lighting suppliers and retail buyers a summary of their Dominion sales to refresh their memory on their involvement with the Dominion program, since most lighting suppliers participate in many similar programs in other jurisdictions. However, it also gives DNV another opportunity to verify the reported quantity of lamp sales.

For each invoice/application selected for verification, we will compare the program tracking data to what is provided in electronic form. In addition to the quantity of utility-discounted products shipped, we will attempt to verify the following key metrics:

- Manufacturer name
- Measure name
- Product type
- Retailer name and location
- Per unit rebate
- Total rebate paid
- Shipment and sales dates

For the sake of consistency, and to allow for a time series of NTG ratios, DNV plans to use the same NTG questions in the interview guide that it used in the last evaluation. However, the study team will still submit these interview guides for Dominion review in case Dominion wants to add, remove, or change questions from the legacy interview guide.

The lighting suppliers' and retail buyers' estimates of their expected decline in sales absent the program forms the basis of DNV's NTG estimates for the upstream lighting program. DNV will use the volume of program sales of the different suppliers or retailers participating in the program to sales weight the individual NTG estimates when combining them to come up with program-level NTG estimates.

As demonstrated in the last evaluation, this NTG methodology can provide separate NTG estimates for different LED lamp types. However, since most lighting suppliers and retailers sell multiple LED lamp types, asking them to provide separate NTG estimates for each lamp type would be burdensome. To overcome this, DNV groups similar lamp types to reduce respondent fatigue.

Additional Areas of Inquiry

Although developing NTG estimates will be the focus of the lighting supplier and retail buyer interviews, DNV plans to ask some additional questions to better understand the lighting market in the Dominion service territory. These questions will cover the extent to which these suppliers and retail buyers sell program-qualified LEDs outside the program, why they sell these qualified lamps outside the program, whether they sell non-Energy Star LEDs, and how the quality of these lamps differs from their Energy Star models. If Dominion and the program implementation contractor are interested, DNV can also ask the lighting suppliers and retail buyers about their level of satisfaction with the program.

DNV will attempt to contact manufacturers 5-6 times before exhausting each contact.

Supplemental Data Collection

Because a few of the lighting suppliers participating in the upstream lighting program account for a large percentage of program sales, there is a risk that if one or more of these suppliers decline to provide NTG estimates, the validity of the program-level NTG estimates will be reduced.

If this occurs, DNV will consult with Dominion staff about alternative sources of NTG estimates. One possible option would be to supplement the lighting supplier and retail buyers' interviews with computer-aided telephone (CATI) surveys with managers at participating retail locations. The CATI surveys will ask the store managers NTG questions like those described above for the lighting suppliers and retail buyers. Since the store managers have first-hand experience with upstream lighting program stocking and signage practices, these surveys can also be used to collect the store manager's perspectives on the effectiveness of program delivery. However, these lighting retailer surveys would require an expansion in the study scope and budget.

Impact evaluation approach – appliance rebates

As it did in the last evaluation of this program. DNV will use an online survey which will allow for agile data collection given the accelerated project timeline. Online data collection has advantages over traditional print or telephone methods including, but not limited to:

- *Accelerated response time.* Online surveys are faster to complete, thus relieving the burden on the customer.
- *Improved data quality.* Online surveys use visual clues to help the customer identify equipment and technology.
- *Automated skip patterns:* These features of online surveys offer another time-saver and validity check.
- *Convenience:* Customers can participate from multiple platforms, including their computers, tablets, or mobile devices.

Appropriate sample design will target a confidence interval between 85 to 90% with relative precision between 10 to 15% across all appliances.

The AR impact evaluation will verify program savings by verifying tracked measures installation of customers for the calendar year 2021. The survey will cover the following topics:

- Program awareness and participation
- Verification of purchased appliance(s)
- Satisfaction with various program aspects
- Energy attitudes (including COVID-19 impacts)
- Demographics

This survey will be sent to participating customers' email addresses three times with A/B subject testing to strengthen data collection efforts. Testing multiple subject lines will help increase response rates by using the subject that results in the most clicks. An optional opt-out could be added after the verification questions to allow for greater data collection. This could increase the sample size collected for the most important components of the data collection efforts, verification, and program participation, and ensure greater precision.

Communication and reporting

Project schedule

The evaluation schedule is presented below in Table 4-16. We are expecting to begin with program manager interviews in the second half of August and to be producing a draft report in December. Completing the evaluation on this schedule is dependent upon the program responding to data requests in a timely fashion and any delays in receiving complete data sets or collection efforts may require adjustments to this schedule. The schedule may also be impacted by circumstances outside of Dominion’s or DNV’s control resulting from the Covid-19 pandemic.

Table 4-16. Schedule

Tasks / Milestones	Aug	Sep	Oct	Nov	Dec	Jan
Program Manager Interviews						
NTG Survey Instrument - Draft						
NTG Survey Instrument - Final						
AR Survey Instrument - Draft						
AR Survey Instrument - Final						
NTG Survey Implementation						
AR Survey Implementation						
Impact Analysis						
Report - Draft						
Report - Final						

APPENDIX B. LIGHTING RETAIL BUYER IN-DEPTH INTERVIEW GUIDE

RESIDENTIAL EFFICIENT PRODUCTS MARKETPLACE – IMPACT AND NET-TO-GROSS EVALUATION

Interview Information

Interviewer		Survey Length (min)	
Completion Date			

Contact Information

Phone	
Email	

Call Tracking

Date/Time	Notes

Variables

<alines_sold>	Total A-Lines sold through the program
<fixtures_retrofits_sold>	Total fixtures and retrofits sold through the program
<specialty_sold>	Total globes, candelabra, candles, and other specialty bulbs sold through the program
<reflectors_sold>	Total Multifaceted, parabolic aluminized reflectors, bulged and other reflectors sold through the program
<average_buydown>	Average buydown amount from tracking data specific to each retailer

Introduction

[NOTE: THE QUESTIONS IN THIS INTERVIEW GUIDE WILL NOT NECESSARILY BE READ VERBATIM BUT MAY BE MODIFIED TO SUIT THE INTERVIEW]

1. Hi, my name is _______, and I am calling from DNV on behalf of Dominion Energy regarding the Residential Efficient Products Marketplace Lighting Discounts program which supports the sales of efficient lighting products for retailers across Virginia and North Carolina. According to our records, your company has recently sold lighting products as part of that program. I would like to ask you some questions about your participation and trends in the residential lighting market in general.

[IF RESPONDENT IS NOT PROGRAM-FAMILIAR CONTACT, GET IN TOUCH WITH PROGRAM-FAMILIAR CONTACT AND REPEAT]

DNV

[IF ASKED] We anticipate this interview will last about 20-30 minutes. Any information you provide will be treated as confidential.

[IF ASKED] DNV is an independent contractor hired to do this research. You can verify the legitimacy of this research by calling Ryan Burruss from Dominion Energy at 804.217.4652.

VERIFICATION OF PROGRAM SALES

First, I would like to review some information about the nature of your recent participation in Dominion Energy's Residential Efficient Products Marketplace Program which offers discounts on Energy Star LED lighting products in Virginia and North Carolina.

V1. I emailed you information on your sales of energy-efficient lamps through 2021. Does that information appear generally correct? [IF SOME OF THE INFORMATION IS INCORRECT, MAKE ANY CORRECTIONS IN THE SECOND ROW].

V2. My records indicate that in 2019–2020 your company **did not** receive discounts from Dominion Energy's REEC Program for the following lighting applications: [NAME ALL LIGHTING APPLICATION PRODUCTS IN SECOND ROW OF TABLE 1 WHERE QUANTITY IS = 0] Is this information correct? [IF SOME OF THE INFORMATION IS INCORRECT, MAKE ANY CORRECTIONS IN THE THIRD ROW OF THE TABLE.]. Is that correct?

High-Level Verification of Program Tracking Data

Response Category	# of PY 2021 A-Lines	# of PY 2021 Reflectors	# of PY 2021 Specialty*	# of PY 2021 Fixtures & Retrofits
Upstream Program Sales from Tracking Data**				
1-1. Program sales data looks reasonably correct?	Yes No DK Refused	Yes No DK Refused	Yes No DK Refused	Yes No DK Refused
1-2 Is it true that you did not sell these lighting products through the program?	Yes No DK Refused	Yes No DK Refused	Yes No DK Refused	Yes No DK Refused

* Specialty bulbs include Globes, Candelabra Base, Candle, and Other Specialty bulbs
** Interviewers will pre-populate this row with tracking data

2021 Program Attribution

Net-to-Gross – A-Lines

PA3. The Dominion Energy REEC Program paid average buydown or markdown discounts of $0.85 per A-Line bulb and $2.91 per A-Line pack. If these program buydown/ markdown discounts and program promotional materials had not been available during 2021, do you think your sales of these types of bulbs in your stores in Virginia and North Carolina would have been about the same, lower, or higher?

PA3a. [IF THE SAME OR HIGHER] Why do you say this? [RECORD RESPONSE AND SKIP TO PA4]

PA3b. [IF LOWER] By what percentage do you estimate your sales of Energy Star A-Lines would be lower during 2021 if these program buydowns/ markdowns and program promotional materials had not been available? [RECORD % DECREASE]

PA3c.I want to make sure I understand you correctly. You estimate that your sales would have been [PERCENTAGE FROM PA3b] % lower without the program support. So, if you actually sold 100 A-Lines in a given week, you think you'd have sold only about [100 – (PERCENTAGE FROM PA3b) * 100)] in that period if the buydowns/markdowns hadn't been available? [IF RESPONSE IS ≠ YES, THEN CLARIFY ESTIMATED SALES DECREASE]

PA3d. [IF LOWER] You said that you would have sold fewer Energy Star LED A-Lines if the Dominion Energy program price discounts had not been available. In this scenario, would you have tried to make up for these lost Energy Star LEDs A-line sales with sales of less expensive non-Energy Star LED products?

i) [IF YES] About what percent of these lost Energy Star A-Lines sales would you have likely made up with sales of these less expensive non=Energy Star LED products?

Net-to-Gross – Reflectors

PA4. The Dominion Energy lighting program paid average buydown or markdown discounts of $1.12 per reflector bulb and $4.29 per reflector pack. If these program buydown/markdown discounts and program promotional materials had not been available during 2021 do you think your sales of these types of bulbs in your stores in Virginia and North Carolina would have been about the same, lower, or higher?

PA4a. [IF THE SAME OR HIGHER] Why do you say this? [RECORD RESPONSE AND SKIP TO PA5]

PA4b. [IF LOWER] By what percentage do you estimate your sales of reflectors would be lower during 2021 if these program buydowns/ markdowns and program promotional materials had not been available? [RECORD % DECREASE]

PA4c. I want to make sure I understand you correctly. You estimate that your sales would have been [PERCENTAGE FROM PA4b] % lower without the program support. So, if you actually sold 100 reflector bulbs in a given week, you think you'd have sold only about [100 – (PERCENTAGE FROM PA4b * 100)] in that period if the buydowns/markdowns hadn't been available? [IF RESPONSE IS ≠ YES, THEN CLARIFY ESTIMATED SALES DECREASE]

PA4d. [IF LOWER. ALSO IF THEY ALREADY SAID, IN RESPONSE TO PREVIOUS QUESTIONS, THAT THEY WOULD NOT SUBSTITUTE NON-ES FOR ES LAMPS UNDER ANY CONDITIONS, YOU CAN SKIP THIS QUESTION] You said that you would have sold fewer Energy Star LED reflectors if the Dominion Energy program price discounts had not been available. In this scenario, would you have tried to make up for these lost Energy Star reflector sales with sales of less expensive non-Energy Star LED products?

i) [IF YES] About what percent of these lost Energy Star reflector sales would you have likely made up with sales of these less expensive non=Energy Star LED products?

PA4e. [IF LOWER] Would you have tried to make up for these lost Energy Star LED reflector sales with sales of less expensive non-LED products such as halogens or incandescents?

i) [IF YES] About what percent of these lost Energy Star LED reflector sales would you have likely made up with sales of these non-LED products?

Net-to-Gross – Specialty

PA5. The Dominion Energy Lighting Program paid average buydown or markdown discounts of $1.06 per Energy Star LED specialty bulb and $3.48 per specialty pack. If these program buydown/ markdown discounts and program promotional materials had not been available during 2021, do you think your sales of these types of bulbs in your Virginia and North Carolina stores would have been about the same, lower, or higher?

PA5a. [IF THE SAME OR HIGHER] Why do you say this? [RECORD RESPONSE AND SKIP TO PA6]

PA5b. [IF LOWER] By what percentage do you estimate your Virginia & North Carolina sales of Energy Star specialty LED bulbs would be lower during 2021 if these program buydowns/ markdowns and program promotional materials had not been available? [RECORD % DECREASE]

PA5c. I want to make sure I understand you correctly. You estimate that your sales would have been [PERCENTAGE FROM PA4b] % lower without the program support. So, if you actually sold 100 bulbs in a given week, you think you'd have sold only about [100 – (PERCENTAGE FROM PA4b) * 100)] in that period if the buydowns/markdowns hadn't been available? [IF RESPONSE IS ≠ YES, THEN CLARIFY ESTIMATED SALES DECREASE]

PA5d. [IF LOWER. ALSO IF THEY ALREADY SAID IN RESPONSE TO PREVIOUS QUESTIONS, THAT THEY WOULD NOT SUBSTITUTE NON-ES FOR ES LAMPS UNDER ANY CONDITIONS, YOU CAN SKIP THIS QUESTION] You said that you would have sold fewer Energy Star specialty LED lamps if the Dominion Energy program price discounts had not been available. In this scenario, would you have tried to make up for these lost Energy Star LEDs specialty lamp sales with sales of less expensive non-Energy Star LED products?

i) [IF YES] About what percent of these lost Energy Star specialty LED sales would you have likely made up with sales of these less expensive non=Energy Star LED products?

PA5e. [IF LOWER] Would you have tried to make up for these lost Energy Star specialty LED sales with sales of less expensive non-LED products such as halogens or incandescents?

i) [IF YES] About what percent of these lost Energy Star LED specialty LED sales would you have likely made up with sales of these non-LED products?

Net-to-Gross – Fixtures and Retrofit Kits

PA6. The Dominion Energy REEC Program paid average buydown or markdown discounts of $2.19 per fixtures/retrofit kit and $3.16 per fixture/retrofit pack. If these program buydown/ markdown discounts and program promotional materials had not been available during 2021, do you think your sales of these types of LED fixtures and retrofit kits through your stores in Virginia and North Carolina would have been about the same, lower, or higher?

PA6a. [IF THE SAME OR HIGHER] Why do you say this? [RECORD RESPONSE AND SKIP TO PA5]

PA6b. [IF LOWER] By what percentage do you estimate your Virginia & North Carolina sales of Energy Star fixtures and retrofit kit LED would be lower in 2021 if these program buydowns/ markdowns and program promotional materials had not been available? [RECORD % DECREASE]

PA6c. I want to make sure I understand you correctly. You estimate that your sales would have been [PERCENTAGE FROM PA4b] % lower without the program support. So, if you actually sold 100 bulbs in a given week, you think you'd have sold only about [100 – (PERCENTAGE FROM PA4b) * 100)] in that period if the buydowns/markdowns hadn't been available? [IF RESPONSE IS ≠ YES, THEN CLARIFY ESTIMATED SALES DECREASE]

PA6d. [IF LOWER. ALSO IF THEY ALREADY SAID (IN RESPONSE TO PREVIOUS QUESTIONS) THAT THEY WOULD NOT SUBSTITUTE NON-ES FOR ES LAMPS UNDER ANY CONDITIONS, YOU CAN SKIP THIS QUESTION] You said that you would have sold fewer Energy Star lighting fixtures if the Dominion Energy program price discounts had not been available. In this scenario, would you have tried to make up for these lost Energy Star LED fixture sales with sales of less expensive non-Energy Star LED products?

i) [IF YES] About what percent of these lost Energy Star LED fixture sales would you have likely made up with sales of these less expensive non=Energy Star LED products?

PA6e. [IF LOWER] Would you have tried to make up for these lost Energy Star LED fixture sales with sales of less expensive non-LED products such as halogens or incandescents?

ii) [IF YES] About what percent of these lost Energy Star LED fixture sales would you have likely made up with sales of these non-LED products?

Lighting Market Trends and Program Design

This last set of questions will address lighting market trends and aspects of the Dominion Energy REEC Program's design.

Market Trends

LM1. What are the most important factors that are limiting customer demand for LED products? Please explain.

LM1a. To what degree have these demand barriers varied with the type of LED product?

LM1b. [IF DEMAND BARRIERS IDENTIFIED] Has there been any progress recently to reduce these barriers?

LM1c. [IF YES] What factors lead to the reduced barriers?

LM1d. [IF DEMAND BARRIERS IDENTIFIED] What needs to happen to overcome these demand-side barriers?

LM2. Do you think LED lighting product prices will increase, decrease, or stay the same in 2023?

LM2a. What factors are causing you to make this prediction?

LM2b. [IF SAID PRICES WILL DROP] By what percentage do you think LED prices will drop in 2023? [RECORD %]

Program Satisfaction

Finally, I would like to find out your level of satisfaction with Dominion Energy's REEC Program.

PS1. Using a scale of 1 to 5 where 5 = very satisfied and 1 = very dissatisfied, how satisfied have you been with CLEAResult, the contractor delivering the Dominion Energy REEC Program?

PS1a. [ASK ONLY IF SATISFACTION RATING IS 1-3] Why do you say that?

PS2. Have you had any interaction with Dominion Energy staff while participating in this program?

PS2a. [IF YES] Using a scale of 1 to 5 where 5 = very satisfied and 1 = very dissatisfied, how satisfied have you been with the Dominion Energy staff who you interacted with?

i) ASK ONLY IF SATISFACTION RATING IS 1-3] Why do you say that?

PS3. Using the same scale, how would you rate your level of satisfaction with the program in general? Vendors do a large portion of the heavy lifting on the programs.

PS3a. [ASK ONLY IF SATISFACTION RATING IS 1-3] Why do you say that?

PS4. In what way could the program processes be improved?

PS5. Are there any lighting products not currently offered through the program that you would like to be included in the program?

PS5a. [IF YES] Which products?

PS6. Are you planning to participate in the program going forward?

PS6a. [IF YES] Why do you say that?

Closing

Thank you for your time with this interview and for participating in this program. Have a great day.

APPENDIX C. LIGHTING MANUFACTURER AND DISTRIBUTOR IN-DEPTH INTERVIEW GUIDE

RESIDENTIAL EFFICIENT PRODUCTS MARKETPLACE – IMPACT AND NET-TO-GROSS EVALUATION

Interview Information

Interviewer		Survey Length (min)	
Completion Date			

Contact Information

Phone	
Email	

Call Tracking

Date/Time	Notes

Variables

<alines_sold>	Total A-Lines sold through the program
<fixtures_retrofits_sold>	Total fixtures and retrofits sold through the program
<specialty_sold>	Total globes, candelabra, candles, and other specialty bulbs sold through the program
<reflectors_sold>	Total Multifaceted, parabolic aluminized reflectors, bulged and other reflectors sold through the program
<retailer_string>	A list of retailers that received bulbs from a specific manufacturer
<average_buydown>	Average buydown amount from tracking data specific to each manufacturer

Introduction

[NOTE: THE QUESTIONS IN THIS INTERVIEW GUIDE WILL NOT NECESSARILY BE READ VERBATIM BUT MAY BE MODIFIED TO SUIT THE INTERVIEW]

1. Hi, my name is _______, and I am calling from DNV on behalf of Dominion Energy regarding the Residential Efficient Products Marketplace Lighting Discounts program which supports the sales of efficient lighting products for retailers across Virginia and North Carolina. According to our records, your company has recently sold lighting products as part of that program. I would like to ask you some questions about your participation and trends in the residential lighting market in general.

DNV

[IF RESPONDENT IS NOT PROGRAM-FAMILIAR CONTACT, GET IN TOUCH WITH PROGRAM-FAMILIAR CONTACT AND REPEAT]

[IF ASKED] We anticipate this interview will last about 20-30 minutes. Any information you provide will be treated as confidential.

[IF ASKED] DNV is an independent contractor hired to do this research. You can verify the legitimacy of this research by calling Ryan Burruss from Dominion Energy at 804.217.4652.

VERIFICATION OF PROGRAM SALES

First, I would like to review some information about the nature of your recent participation in Dominion Energy's Residential Efficient Products Marketplace (REEC) Program which offers discounts on Energy Star LED lighting products in Virginia and North Carolina.

V1. I emailed you information on your sales of energy-efficient lamps through 2021. Does that information appear generally correct? [IF SOME OF THE INFORMATION IS INCORRECT, MAKE ANY CORRECTIONS IN THE SECOND ROW].

V2. My records indicate that in 2021 your company **did not** receive discounts from the Dominion Energy REEC Program for the following lighting applications: [NAME ALL LIGHTING APPLICATION PRODUCTS IN SECOND ROW OF TABLE 1 WHERE QUANTITY IS = 0] Is this information correct? [IF SOME OF THE INFORMATION IS INCORRECT, MAKE ANY CORRECTIONS IN THE THIRD ROW OF THE TABLE.]. Is that correct?

High-Level Verification of Program Tracking Data

Response Category	# of PY 2021 A-Lines	# of PY 2021 Reflectors	# of PY 2021 Specialty*	# of PY 2021Fixtures & Retrofits
Upstream Program Sales from Tracking Data**				
1-1. Program sales data looks reasonably correct?	Yes No DK Refused	Yes No DK Refused	Yes No DK Refused	Yes No DK Refused
1-2 Is it true that you did not sell these lighting products through the program?	Yes No DK Refused	Yes No DK Refused	Yes No DK Refused	Yes No DK Refused

* Specialty bulbs include Globes, Candelabra Base, Candle, and Other Specialty bulbs
** Interviewers will pre-populate this row with tracking data

2021 Program Attribution

Whether They Would Have Sold Any EE Lighting Products without the Program

PA1. The Dominion Energy REEC Program paid average buydown or markdown discounts of $2.91 per pack for A-Line lamps and $4.29 per pack for Reflectors. Are there any retailers or retailer categories that you worked with through the program that you think would not have been selling any A-Lines or reflector products if these discounts had not been available? As a reminder, you worked with <retailer_string>. [IF NEEDED/USEFUL, INCENTIVES ARE $0.85 PER A-LAMP AND $1.12 PER REFLECTOR]

PA1a. [IF YES] Which retailers or retailer categories?

PA1b. [IF YES] Why do you say this?

PA2. The Dominion Energy REEC Program paid average buydown or markdown discounts of $3.48 per pack of Specialty lamps and $3.16 per Fixture/Retrofit kit. Are there any retailers or retailer categories that you worked with through the program that you think would not have been selling any of these specialty or fixtures/retrofit kit products in Virginia and North Carolina if these discounts had not been available? As a reminder, you worked with <retailer_string>. [IF NEEDED/USEFUL, INCENTIVES ARE $1.06 PER SPECIALTY LAMP AND $2.19 PER FIXTURE/RETROFIT KIT]

PA2a. [IF YES] Which retailers or retailer categories?

PA2b. [IF YES] Why do you say this?

Net-to-Gross – A-Lines

PA3. [INSTRUCTIONS TO SURVEYOR: FIRST ASK THE MANUFACTURER THE FREE RIDERSHIP QUESTION SEQUENCE FOR THE RETAILERS (PA1 & PA2) THROUGH WHICH THEY SOLD THE MOST A-LINES THROUGH THE PROGRAM (SEE TRACKING DATA MATRIX). EXCLUDE ANY RETAILERS THAT THEY IDENTIFIED IN QUESTION PA1 AS NOT SELLING ANY LIGHTING PRODUCTS AT ALL WITHOUT THE BUYDOWNS. REPEAT THE FREE RIDERSHIP BATTERY FOR ALL RETAIL CHANNELS WHICH ACCOUNTED FOR AT LEAST 20% OF THEIR TOTAL PROGRAM SALES OR FOR ANY SUBCHANNELS PRE-IDENTIFIED AS "HARD-TO-REACH"]

The Dominion Energy REEC Program paid average buydown or markdown discounts of $0.85 per A-Line bulb and $2.91 per pack. If these program buydown/ markdown discounts and program promotional materials had not been available during 2021, do you think your sales of these types of bulbs through [RETAILER CATEGORY] stores in Virginia and North Carolina would have been about the same, lower, or higher?

PA3a. [IF THE SAME OR HIGHER] Why do you say this? [RECORD RESPONSE AND SKIP TO PA4]

PA3b. [IF LOWER] By what percentage do you estimate your sales of Energy Star A-Lines through [RETAILER CATEGORY] would be lower during 2021 if these program buydowns/ markdowns and program promotional materials had not been available? [RECORD % DECREASE]

PA3c.I want to make sure I understand you correctly. You estimate that your sales would have been [PERCENTAGE FROM PA3b] % lower without the program support. So, if you actually sold 100 A-Lines in a given week, you think you'd have sold only about [100 – (PERCENTAGE FROM PA3b) * 100)] in that period if the buydowns/markdowns hadn't been available? [IF RESPONSE IS ≠ YES, THEN CLARIFY ESTIMATED SALES DECREASE]

PA3d. [IF LOWER] You said that you would have sold fewer Energy Star LED A-Lines if the Dominion Energy program price discounts had not been available. In this scenario, would you have tried to make up for these lost Energy Star LEDs A-line sales with sales of less expensive non-Energy Star LED products?

ii) [IF YES] About what percent of these lost Energy Star A-Lines sales would you have likely made up with sales of these less expensive non=Energy Star LED products?

PA3e. [IF LOWER] Would you have tried to make up for these lost Energy Star LEDs A-line sales with sales of less expensive non-LED products such as halogens or incandescents?

i) [IF YES] About what percent of these lost Energy Star A-Lines sales would you have likely made up with sales of these non-LED products?

Net-to-Gross – Reflectors

PA4. [INSTRUCTIONS TO SURVEYOR: FIRST ASK THE MANUFACTURER THE FREE RIDERSHIP QUESTION SEQUENCE FOR THE RETAILER CATEGORY THROUGH WHICH THEY SOLD THE MOST REFLECTORS THROUGH THE PROGRAM (SEE TRACKING DATA MATRIX). EXCLUDE ANY RETAILER CATEGORIES THAT THEY IDENTIFIED IN PA1 AS NOT SELLING ANY REFLECTORS AT ALL WITHOUT THE BUYDOWNS. REPEAT THE FREE RIDERSHIP BATTERY FOR ALL RETAIL CHANNELS WHICH ACCOUNTED FOR AT LEAST 20% OF THE SUPPLIER'S PROGRAM SALES]

The Dominion Energy Lighting Program paid average buydown or markdown discounts of $1.12 per reflector bulb and $4.29 per reflector pack. If these program buydown/markdown discounts and program promotional materials had not been available during 2021, do you think your sales of these types of bulbs through <retailer_string> in Virginia and North Carolina would have been about the same, lower, or higher?

PA4a. [IF THE SAME OR HIGHER] Why do you say this? [RECORD RESPONSE AND SKIP TO PA5]

PA4b. [IF LOWER] By what percentage do you estimate your sales of reflectors would be lower during 2021 if these program buydowns/ markdowns and program promotional materials had not been available? [RECORD % DECREASE]

PA4c. I want to make sure I understand you correctly. You estimate that your sales would have been [PERCENTAGE FROM PA4b] % lower without the program support. So, if you actually sold 100 reflector bulbs in a given week, you think you'd have sold only about [100 – (PERCENTAGE FROM PA4b * 100)] in that period if the buydowns/markdowns hadn't been available? [IF RESPONSE IS ≠ YES, THEN CLARIFY ESTIMATED SALES DECREASE]

PA4d. [IF LOWER. ALSO IF THEY ALREADY SAID, IN RESPONSE TO PREVIOUS QUESTIONS, THAT THEY WOULD NOT SUBSTITUTE NON-ES FOR ES LAMPS UNDER ANY CONDITIONS, YOU CAN SKIP THIS QUESTION] You said that you would have sold fewer Energy Star LED reflectors if the Dominion Energy program price discounts had not been available. In this scenario, would you have tried to make up for these lost Energy Star reflector sales with sales of less expensive non-Energy Star LED products?

ii) [IF YES] About what percent of these lost Energy Star reflector sales would you have likely made up with sales of these less expensive non=Energy Star LED products?

PA4e. [IF LOWER] Would you have tried to make up for these lost Energy Star LED reflector sales with sales of less expensive non-LED products such as halogens or incandescents?

ii) [IF YES] About what percent of these lost Energy Star LED reflector sales would you have likely made up with sales of these non-LED products?

Net-to-Gross – Specialty

PA5. [INSTRUCTIONS TO SURVEYOR: FIRST ASK THE MANUFACTURER THE FREE RIDERSHIP QUESTION SEQUENCE FOR THE RETAILER CATEGORY THROUGH WHICH THEY SOLD THE MOST SPECIALTY BULBS THROUGH THE PROGRAM (SEE TRACKING DATA MATRIX). EXCLUDE ANY RETAILER CATEGORIES THAT THEY IDENTIFIED IN PA1 AS NOT SELLING ANY SPECIALTY BULBS AT ALL WITHOUT THE BUYDOWNS. REPEAT THE FREE RIDERSHIP BATTERY FOR ALL RETAIL CHANNELS WHICH ACCOUNTED FOR AT LEAST 20% OF THE

SUPPLIER'S PROGRAM SALES] *Reminder: Specialty bulbs include Globes, Candelabra Base, Candle, and Other Specialty bulbs*

The Dominion Energy Lighting Program paid average buydown or markdown discounts of $1.06 per Energy Star LED specialty bulb and $3.48 per specialty pack. If these program buydown/ markdown discounts and program promotional materials had not been available during 2021, do you think your sales of these types of bulbs to <retailer_string> in Virginia and North Carolina would have been about the same, lower, or higher?

PA5a. [IF THE SAME OR HIGHER] Why do you say this? [RECORD RESPONSE AND SKIP TO PA6]

PA5b. [IF LOWER] By what percentage do you estimate your Virginia & North Carolina sales of Energy Star specialty LED bulbs would be lower during 2021 if these program buydowns/ markdowns and program promotional materials had not been available? [RECORD % DECREASE]

PA5c. I want to make sure I understand you correctly. You estimate that your sales would have been [PERCENTAGE FROM PA4b] % lower without the program support. So, if you actually sold 100 bulbs in a given week, you think you'd have sold only about [100 – (PERCENTAGE FROM PA4b) * 100)] in that period if the buydowns/markdowns hadn't been available? [IF RESPONSE IS ≠ YES, THEN CLARIFY ESTIMATED SALES DECREASE]

PA5d. [IF LOWER. ALSO IF THEY ALREADY SAID IN RESPONSE TO PREVIOUS QUESTIONS, THAT THEY WOULD NOT SUBSTITUTE NON-ES FOR ES LAMPS UNDER ANY CONDITIONS, YOU CAN SKIP THIS QUESTION] You said that you would have sold fewer Energy Star specialty LED lamps if the Dominion Energy program price discounts had not been available. In this scenario, would you have tried to make up for these lost Energy Star LEDs specialty lamp sales with sales of less expensive non-Energy Star LED products?

ii) [IF YES] About what percent of these lost Energy Star specialty LED sales would you have likely made up with sales of these less expensive non=Energy Star LED products?

PA5e. [IF LOWER] Would you have tried to make up for these lost Energy Star specialty LED sales with sales of less expensive non-LED products such as halogens or incandescents?

iii) [IF YES] About what percent of these lost Energy Star LED specialty LED sales would you have likely made up with sales of these non-LED products?

Net-to-Gross – Fixtures and Retrofit Kits

PA6. [INSTRUCTIONS TO SURVEYOR: FIRST ASK THE MANUFACTURER THE FREE RIDERSHIP QUESTION SEQUENCE FOR THE RETAILERS THROUGH WHICH THEY SOLD THE MOST FIXTURES & RETROFIT KITS THROUGH THE PROGRAM (SEE TRACKING DATA MATRIX). EXCLUDE ANY RETAILERS THAT THEY IDENTIFIED IN QUESTION PA1 AS NOT SELLING ANY FIXTURE AND RETROFIT KIT PRODUCTS AT ALL WITHOUT THE BUYDOWNS. REPEAT THE FREE RIDERSHIP BATTERY FOR ALL RETAILERS WHICH ACCOUNTED FOR AT LEAST 20% OF THE SUPPLIER'S PROGRAM SALES. OR FOR ANY SUBCHANNELS PRE-IDENTIFIED AS "HARD-TO-REACH"]

The Dominion Energy REEC Program paid average buydown or markdown discounts of $1.06 per Energy Star LED specialty bulb and $3.48 per specialty pack. If these program buydown/ markdown discounts and program promotional materials had not been available during 2021, do you think your sales of these types of bulbs through [RETAILER CATEGORY] stores in Virginia and North Carolina would have been about the same, lower, or higher?

PA6a. [IF THE SAME OR HIGHER] Why do you say this? [RECORD RESPONSE AND SKIP TO PA5]

PA6b. [IF LOWER] By what percentage do you estimate your Virginia & North Carolina sales of Energy Star fixtures and retrofit kit LED bulbs would be lower during 2021 if these program buydowns/ markdowns and program promotional materials had not been available? [RECORD % DECREASE]

PA6c. I want to make sure I understand you correctly. You estimate that your sales would have been [PERCENTAGE FROM PA4b] % lower without the program support. So, if you actually sold 100 bulbs in a given week, you think you'd have sold only about [100 – (PERCENTAGE FROM PA4b) * 100)] in that period if the buydowns/markdowns hadn't been available? [IF RESPONSE IS ≠ YES, THEN CLARIFY ESTIMATED SALES DECREASE] [REPEAT QUESTION BATTERIES FOR ALL RETAIL CHANNELS WHICH ACCOUNTED FOR AT LEAST 20% OF THE SUPPLIER'S PROGRAM SALES]

PA6d. [IF LOWER. ALSO IF THEY ALREADY SAID (IN RESPONSE TO PREVIOUS QUESTIONS) THAT THEY WOULD NOT SUBSTITUTE NON-ES FOR ES LAMPS UNDER ANY CONDITIONS, YOU CAN SKIP THIS QUESTION] You said that you would have sold fewer Energy Star lighting fixtures if the Dominion Energy program price discounts had not been available. In this scenario, would you have tried to make up for these lost Energy Star LED fixture sales with sales of less expensive non-Energy Star LED products?

ii) [IF YES] About what percent of these lost Energy Star LED fixture sales would you have likely made up with sales of these less expensive non=Energy Star LED products?

PA6e. [IF LOWER] Would you have tried to make up for these lost Energy Star LED fixture sales with sales of less expensive non-LED products such as halogens or incandescents?

iv) [IF YES] About what percent of these lost Energy Star LED fixture sales would you have likely made up with sales of these non-LED products?

Lighting Market Trends and Program Design

This last set of questions will address lighting market trends and aspects of the Dominion Energy REEC Program's design.

Market Trends

LM1. What are the most important factors that are limiting customer demand for LED products? Please explain.

LM1a. To what degree have these demand barriers varied with the type of LED product?

LM1b. [IF DEMAND BARRIERS IDENTIFIED] Has there been any progress recently to reduce these barriers?

LM1c. [IF YES] What factors lead to the reduced barriers?

LM1d. [IF DEMAND BARRIERS IDENTIFIED] What needs to happen to overcome these demand-side barriers?

LM2. Do you think LED lighting product prices will increase, decrease, or stay the same in 2023?

LM2a. What factors are causing you to make this prediction?

LM2b. [IF SAID PRICES WILL DROP] By what percentage do you think LED prices will drop in 2023? [RECORD %]

Program Satisfaction

Finally, I would like to find out your level of satisfaction with Dominion Energy's REEC Program.

PS1. Using a scale of 1 to 5 where 5 = very satisfied and 1 = very dissatisfied, how satisfied have you been with CLEAResult, the contractor delivering the Dominion Energy REEC Program?

PS1a. [ASK ONLY IF SATISFACTION RATING IS 1-3] Why do you say that?

PS2. Have you had any interaction with Dominion Energy staff while participating in this program?

PS2a. [IF YES] Using a scale of 1 to 5 where 5 = very satisfied and 1 = very dissatisfied, how satisfied have you been with the Dominion Energy staff who you interacted with?

ii) ASK ONLY IF SATISFACTION RATING IS 1-3] Why do you say that?

PS3. Using the same scale, how would you rate your level of satisfaction with the program in general?

PS3a. [ASK ONLY IF SATISFACTION RATING IS 1-3] Why do you say that?

PS4. In what way could the program processes be improved?

PS5. Are there any lighting products not currently offered through the program that you would like to be included in the program?

PS5a. [IF YES] Which products?

PS6. Are you planning to participate in the program going forward?

PS6a. [IF YES] Why do you say that?

Closing

Thank you for your time with this interview and for participating in this program. Have a great day.

APPENDIX D. DOMINION ENERGY RESIDENTIAL EFFICIENT MARKETPLACE PROGRAM – WEB SURVEY

EMAIL INVITE

From: "Dominion Energy Appliance Rebate Program Evaluation" <energyuse@domenergy.com>
Subject: Invite: Tell us about your experience with Dominion Energy's appliance rebate program

Dear [F2 <customer name>],

How was your recent experience claiming a rebate through Dominion Energy's home appliance Marketplace Rebate Program?

Dominion Energy is seeking feedback on your experience with the Dominion Energy Marketplace Rebate Program. As a rebate recipient in the 2021-2022 program, your opinions are important. Dominion would like your input and perspective in a brief online survey to understand how to best structure future energy efficiency programs designed to serve customers like you.

To get started click on this link: [https://app.form.com/f/41525664/7bcb/testlink=yes]

Your answers will be held in the strictest confidence. The information you provide will be combined with information from other households that complete the survey. Individual household data will not be published. The results are reported in summaries such as group averages, percentages, and other general statistics.
Thank you for helping to improve energy efficiency programs in Virginia.

Edward Hall
Energy Market Strategic Advisor
Dominion Energy
PO Box 26666
Richmond, VA 23261-6666

We need your help. DNV is the research provider retained by Dominion Energy to help administer this survey. DNV, is a company that specializes in energy research and analysis. Your participation is very important as only a limited number of customers were selected to take this survey.
To learn more about the appliance rebate program, visit: Dominion Energy Marketplace Program.

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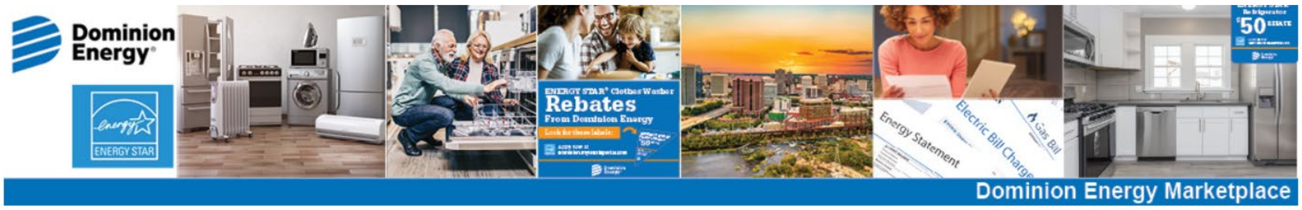
DNV

WEB SURVEY



Appliance Rebate Program Evaluation

Hello ,

According to Dominion Energy's records, your household received rebates for one or more household appliances from the Dominion Energy Retail Marketplace program. This survey includes a set of questions about the rebated:

{meas1}
{meas2}

1. Are you familiar with this/these purchase(s)?

   i. Yes
   ii. No
   iii. I no longer live there

2. Is there someone else who may be familiar with this purchase?

   i. Who should we contact? Please provide an alternate email:

Verify Installation

3. In this survey, we ask about {Q7} rebated appliance(s).

Measures	To verify, did you install the following appliance(s) at this address: {Q4}?	What did you do with the appliance?	Is the location where the appliance is installed served by Dominion Energy?
{ – repeat for each measure}	Yes, installed No, not installed	Returned to the store Still in storage Installed in my business Installed at a different address Gave it away Don't recall	Yes No Don't know

Your Experience with this Program

4. How did you first learn about the rebates available to you?

   i. In-store, home improvement /retail stores (e.g., Lowes, Costco, Home Depot, etc.)

ii. Online, home improvement /retail store
iii. Dominion Energy email/website/
iv. Dominion Energy bill insert
v. Word of mouth, e.g., friends, relatives, co-worker
vi. Previous participation
vii. Don't know
viii. Other, specify:

5. Did you purchase the rebated appliance(s) at a store or through an online retailer?

i. In-store
ii. Online
iii. Both in-store and online

6. In the store, did you observe any Dominion Energy promotional rebate/discount materials such has stickers on merchandise, clings, or signs in the aisle or in the store?

i. Yes
ii. No
iii. Don't recall

7. The type of equipment you purchased was more energy efficient than the standard type. Did the availability of the rebate or Dominion Energy's endorsement influence your purchase decision(s)?

i. Yes
ii. No

Importance of the Rebate in your Purchase Decision

8. What was the main reason why you decided to purchase this appliance?

i. Existing appliance at the end useful life or broken
ii. Lower my energy bills
iii. Upgraded/remodel
iv. Need, no existing appliances
v. Other

9. Consumers have many choices, when considering your purchase what factors where the important in your purchase decision?

i. Brand reputation
ii. Price
iii. Energy efficiency, e.g., Energy Star
iv. Buy-down, manufacturer or other entity store rebate
v. Buy-down, rebate through Dominion
vi. Design or physical characteristics
vii. Information, in-store, contractor, or friend
viii. Previous experience
ix. Availability

x. Other reasons

10. Without the Dominion Energy rebate, how likely would you have been to purchase the same high efficiency appliance(s) at your own expense, would you say...?

    Repeat for each measure

    Very likely   Somewhat likely   Likely   Somewhat unlikely   Very unlikely

11. If the rebate program had NOT been available, when would you have made the new appliance(s) purchase?

    Repeat for each measure

    i. At the same time or sooner
    ii. Within 1 to 24 months
    iii. More than 24 months later
    iv. Would not have purchased it at all
    v. Don't know

12. Use the sliding scale to specify the number of months: *Click and drag the square on the bar.

    Months: ---

13. We would like to know the effect the rebate had on your decision to purchase an ENERGYSTAR rated appliance(s) as opposed to a standard or lesser efficient model. Without the rebate, would you have purchased the same high efficiency appliance?

    Repeat for each measure

    1. Yes   2. No   3. Don't know

14. Without the rebate, what appliance efficiency level would you have selected?

    Repeat for each measure

    1. Standard efficiency on the market at time
    2. Slightly higher than standard efficiency
    3. Between standard efficiency and the efficiency purchased
    4. Slightly lower than the efficiency purchased
    5. Don't know

Satisfaction with Program

15. Please rate your satisfaction with the following program processes:

    1. Very satisfied (5)   2. Satisfied (4)   3. (3)   4. Somewhat dissatisfied (2)   5. Very dissatisfied (1)

    1. Ease of use, navigate the website and find what you're looking

2. Requirements for claim rebate, e.g., forms and proof of purchase
3. Timeliness/fulfilment of rebate
4. Rebate dollar amount
5. Program experience overall
6. Appliance purchased

16. What could Dominion Energy had done better to improve your website search experience?
17. What could Dominion Energy had done better as it relates to submitting forms and proof of purchase?
18. What could Dominion Energy had done better as it relates to timeliness and fulfilment of the rebate?
    1. Rebate payment took too long to arrive
    2. Never received rebate for one or more claims
    3. Had to follow up and request payment
    4. Rebate was sent to the wrong address
    5. Don't know
    6. Other
19. As it relates to rebate dollar amount, what could the program have done better?
    1. Rebate amount was not high enough
    2. Took too long/did not receive rebate
    3. Process/application too difficult or complicated
    4. Not beneficial/no observed impact
    5. Equipment did not work
    6. Needed more information
    7. Don't know
    8. Other
20. As it relates to the program overall, what could the program have done better?
21. If Dominion wanted to inform customers like yourself about the rebates and services they offer for energy-efficient programs, what do you suggest would be the best way to do that?
    1. Email or bill insert from Dominion
    2. In store displays
    3. Retailer website advertisements
    4. Include information/pamphlet inside bill

5. Contractor
6. Television
7. Social media advertising
8. I don't want such information
9. No suggestions
10. Don't know
11. Other

22. Do you have any suggestions to improve the delivery of this program for customers like yourself?
    1. Yes
    2. No

23. [If yes] What do you suggest?

Concerns with Energy Use

24. How concerned are you with reducing your home's energy use? Would you say...
    1. Very concerned
    2. Concerned
    3. Somewhat concerned
    4. Not concerned

25. Before the COVID-19 pandemic began, did you have any plans to install or perform energy efficiency upgrades like a new appliance or insulation in your home?
    1. Yes
    2. No

26. What energy efficiency actions were you planning?
    1. Purchase new appliances
    2. Replace windows or doors
    3. Purchase new light bulbs or fixtures
    4. Replace heater
    5. Replace air conditioner
    6. Add insulation or make weatherization improvements
    7. Aesthetic enhancements

8. Prefer not to say
9. Other, specify:

27. Did the COVID-19 pandemic and the resulting stay-at-home orders change the timing or size of those planned energy efficiency projects?
    1. Yes
    2. No
28. Which of the following describes how the pandemic changed your planned efficiency activities?
    1. Accelerated the completion schedule of planned activities
    2. Postponed planned activities
    3. Had energy efficiency activities underway that you had to put on hold
    4. Cancelled planned energy efficiency activities entirely
    5. Reduced the size or quantity of planned activities
    6. Increased the size or quantity of planned activities
    7. Don't know
    8. Prefer not to say
29. Why did your planned energy efficiency activities change?
    1. Financial considerations
    2. Availability of contractors
    3. Uncomfortable with contractors entering home
    4. Risk averse, spending money when the economy is down
    5. Family/friend directly impact by COVID
    6. Prefer not to say
    7. Other, specify:

Dwelling and Demographics

30. To ensure that energy efficiency programs serve all customer segments fairly, we would like to learn more about your dwelling and household demographics. Do you own or rent?
    1. Own
    2. Rent
31. Which of the following best describes your home building type?
    1. Single-family detached home (a stand-alone home)
    2. Single-family attached house (e.g., duplex, condo)

3. Apartment or condominium with 2 or more units
4. Other

32. Approximately how many square feet of living space is there in your home, including bathrooms, foyers, and hallways? Exclude garages, basements, or unheated porches?
    1. Under 1,500 SQFT
    2. 1,501 - 2,000 SQFT
    3. 2,001 - 2,500 SQFT
    4. 2,501 - 3,000 SQFT
    5. Greater than 3,000 SQFT
    6. Don't know
33. How many people live in your home year-around?
34. What is the highest level of education you have completed?
    1. Less than a high school diploma
    2. High school degree or equivalent (e.g., GED)
    3. Vocational/trade school degree
    4. Some college (AA, AS) degree
    5. Bachelor's degree (BA, BS)
    6. Master's Degree or higher (MA, MS, Med, PhD, MD, EdD)
    7. Prefer not to answer
35. Please select the range that best describes your household's total annual income:
    1. Under $50,000
    2. $50,000 to $74,999
    3. $75,000 to $99,999
    4. $100,000 to $124,999
    5. $125,000 to $174,999
    6. $175,000 to $200,000
    7. $200,000 or more
    8. Prefer not to answer

Thank you for completing this survey.

About DNV

DNV is an independent assurance and risk management provider, operating in more than 100 countries, with the purpose of safeguarding life, property, and the environment. Whether assessing a new ship design, qualifying technology for a floating wind farm, analyzing sensor data from a gas pipeline or certifying a food company's supply chain, DNV enables its customers and their stakeholders to manage technological and regulatory complexity with confidence. As a trusted voice for many of the world's most successful organizations, we use our broad experience and deep expertise to advance safety and sustainable performance, set industry standards, and inspire and invent solutions.

Appendix H
Residential Home Energy Assessment Program (2020-2022) Impact Evaluation

Dominion Energy

Date: June 5, 2023

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DNV

EXECUTIVE SUMMARY

This report presents the results of the impact evaluation of the Residential Home Energy Assessment Program administered by Dominion Energy. This program provides home energy audits, personalized energy insight reports, and direct installation of energy efficiency measures to residential customers in Dominion Energy's Virginia and North Carolina service territories. The program began in Virginia in October 2019 and in North Carolina in January 2020.

Evaluation objectives

The goal of the evaluation is to estimate energy impacts (kWh/year) and calculate the realization rate (RR) by program years 2020–2022, and across all years combined. The impact evaluation provides estimates of ex post net energy savings attributed to the program.

The impact evaluation calculated net energy savings using an augmented comparison approach that compared pre-installation normalized annual consumption to post-installation normalized annual consumption and adjusted the difference using a well-matched comparison group.

DNV performed an engineering review of the deemed (or tracked) saving estimates that included the lighting savings calculations in the DE TRM, input assumptions to the DE TRM compared other TRM's, Virginia's household lighting characteristics relative to other jurisdictions, and assessed the difference between the planned, installed, and DE TRM lighting baselines to determine to what extent savings rates are driven by uncertainty in TRM and baseline assumptions.

Key findings

- The average three-year per-participant savings was 562 kWh/year.
- Lighting measures dominated this program with over 94% of the expected savings and produced an overall 27% realization rate (RR).
- About 8% of the participants received space conditioning and water heating measures. The RR for these customers was over 100%.
- The program RR improved each year and the 40% program RR for 2022 is substantially higher than the previous two years
- Based on recent Dominion evaluations, there is currently no evidence that the lower than expected lighting RR seen in the Home Energy Assessment program will carry over to lighting measures in other Dominion Energy DSM programs.

Although it is impossible to determine exactly what is driving the program RR, DNV identified three potential contributing factors:

- The largest potential contributor to the low lighting measure RR may be the difference between the installed lighting baseline, the TRM lighting baseline, and planned lighting baseline. The baseline wattages in the program planning assumption and the DE TRM may be higher than program conditions, resulting in overstated deemed savings estimates. This is because the installed baseline (or program condition) includes compact fluorescents (CFLs) but neither the planned program EISA compliant baseline, nor the EISA compliant DE TRM baseline, includes CFLs in the baseline wattage assumption. (See Appendix I).

- The lighting measure RR changes relative to the number of installed lamps per household such that the RR of lighting measures increases as the number of lamps installed per household decreases. Dominion Energy implemented program design changes in the program's second year by limiting the number of lamps installed to 70 per household. Improvements in the RR from this program reset can be seen late in 2021 and throughout 2022 (Appendix III).
- The program pause initiated at the beginning of the COVID-19 pandemic in March 2020 lowered participation and decreased measure mix diversity. Even after the program was reinstated later in 2020, customers were generally hesitant to invite contractors into their homes.

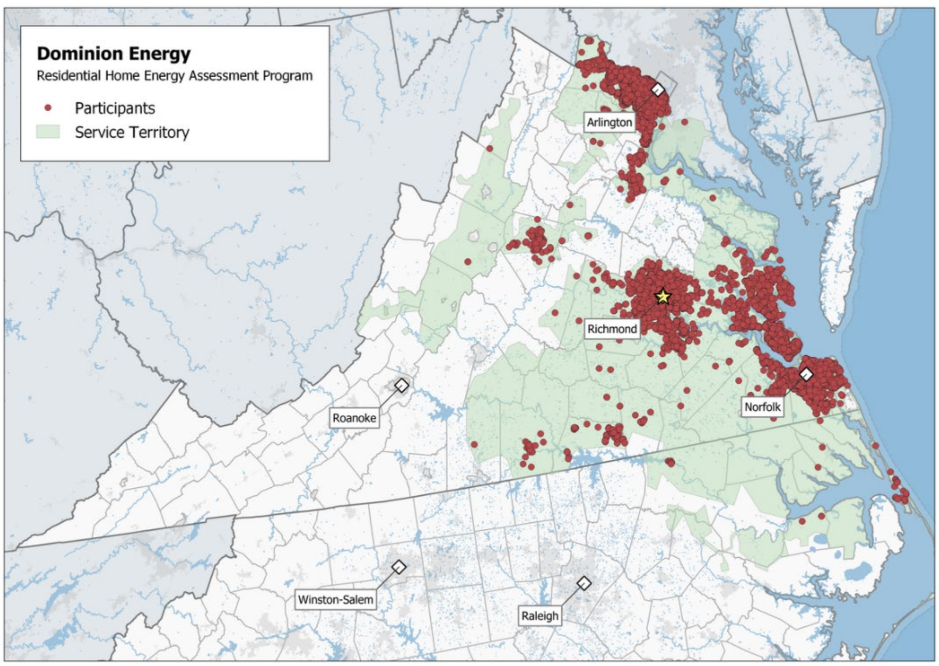
1 INTRODUCTION

This report presents the results of the impact evaluation of the Residential Home Energy Assessment Program administered by Dominion Energy. DNV conducted this evaluation using the methods defined in the Home Energy Assessment program EM&V plan across Program Years 2020–2022.[1]

1.1 Program background

The Home Energy Assessment Program includes a walk-though home audit, direct install measures, and recommendations for additional home energy improvements to residential customers living in single-family residences or townhomes in Dominion Energy's Virginia and North Carolina service territories. Customers receive the home-audit recommendations in a personalized report showing the projected energy and cost savings for the energy saving measures identified during the audit. The program began operating in Virginia in October 2019 and in North Carolina in January 2020 but paused operations in March 2020 due to the COVID-19 pandemic.[2] Figure 1-1 shows the locations of the households served by the program.

Figure 1-1. Locations of households that participated in the Home Energy Assessment Program (2019–2022)



1.2 Program services, delivery, and measures

A customer enters the program by contacting a qualified Dominion Energy contractor. Once contact is initiated, the contractor performs a home energy assessment walk through audit to identify where energy efficiency measures can be

1 The Home Energy Assessment Program's EM&V Plan is included as Appendix E5. to the Residential Home Energy Assessment Program EM&V Plan. Evaluation, Measurement, and Verification Report for Virginia Electric and Power Company (Dominion Energy), Case No. PUR-2020-00274 (Virginia), Docket No. E-22 Sub 604 (North Carolina), Volume 1 of 4, June 15, 2022, Prepared by DNV Energy Insights USA Inc. (DNV). The evaluation workplan is included as Appendix IV to this report.

2 The Virginia SCC approved this program, as part of the DSM Phase VII programs, on May 2, 2019, (Case No. PUR-2018-00168) for a five-year period of July 1, 2019, through June 30, 2024. The program officially launched on October 1, 2019. The North Carolina Utilities Commission approved this program on November 13, 2019 (Docket No. E-22, SUB 567). The program officially launched on January 1, 2020.

installed. Not all households qualify for all measures; applicability is determined based on the presence or absence of qualified measures and required pre-conditions such as the level of existing insulation or existing lighting types. The contractor then reviews the energy assessment with the customer, using it as a vehicle to provide energy education, and installs the measures if warranted and requested by the customer. Table 1-1 lists the direct installed program measures.[3]

Table 1-1. Direct install measures in the Residential Home Energy Assessment Program

End Use	Measures
Building Envelope	Cool Roof
Lighting	LED Lighting
HVAC	HVAC Upgrades
	Air-conditioner/Heat-pump Tune-up
	Electronically Commutated Motor (ECM) at Heat Pump Fan
	Duct Insulation
	Duct Testing & Sealing
Domestic Hot Water	Pipe insulation
	Heat Pump Water Heater
	Faucet Aerator
	Low-flow Showerhead
	Temperature Setback

1.3 Evaluation objectives

The goal of the evaluation is to estimate energy impacts (kWh/year) and calculate the RR by program years 2020–2022, and across all years combined.[4] The impact evaluation provides estimates of ex post net energy savings attributed to the program.

DNV performed an engineering review of the deemed (or tracked) saving estimates that included the lighting savings calculations in the DE TRM, input assumptions to the DE TRM compared other TRM's, Virginia's household lighting characteristics relative to other jurisdictions, and assessed the difference between the planned, installed, and DE TRM lighting baselines to determine to what extent savings rates are driven by uncertainty in TRM and baseline assumptions.

The remainder of this report includes the savings impact estimates, a description of the source data, and a summary of the evaluation methodology. The appendices include an engineering review of the lighting realization rates (Appendix I), a more in-depth description of the evaluation methodology (Appendix II), an analysis of the relationship of installed lamp quantities to the realization rate (Appendix III), a description of the tracking data (Appendix IV), and the evaluation work plan (Appendix V.).

[3] Direct installed measures, including lighting, are installed by the contractor.

[4] The realization rate is the proportion of evaluated (ex post) annual savings (kWh) taken against deemed (ex-ante) savings estimates (kWh). It is expressed as a percentage. Measure-level savings estimates are calculated using the deemed methods defined in the Company's Technical Reference Manual (TRM). The DE TRM is updated annually and included as an appendix to the annual EM&V report.

2 IMPACT ESTIMATES

The following sections describe the annual and aggregate program results of the impact analysis. The analysis calculated estimates of ex post net energy savings attributed to program years 2020–2022, and across all years combined. Realization rates by lamp quantity and for non-lighting measures is included in Appendix III.

Net savings impacts were calculated using a billing analysis with an augmented comparison approach that compared pre-installation normalized annual consumption to post-installation normalized annual consumption (NAC) and adjusted the difference using a well-matched comparison group.[5]

2.1 Program impacts

Over 73% of the 2020–2021 participants were included in the analysis. However, only 20% of the 2022 participants were included due to the requirement for a minimum number of bills after program participation and billing data only being available through December 2022. The 945 participants from 2022 who were available for the analysis were those who participated early in the year. Our analysis assumes that these early 2022 participants are representative of program participants for the full calendar year.

The average three-year per-participant savings was 562 kWh/year. Comparing the evaluated net program savings to the expected or tracked savings yielded an overall RR of 27% (i.e., the ratio of actual savings to tracking savings). The program RR improved each year and the 40% RR for 2022 is substantially higher than the previous two years. Some of the possible reasons for this improving RR are discussed below.

The first two columns show the number of participants in the program and the number of participants in the analysis sample by year, and for the program overall. Columns three and four show the pre- and post-participation NAC, which is followed by the tracked savings, and the RR. The final two columns show the 90% confidence intervals and the relative confidence intervals.

Table 2-1. Participants, analysis sample, NAC, savings, and confidence intervals

			Normalized Annual Consumption (NAC)		Savings (kWh/year-participants)				
Year	# of Participants	# in Sample	Pre-Participation	Post-Participation	Tracked	Evaluated	Realization Rate (%)	90% Confidence Intervals	Relative Confidence Interval
2020	2,755	2,070	15,532	15,243	1,885	416	**22%**	120	29%
2021	9,864	7,167	15,507	14,984	2,289	518	**23%**	64	12%
2022	4,561	945	16,003	15,441	1,849	746	**40%**	197	26%
All Years	17,180	10,182	15,643	15,147	2,107	562	**27%**	55	10%

[5] Agnew, K.; Goldberg, M. (2017). “Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol,” The Uniform Methods Project: Methods for Determining Energy- Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68564. http://www.nrel.gov/docs/fy17osti/68564.pdf; Fels, Margaret F. 1986. "PRISM: An Introduction". Energy and Buildings. 9, 5-18.

Figure 2-1. Program tracked savings, evaluated savings, and RR by year (2020–2022)

2.2 Discussion

About 8% of the participants received space conditioning and water heating measures. The RR for these customers was over 100%. The high RR of non-lighting measures indicates that lighting measures are dampening the overall program RRs. Although it is difficult to precisely identify why lighting has a lower-than-expected savings rate, or all the possible factors that contributed to the improved RR over time, DNV identified several contributing factors. However, based on recent evaluations there is currently no evidence that the lower-than-expected lighting measure savings seen in the Home Energy Assessment program will carry over to lighting measures in other Dominion Energy DSM programs.[6]

DNV found that the lighting measure RR changes relative to the number of installed lamps per household such that the RR of lighting measures increases as the number of lamps installed per household decreases. The RR decreased from 36% for participants with less than 29 lighting measures to 14% for participants with over 100 lighting measures. Dominion Energy implemented program design changes in the program's second year by limiting the number of installed lamps to 70 per household. Improvements in the RR from this program reset can be seen late in 2021 and throughout 2022 (Appendix III).

We also found that the largest potential contributor to the lower-than-expected savings may be the difference between the installed lighting baseline, the TRM lighting baseline, and planned lighting baseline. The baseline wattages in the program planning assumption and the DE TRM may be higher than program conditions, resulting in overstated deemed savings estimates. This is because the installed baseline (or program condition) includes compact fluorescents (CFLs) but neither

[6] Appendix G., Impact Evaluation of the Residential Income and Age Qualifying Home Improvement Program (2015–2020), 2022 Evaluation, Measurement, and Verification Report for Virginia Electric and Power Company (Dominion Energy).

the planned program EISA compliant baseline, nor the EISA compliant DE TRM baseline, includes CFLs in the baseline wattage assumption. (See Appendix I).[7]

Lastly, the program pause initiated at the beginning of the COVID-19 pandemic in March 2020 lowered participation and decreased measure mix diversity. Even after the program was reinstated later in 2020, customers were generally hesitant to invite contractors into their homes.

2.2.1 Participants, the sample, NAC, savings, and confidence intervals

Table 2-1 shows that the amount of the participants' average annual electricity usage was consistent year to year, approximately 16,000 kWh/year. The analysis showed that the average participant tracking savings varied from year to year, with 2020 having the largest expected savings.

Lighting measures account for the preponderance of the expected energy savings of the program. The overall participant savings of 562 kWh/year-participant has a ±55 kWh/year confidence interval (10% relative confidence interval).

Because lighting accounted for such a large share of the program's expected energy savings, it was not prudent to try to estimate savings for the non-lighting measure groups (e.g., space conditioning and water heating). However, the distribution of RRs by lighting measure groups detailed in Appendix III does offer valuable insights into measure group influence on the overall program realization rate.

[7] H. R. 6, 110th Congress, 1st Session, An Act To move the United States toward greater energy independence and security, to increase the production of clean renewable fuels, to protect consumers, to increase the efficiency of products, buildings, and vehicles, to promote research on and deploy greenhouse gas capture and storage options, and to improve the energy performance of the Federal Government, and for other purposes. Subtitle B—Lighting Energy Efficiency, p. H. R. 6—82, https://www.govinfo.gov/content/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf.

3 EVALUATION DATA

3.1 Source data

DNV used the following three primary data sources in this evaluation:

1. **Billing data.** Dominion Energy provides monthly premise-level billing data for all active residential customers on an annual basis.
2. **Program tracking data.** The program tracking database contains all participant, measure, and program-related information. The tracking data is used for program reporting and to calculate tracked or ex ante savings. Dominion Energy delivers monthly program tracking data from its Business Intelligence (BI) system. The list of all fields contained in the tracking data can be found in Appendix IV. The billing data is merged with the tracking data to establish the participant analysis group.
3. **Weather data.** Each premise in the participant and comparison group is assigned to one of 10 weather stations. The temperature data for each of these stations was obtained from the National Oceanic and Atmospheric Administration (NOAA).[8] The billing analysis used weather data from the NOAA weather station closest to the customer service address. Daily weather data were retained for each of the 10 stations from January 1, 2010, to December 1, 2021. In cases of missing temperature data, DNV filled the gaps using the relationship between the target weather station and the weather station at the Richmond International Airport.

3.1.1 Billing data cleaning and prep

This analysis was conducted using monthly customer billing data. For the participating customers, billing data for each customer was matched with data for that same customer from the tracking database. For the participants, an "installation window" was determined by the minimum and maximum installation dates.[9] Care was taken to include as much of the source billing data as possible. However, certain types of bills were identified as possible anomalies. The following billing data types resulted in data or participants being removed from the analysis set:

- Billing data with zero or negative energy consumption
- Billing data with short or long monthly read cycles (less than 20 days or greater than 40 days)
- Billing data that was obtained by postcard, estimated, rebilled, PC-read, or phoned in
- Participants without at least two months of billing data covering May through October or without two months of billing data covering November through April
- Duplicate records

After accounting for the conditions listed above, a participant (a combination of premise and account number) must have at least 8 months of billing data before and after the installation window to be eligible to be included in the analysis set. As a second related condition, if a customer engages with the program sooner than 8 months after they have moved into the premise or moves out sooner than 8 months after project completion, there is not enough billing data for that site to establish a reliable model of normalized energy consumption (NAC).[10] After all the removals mentioned above, 10,182 participants remained in the analysis set.

[8] NOAA, National Centers for Environmental Information, Climate Data Online, https://www.ncdc.noaa.gov/cdo-web/ (accessed Mar 29, 2023).

[9] A limited number of participants participated more than one time. To avoid the influence of partial participation, this period between the minimum participation date and the maximum participation date was excluded from the analysis. For the participant that only participated once, the min and max participation dates are the same.

[10] See Appendix II for a more detailed description of NAC.

4 METHODOLOGY

4.1 Research design

This impact evaluation used a time-series comparison/cross-sectional research design. This research design estimates the program impacts by examining the changes in a participant's electric usage patterns from before (pre-treatment) and after (post-treatment) the measure installation window.

A representative comparison group is key to determining program-attributable net energy savings. A comparison group is used to account and adjust for exogenous (non-program) factors that may be impacting participant energy usage over a given period. These exogenous factors might include changes in the economy, changes in energy prices, and trends in equipment efficiency. Controlling for these non-program factors allows the analysts to better isolate the program-related savings.

4.2 Analysis

This analysis used all non-participant premises as the comparison group pool. To establish a representative comparison group, we compared non-participants in the pool to program participants based on established criteria. The customers whose criteria best matched the program participants were included in the comparison group. This research design also helps reduce concerns about self-selection bias and free-ridership and improves the evaluation's internal and external validity.[11]

To estimate program energy savings, we applied an augmented comparison approach methodology. This approach compares the participants' post-participation usage with their pre-installation usage, with further adjustments made based on changes in energy consumption over the program period among the comparison group. The analysis had five steps, with each step building on the one before it:

1. Merging the tracking and billing data
2. Creating the comparison group pool
3. Identifying a representative and a matched comparison group using the pre-participation annualized consumption
4. Temperature-normalizing the annual consumption of the participant and comparison group during the pre-participation and post-participation periods using monthly billing data from both groups
5. Estimating the annual and aggregate program-level total energy savings

The following sections provide more details on these analysis steps. A more in-depth description of the methodology and how the comparison group was established is included in Appendix II.

4.2.1 Merging the tracking and billing data

DNV merged the billing data with the tracking data using matching electric account numbers. We then disaggregated the participant data into pre-program and post-program data sets based on their measure installation windows. We only used bills that were within two years of the participation window. To be included in the analysis, a participant also needed to have

[11] Internal validity means the evaluation is conducted in a manner that allows the results to isolate the impact of the activity being studied. When other factors are not recognized, the changes attributed to the program may be the result of other phenomena. For example, if the experiment does not recognize the dynamic nature of a participant's characteristics, their change in usage could be explained by the impact of the implementation of the program or, alternatively, by the change in other participant characteristics. A research design can help achieve external validity by ensuring that the results are representative of a larger population of interest, allowing for the findings to be generalized. For example, for the selected program, the information determined by a sample of participants, and the corresponding comparison group, permits the evaluation to represent the total program impacts.

at least 8 bills in each period, and at least two winter bills (November through April) and two summer bills (May through October).[12] Data from the 13,869 participants who met these requirements was available for analysis.

4.2.2 Temperature normalization

To better isolate and quantify the program's impacts on energy consumption, we had to control for significant non-program influences such as weather. Accordingly, the first step in the analysis was to develop NAC during the pre-installation and the post-installation periods for each of the accounts in the participant group and for each of the account/installation window combinations for the comparison group. The temperature normalization procedure was taken from the U.S. Department of Energy's (DOE) Uniform Methods Project (UMP) and based on the Princeton Scorekeeping Method (PRISM®).[13] The temperature normalization model isolates the relationship between temperature and energy consumption. We developed models to normalize each participant and comparison group pool member's energy consumption values and remove the effects of weather for both the pre-installation and the post-installation periods.

The models estimated the component of each customer's energy usage that was attributable to baseload consumption (e.g., lighting and hot water) and to space conditioning (heating and cooling). The models then isolated the baseload usage from the space conditioning usage and estimated the incremental rate of energy consumption per degree day for space conditioning, and the set point (or outdoor temperature) at which space conditioning occurred. These set points can be influenced by the physical characteristics of the houses and the thermostat behavior of its occupants and are unique to each site. Therefore, heating degree days are not assumed to accumulate at or below 65ºF for every site under this model.

The site-level temperature normalization models recognize that each customer has unique operating characteristics that influence the rate of energy consumption for space conditioning under given temperature conditions. These characteristics include structure type, appliance mix, the types of space conditioning equipment, how this space conditioning equipment is operated, and the demographics of the customer. To capture these unique space conditioning characteristics, the normalization process compares multiple models across a range of heating and cooling references, or set point temperatures, for each customer account. The model we chose to represent a customer's energy use is the best-fit model, e.g., the one that best linearizes the relationship between usage and degree days. For each customer and site, the best-fit model is identified based on their unique temperature reference or set point. A more detailed description of the model and the model results can be found in Appendix II.

4.2.3 Establishing a representative comparison group

We constructed a representative comparison group from the pool of non-participants. We first determined the annualized usage and seasonalized (winter and summer) usage of each member of the comparison group pool for each minimum installation date, within a weather station region. We then calculated the root mean square error (RMSE) between the

[12] The eight total bills and the three seasonal bill requirements were included to assure that the participant had enough degrees of freedom to estimate an adequate weather normalization model.

[13] Agnew, K.; Goldberg, M. (2017). Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol; Fels, Margaret F. 1986. "PRISM: An Introduction," 5-18.

participants and comparison group's pre-installation annualized consumption. For each participant, the five comparison customers with the lowest RMSE were included in the final comparison group.

We checked the comparison group's billing data using the same procedure described above for the participant group. After these edits, the comparison group had 69,345 premises.

The comparison group was chosen *with replacement*. Selecting a sample *with replacement* allows a comparison group customer to have the potential to be designated as a comparison group member for more than one participant. Table 4-1 presents a comparison of the pre-installation NAC for the participants and the comparison groups. This table demonstrates that the comparison group was well-matched to the participants' NAC in the pre-program period. We used the best two comparison group matches for each participant in the analysis.

Table 4-1. Pre-Installation NAC for the participants and the comparison group

	Participant Pre-installation NAC	Comparison Group Pre-Installation NAC	Difference
N	13,869	69,345	
Period			
Annual	15,223	15,223	0.00%
Summer	7859	7859	0.00%
Winter	7373	7374	0.01%

4.3 Program impact analysis

The objectives of the impact analysis of the Home Energy Assessment Program were to:

- Calculate the program impacts and the RR for program years 2020-2021
- Conduct the analysis according to protocols defined in the program EM&V plan[14]

4.3.1 Weighting the sample back to the population

To ensure that the results of the sample were an unbiased estimate of the population, we weighted the results of the analysis using case weights. A case weight is the number of population participants represented by a sample participant. To determine the case weights, we stratified the population into homogeneous groups. For this analysis, we based the stratification groups on program year and a tracked savings category based on the quartiles of the distribution of the total tracking savings of all participants. The strata of tracked savings based on the distribution of the tracked savings for all participants can be found in Appendix II.

4.3.2 Total savings estimates

For the total program savings, we used an augmented comparison approach. In this approach, we defined savings as the difference between the pre-installation and post-installation NACs. We adjusted the pre-installation NAC using the ratio of the post-installation to pre-installation NAC of the comparison group. We then weighted the individual savings estimates using the case weights and summed them up based on variables of interest (e.g., program year) to provide the estimated overall program savings. The basic form of this model is shown in Appendix II.

[14] Appendix E5. Evaluation, Measurement, and Verification Report for Virginia Electric and Power Company (Dominion Energy), 2021.

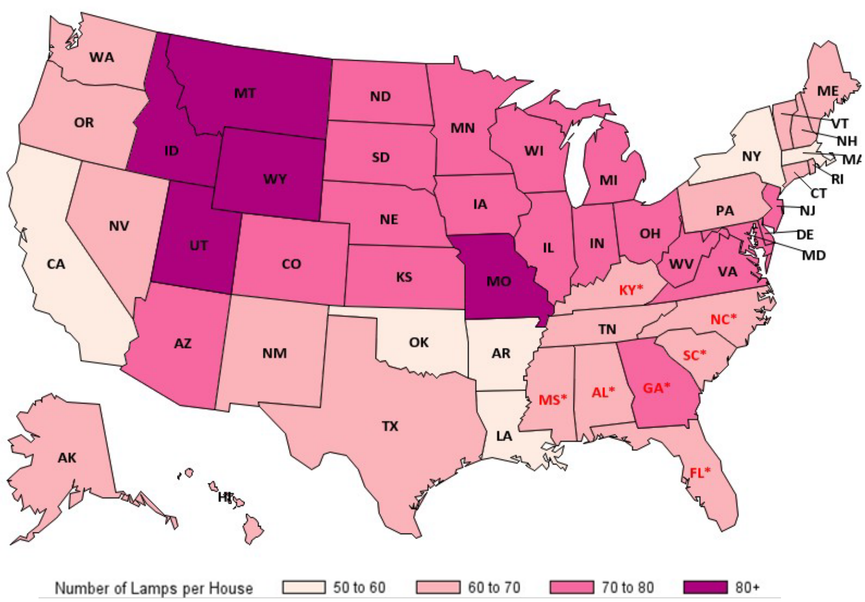
APPENDIX I. ENGINEERING REVIEW OF LIGHTING REALIZATION RATES

Energy savings in the Residential Home Assessment Program are primarily attributed to LED lighting measures. To assess why the realization rate is low, DNV reviewed the lighting savings calculations, input assumptions to the DE TRM, compared Virginia's household lighting characteristics to other jurisdictions, and reviewed the differences between the planned, installed, and DE TRM lighting measure baseline. DNV found the largest potential contributor to the low lighting measure realization rate is the difference between the TRM, planned, and installed lighting baselines. Based on this finding and recent Dominion Energy impact evaluations, there is currently no evidence that the low realization rate seen in the Home Energy Assessment program will carry over to lighting measures in other Dominion Energy DSM programs.[15]

Installed Lamps Per Household

A 2012 DOE Study highlighted the variation in estimated regional lighting usage across the United States. The study reported that Virginia averaged 70–80 installed lamps per household. Comparing the PNNL findings in Figure I-1 to the Home Energy Assessment program's installation rate of 60 lamps per household raises the possibility that in some cases, virtually every lamp in a household was replaced by the program. This may lower the average hours of assumed by most TRMs as the evaluations they reference do not account for such high rates of installation as a result, program conditions may contribute to higher-than-average uncertainty in the hours of use (HOU) in TRM (and DE TRM) assumptions.

Figure I-4-1. Regional variation in average number of lamps per household (PNNL).



* Note: Lighting inventory data for this state or its neighbor was not available.

15 See for example Appendix G to the Evaluation, Measurement, and Verification Report For Virginia Electric and Power Company (Dominion Energy) 2021, Income and Age Qualifying (IAQ) Home Improvement Program Impact Evaluation of Program Years 2015–2020.

Uncertainty in DE TRM Estimates

Table I-2 lists other lighting parameters that introduce variability or uncertainty in all TRM estimates. The only inputs that are not included below are the LED Wattage and waste heat factors. The LED wattage is defined by the equivalent incandescent wattage. There is little variability in the actual LED wattages within the equivalent wattage. Waste heat factors are minor adjustments to account for interactive effects to heating and cooling loads. The baseline wattage may also have a significant influence on the low realization rates and are discussed in more detail below.

Table I-4-2. DE TRM parameters likely to have the highest variability and/or uncertainty

Component	Definition	Type	Value	Sources
Baseline Wattage	Baseline lamp power in Watts	Variable, determined by the lamp category and the incandescent wattage equivalent		Program design assumptions and EISA standards
ISR	In service rate	Fixed, to account for removed lamps	0.965	Maryland/Mid-Atlantic TRM v10, p. 30-32
HOU	Operating HOU, hours per year	Variable, determined by location		DE TRM

Baseline Wattage

The baseline wattages in the DE TRM may be higher than program conditions resulting in overstated deemed savings estimates. This is because installed lamp types include CFLs. The DE TRM does not include CFLs in the baseline wattage assumption. This mismatch in assumptions is because the DE TRM is based on program planning documentation and the EISA compliant baseline in the Mid-Atlantic TRM, neither which include CFLs.

The program planning documentation specified Energy Independence and Security Act of 2007 (EISA) compliant lamps. This is consistent with the TRMs referenced Maryland/Mid-Atlantic. EISA complaint lamps are about equivalent to a halogen lamp in most categories. Halogen lamps are more efficient than a conventional incandescent lamp but less efficient than a CFL. If the program only allowed incandescent and halogen lamps to be replaced with LED lamps, the EISA compliant baseline would be aligned with the installed baseline and evaluated savings would likely be higher, thus increasing the realization rate.

To account for CFLs, a blended baseline would need to be applied in the DE TRM. However, the program does not track the type of replaced lamps so the extent of the impacts to savings is unknown. However, using the Dominion Energy Residential Home Energy Use Survey 2019-2020 results for residential customers in Dominion Energy's service territory, for non-LED lamp types, 63% are incandescent/halogen and 37% are CFLs.[16] This number will be updated in the 2023 Residential Home Energy Use Survey.

Table I-3 provides a summary of the wattages for several lighting measures. It compares what was specified during

[16] Dominion Energy Residential Home Energy Use Survey 2019-2020, DNV. Question 57, average home has 9.6 incandescent or halogen bulbs and 5.6 CFL bulbs. This is 63% incandescent (9.6/15.2 = 63%) and 37% CFL (5.6/15.2 = 37%). The remained are LEDs and linear lamps, which are not included in the Residential Home Energy Assessment Program eligible lamp types.

program planning, the DE TRM value, and the implications of using a blended CFL and halogen baseline compared to using the EISA halogen baseline alone. For the blended values, the percent values are applied from Residential Home Energy Use Survey. Note this table only shows some common example lamp type.

Table I-4-3. A comparison of the example lamp wattages specified during program planning, the DE TRM value, and the implications of using a blended CFL and halogen baseline compared to using the EISA halogen baseline.

Measure	Program Planning Baseline (Watts)	CFL (watts)	Halogen (DE TRM baseline Watts)	CFL/Halogen (Bended, baseline Watts)	Blended savings Percent Reduction
A-line LED 40 W Equivalent	39.5	11	29	22.4	27.6%
A-line LED 60 W Equivalent	43	14	43	32.3	31.4%
A-line LED 75 W Equivalent	53	21.5	53	41.3	28.3%

Table I-4 illustrates that the DE TRM and program planning baseline may have overstated the installed baseline wattage resulting in a 29% overstated savings. It should be noted that the actual blend of technology types replaced by the program may be different.

Table I-4-4. Impacts of different CFL weights in the installed baseline and their impacts to tracked savings estimates.

Percent CFL	Blended W_{base}	Blended Delta Watts	Tracked Savings Reduction relative to 100% Halogen
0%	41.7	33.0	0%
5%	40.4	31.7	4%
10%	39.1	30.4	8%
15%	37.7	29.1	12%
20%	36.4	27.8	16%
25%	35.1	26.5	20%
30%	33.8	25.2	24%
35%	32.5	23.8	28%
37%	**32.0**	**23.4**	**29%**[17]
40%	31.2	22.5	32%
45%	29.9	21.2	36%
50%	28.6	19.9	40%
100%	15.5	6.8	79%

[17] The 37% installed CFL rate was reported as the average installed CFLs rate in Dominion Energy's Residential Home Energy Use Survey Dominion Energy Efficiency. See also the 2021 Dominion Energy Potential Study: 2020 to 2029, Table 5-4. Average Number of Lamps per Home by Type and Usage, Virginia, and North Carolina.

DNV

Hours of Use

Inherent uncertainty in the HOU applied to the tracked or deemed ex ante savings may be another contributing factor to the low realization rate. The DE TRM applies HOU factors based on the installed lamp location.[18]

There are variations in the HOU depending on the source. Most TRMs use a single number for the HOUs for residential lighting measures. In some cases, location-based hours are applied. The Residential Home Assessment Program collects lighting location. Therefore, the DE TRM and tracked savings estimates leverage the location data provided in the program tracking data (Appendix IV). Table I-5 shows interior average household HOU. The DE TRM values are weighted by the quantity of lamps and location.

Table I-4-5. Interior residential lighting average household HOU

Source	HOU per day	HOU per year	Reference
TRM average	2.8	1072	Mid-Atlantic Technical Reference Manual Version 7.0/May 2017
Program Planning	2.5	920	Navigant Consulting. 2017. EmPOWER Residential Lighting Program: 2016 Residential Lighting Inventory and Hours of Use Study, p. 13.
Mid-Atlantic Technical Reference Manual Version 8 and 10	1.9	679	Navigant Consulting. 2017. EmPOWER Residential Lighting Program: 2016 Residential Lighting Inventory and Hours of Use Study, p. 13.
Mid-Atlantic Technical Reference Manual Version 7.0/May 2017	2.5	920	Navigant Consulting. 2017. EmPOWER Residential Lighting Program: 2016 Residential Lighting Inventory and Hours of Use Study, p. 13.
Ameren Missouri, Vol3: Residential Measures 2019 - 2021 Plan	2.7	995	Ameren Missouri Lighting Evaluation PY2018
Illinois Statewide TRM for EE v10	3.0	1089	Illinois Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs
Colorado TRM DSM 2021-2022	2.7	986	Northeast Residential Lighting Hours-of-Use Study, pgs. XVI, 37
Regional Technical Forum Residential Lighting	2.3	840	Hours of Use by lamp type, lumen range, and space type are determined by mapping 2011 RBSA metered HOU (by room type) to the distribution of lamps in room types in the broader 2017 RBSA Lighting audit.
Efficiency Maine Retail/Residential TRM v2022.3	2.1	767	Demand Side Analytics. 2021. Retail and Distributor Lighting Impact Evaluation
Pennsylvania TRM 2021	2.5	913	GDS Associates, Inc, Nexant, Research into Action, Apex Analytics LLC.2014. Commercial & Residential Light Metering Study. Based on data derived from Tables 1-2 and1-3 but exclusive of inefficient lamps
Rhode Island TRM 2022	2.6	965	DNV GL and NMR. 2020. MA19R12-E - Residential Lighting Hours-of-Use Quick Hit Study, Hours Note
Wisconsin TRM 2022	2.3	829	Cadmus. 2016. Focus on Energy Deemed Savings Changes.
Average	**2.5**	**918**	

[18] The program design limits lamp replacements to locations with HOUs equal to or exceeding 2 hours per day.

Table I-6 shows the location specific HOUs applied to the Dominion Energy Home Assessment program compared to other well established TRMs. In general, the DE TRM is within range of the other TRMs except for kitchen HOUs.

Table I-4-6. location specific HOU applied to the Dominion Energy Home Assessment program compared to other well established TRMs.

Source	DE TRM	Pennsylvania TRM 2021	Regional Technical Forum Residential Lighting	Mid-Atlantic Technical Reference Manual, V9 (2019)	Illinois Statewide TRM for EE, v10	Average (excluding DE TRM)
Reference	Navigant. 2013. EM&V Report for the 2012 Energy Efficient Lighting Program, Duke Energy Progress, p. 23. All but exterior lighting.	GDS Associates, Inc, Nexant, Research into Action, Apex Analytics LLC	Ecotope Inc. 2014. Residential Building Stock Assessment: Metering Study. NEEA #E14-283.	Nexus Market Research. 2014. Impact Evaluation of the Mass., RI, and VT 2003 Residential Lighting Programs, Final Report.	Lighting logger study conducted as part of the PY5/6, ComEd Residential Lighting Program evaluation	
Kitchen	8.0	4	3.6			3.8
Living Room	2.5	4	2.8			3.3
Bathroom	2.2	2	1.2			1.8
Bedroom	1.8	2	1.4			1.6
Dining Room	2.1	3	1.9			2.3
Exterior	4.5	4	3.7	4.5	6.8	4.7
Garage	1.1	2	1.1			1.4
Hallway	2.5	2	2.0			1.9

In Service Rate (ISR)

The in-service rate is the percentage of lamps that are provided through the program and are installed. This factor can account for lamps that are not being used or have been removed. For a direct install program with contractors replacing lamps while onsite, this rate should be near 1.0. However, to account for some of the lamps that may have been removed a value of 0.965 is applied. This value is from the Maryland/Mid-Atlantic TRM, v.10, which is based on an evaluation recommendation. With further study this factor could be modified. However, this ISR may be impacted by field conditions.

APPENDIX II. IMPACT ANALYSIS–DETAILED METHODOLOGY

Temperature normalization and Normalized Annual Consumption

This appendix is a continuation of the summary methodology description in Section 4.2.2.

To capture a household's unique space conditioning characteristics, the normalization or billing analysis process compares multiple models across a range of heating and cooling reference temperatures for each customer account. The model chosen to represent a customer's energy use is the one that best linearizes the relationship between usage and degree days, or the best-fit model.[19] For each customer and site, the best-fit model is identified based on their unique temperature reference or set point. Equation 1 shows the temperature normalization model to consider heating and cooling loads.

Equation 1. The temperature normalization heating and cooling model

$$u_i = \beta_0 + \beta_1 * HDD_i(\tau_1) + \beta_2 * CDD_i(\tau_2) + e_i$$

Where:

U_i	=	Average daily usage during cycle i
$HDD_i(\tau_1)$	=	Average daily heating degree days during cycle i based on reference temperature τ_1
$CDD_i(\tau_2)$	=	Average daily cooling degree days during cycle i based on reference temperature τ_2
e_i	=	Error in predicting U_i

The optimal model for each account is determined using the regression models and assessing the model fit across a range of reference or set point values (τ_1 and τ_2). For this analysis, the heating degree set points considered ranged from 54ºF to 70ºF and the cooling degree set points considered ranged from 64ºF to 75ºF. Recognizing that homes may not have electric space heating or cooling loads, "heating and cooling," "heating only," "cooling only," and "base load only" models were considered. Accordingly, to identify the best-fit model, each customer had 204 models estimated for each period (pre- and post-installation.)

After the initial model estimates were established, the results were examined. Poorly modeled sites (e.g., negative heating or cooling coefficients) were eliminated from consideration. From the remaining models, the model that minimized the root mean squared error (RMSE) for each account for each period was identified as the initial model and reviewed. Poorly performing models (e.g., models with an R^2 less than .80) were identified, examined for anomalous data, and if found, re-estimated. The re-estimated models were compared to the initial models. The model with the lowest RMSE is considered the optimal, or final, model.

Once the optimal models were determined, normalized annual degree days are applied to the optimal model to calculate NAC and then the expected daily degree days are applied to the optimal model to calculate the normalized daily consumptions (NDC).

From Equation 1, the results of the model can be interpreted as:

- β_o is an estimate of the average base load per day for a cycle
- β_1 represents the heating slope, or the increase in electric usage for each incremental increase in heating degree days
- β_2 represents the cooling slope, or the increase in electric usage for each incremental increase in cooling degree days

[19] The reference temperature is the outdoor temperature at which heating, or cooling is called by the HVAC equipment. It is derived from the best-fit model and varies a few degrees from 65F° depending on indoor conditions and customer behavior (set point values).

The NACs were examined to identify anomalies. Participants or comparison group members were eliminated from the analysis under the following model conditions:

- Net metered customers
- The variables included in the pre- and post-model were not consistent, with group, and for the matched comparison group member
- A large change in NAC from the pre- to the post-installation period (±7000 kWh/year)
- A large relative change in NAC from the pre- to the post-installation period (<-67 or >46% for participants and <-78 or >45% for the comparison group)
- Tracked savings were equal to 0 or greater than 63% of the pre-NAC

Table II-7 summarizes the final billing analysis models for the participants and comparison group. The three model types are heating and cooling (electric heating and cooling), heating only (electric heating, no cooling), or cooling only (no electric heating). Table II-8 shows the annual consumption for the participants and comparison group by season and year and Table II-9 shows the distribution of model R2 for the same group.

Table II-4-7. Model summary for the participants and the comparison group by program period

Distribution of models		
Type	**Participants**	**Comparison**
Heating and Cooling	91%	91%
Heating Only	0%	0
Cooling Only	9%	8%

Table II-4-8. Final annual consumption (kWh) for the participants and comparison group by season and year

	Participant (kWh)	Comparison Group (kWh)	Difference
N	13,869	69,345	
Period			
Annual	15,223	15,223	0.00%
Summer	7859	7859	0.00%
Winter	7373	7374	0.01%

Table II-4-9. Distribution of model R2 for the participants and the comparison group

Distribution of Model R2				
	Participant		Comparison Group	
	Pre	**Post**	**Pre**	**Post**
Median	0.84	0.93	0.84	0.92
10th	0.56	0.73	0.53	0.98
90th	0.95	0.98	0.95	0.66

Total savings estimates

The section provides a more detailed description of the basic form of the augmented comparison approach methodology summarized in Section 4.2.3

For each participant, savings were estimated by the net change in NAC from the pre-period to the post period. After the normalization of the participant and comparison group pre and post installation consumption, the difference between the pre-program and post-program NACs can be used to determine the gross energy savings that can be attributed to the program. The determination of energy savings is calculated using Equation II-1.

$$GS(p) = NAC_{pre}(p) - NAC_{post}(p)$$

Where:

GS(p)=Gross savings for participant p
$NAC_{period}(t)$=Normalized annual consumption during period, for customer type t

Equation II-1 The augmented comparison approach determination of gross savings

To account for exogenous influences, the raw savings expressed in Equation II-2 is adjusted by a representative comparison group. If it is assumed that the same outside influences are affecting both the comparison and participant groups, then the adjustment will yield an estimate of energy savings that are isolated from all other influences and can be attributed to the program.

$$NS(p) = NAC_{Pre}(p) * \frac{NAC_{Post}(c)}{NAC_{Pre}(c)} - NAC_{Pre}(p)$$

Where:

NS(p)=Net savings for participant p

Equation II-2 The Augmented Comparison Approach, Determination of Net Savings

The adjustment is made by determining the pre- and post-program NAC's for both the participant and comparison Groups. The adjusted savings are calculated by ratio adjusting the participant results by the comparison Group results. This adjustment is shown in Equation II-2.

APPENDIX III. THE RELATIONSHIP OF INSTALLED LAMP QUANTITIES TO REALIZATION RATE (2020–2022)

Table III-10 shows the number of participants, the percent total participants by measure group, and the RR by measure group. This table shows that over 92% of installed measures fell into the lighting measure groups. Because lighting accounted for such a large share of the program's installed measures and expected energy savings, the non-lighting measure groups (e.g., space conditioning and water heating) could not be reliably modeled.

However, the distribution in Table III-10 offers insights into the RR for the lighting measure groups, which are based on the installed number of lamps per household. In late 2021, Dominion Energy reset the allowable number of installed lamps per household. For the customers that did receive lighting measures, the more lighting installed (and the more tracking savings claimed), the lower the RR (a 36% RR for participants with less than 29 lighting measures to 14% for participants with over 100 lighting measures) suggesting diminishing returns with each increase in the number of installed lamps per household. The new limits in the installed number of lamps per household may be a contributing factor to the increase in the program RR over time. The effect of the cap in the number of installed lamps can be seen in Figure III-2 and Figure III-3.

As seen in Table III-10, about 8% of the participants received space conditioning and water heating measures. For these non-lighting measure participants, the RR was 109%. For lighting, the RR decreases as the number of installed lamp per households increases. This can be seen on the evaluation results as the overall program RR increases to 40% in the third year as the influence of the 70 lamp/household cap begins to take effect.

Table III-4-10. Tracked Savings: Measures and Energy, by Year

Measure Group	Number of Participants	% Total Participants by Measure Group	Realization Rate (%)
HVAC and water measures	1400	8%	109%
0–29 Lamps	2715	16%	36%
30–49 Lamps	4185	24%	34%
50–99 Lamps	7230	42%	27%
≥ 100 Lamps	1650	10%	14%
Total	17,180	100%	27%

Figure III-4-2. Lamp quantities distributed across program households expressed as a percent of households

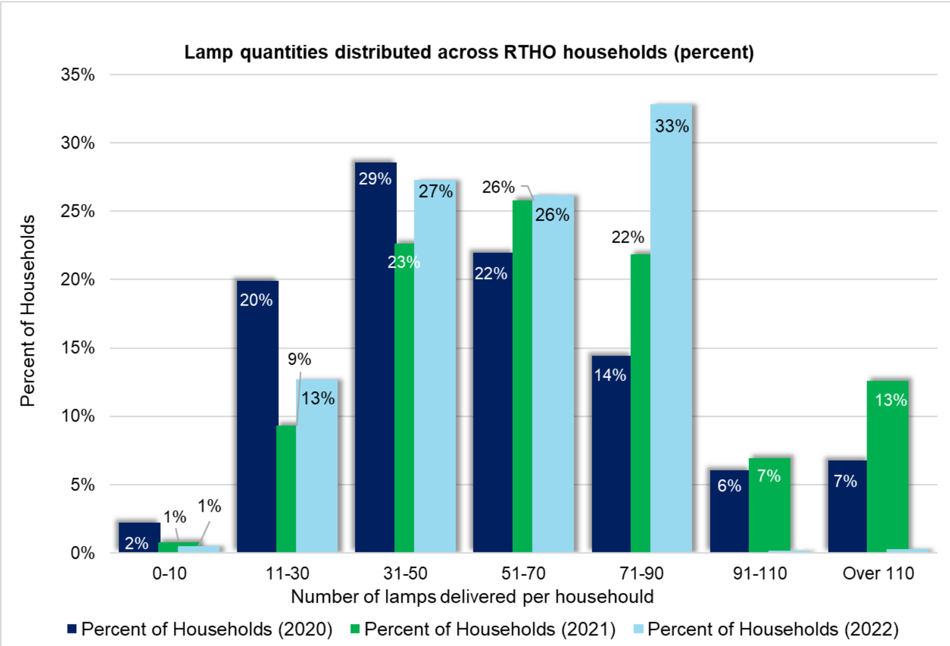
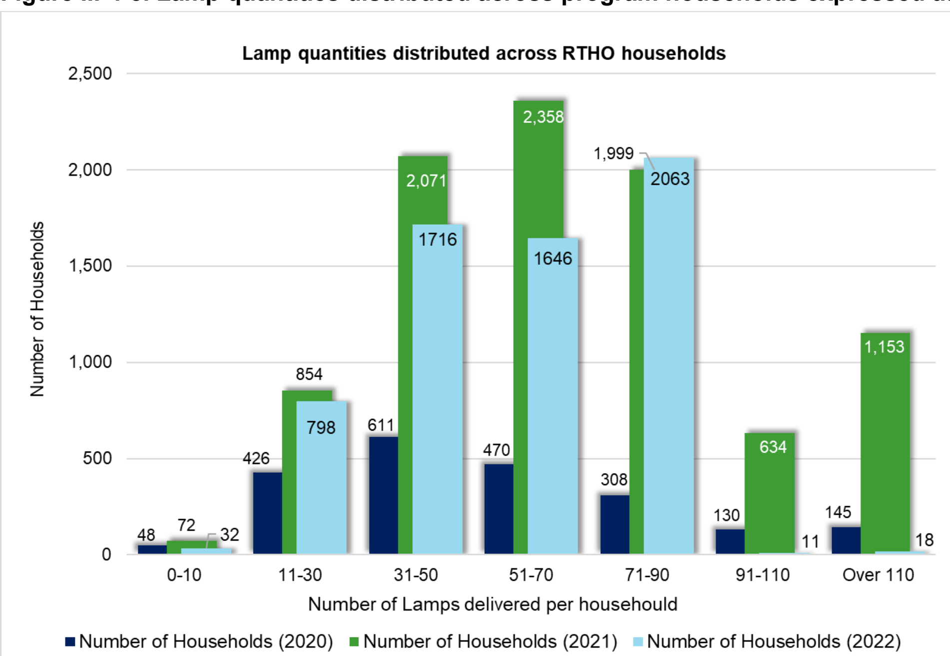


Figure III-4-3. Lamp quantities distributed across program households expressed as number of households



APPENDIX IV. RESIDENTIAL HOME ENERGY ASSESSMENT TRACKING DATA ELEMENTS

The tracking data reports all participant, measure, and program related information. It is generated by Dominion Energy's Business Intelligence system and delivered to DNV monthly. Table IV-11 includes:

- Participant data such as contact information, building type and condition, end use information, and utility identifiers such as rate class
- Program data such as participation dates, vendor information, and pre-existing conditions
- Measure-level data such as measure type, quantity, and installation date

Table IV-4-11. Residential Home Energy Assessment program tracking data

Field	Description
ACTIVITY_DATE	Date record was last updated
EXTRACTION_DATE	Date record was extracted
RECORD_ID	Internal record key for BI data mart
ELECTRIC_ACCOUNT_ID	Account Number
ELECTRIC_PREMISE_ID	Premise Number
CUSTOMER_NAME	Customer Name - Dominion Energy
ADDRESS_1	Service Address
ADDRESS_2	
CITY	Service City
STATE	Service State
ZIP	Service Zip
MAILING_ADDRESS_1	Mailing address
MAILING_ADDRESS_2	
MAILING_CITY	
MAILING_STATE	
MAILING_ZIP	
CUSTOMER_RATE	Primary rate code
APP_CONTACT_PERSON	Contact name on application
APP_EMAIL_ADDRESS	Customer email address
APP_TELEPHONE_NO	Applicant primary telephone number
APP_VENDOR_NAME	Name of contractor that performed work
APP_VENDOR_ADDRESS1	Address of contractor (concatenated)
APP_VENDOR_ADDRESS2	Address of contractor
APP_VENDOR_CITY	
APP_VENDOR_STATE	
APP_VENDOR_ZIP_CODE	
APP_VENDOR_CONTACT_PERSON	Contact at contractor Company
APP_VENDOR_EMAIL	Contractor email address

Field	Description
APP_VENDOR_TELEPHONE	Contractor telephone number
OWNERSHIP_STATUS	Lease or Own
APPROVAL_YN	Was work authorized to be done?
AUDIT_DATE	Date audit was completed
DSM_PROGRAM_ID	Program ID
WORK_ORDER_ID	Work order id assigned to rebate upon creation.
CUSTOMER_DWELLING_TYPE	
NO_OF_HOME_OCCUPANTS	
APPROXIMATE_HOME_SIZE	
APPROXIMATE_HOME_AGE	
APPROXIMATE_ATTIC_SIZE	Sq ft
EXISTING_ATTIC_INSULATION_TYPE	
EXISTING_ATTIC_INSULATION_QTY	In inches
EXISTING_ATTIC_INSULATION_RVAL	Existing insulation R value
ATTIC_INSULATION_TYPE	Type installed
INSTALLED_INSULATION_QUANTITY	In inches
PIPE_DIAMETER	In inches
PIPE_INSULATION_LENGTH	In inches
EXISTING_BULB_TYPE	
WATER_HEATER_TYPE	Type of water heater
WATER_HEATING_FUEL	
MEASURE_NAME	
REASON_CODE	Reason why measure wasn’t installed
REASON	Reason for replacement
COOLING_SYSTEM_TYPE	
HEATING_SYSTEM_TYPE	
HOW_HEAR	How did you hear about this program?
MARKETING_CODES	
SPACE_HEATING_FUEL	
BUDGET_RESOURCE	Provided for accounting purposes
INSTALLD_ATTIC_INSULATION_RVAL	Installed insulation R value

APPENDIX V. EM&V WORKPLAN

Program Years 2020-2021

Residential Home Energy Assessment Program
Impact Evaluation Work Plan

Dominion Energy

Introduction

This is the work plan for conducting an impact evaluation of the Residential Home Energy Assessment Program (RHEA) RHEA administered by the Virginia Electric and Power Company (Dominion Energy).

The evaluation will cover the program years 2020 and 2021 and will be conducted according to the RHEA EM&V Plan. The goal of the evaluation is to quantify the program impacts by year. The impact evaluation will provide estimates of ex post gross energy savings for participants and a comparison group that will inform future program design and implementation.[2]

Program background

The Phase VII Residential Home Energy Assessment Program (RHEA) provides residential customers with an incentive to install a variety of energy-saving measures after a walk-through home energy assessment. Each RHEA participant must be a Dominion Energy residential customer living in a single-family detached residence or a single-family attached residence such as a townhouse.

Overview of implemented measures

Customers are eligible for one rebate application per location for hot water appliances, lighting, efficient faucets, and aerators. Customer may be eligible for more than one rebate application per location for a heat pump tune-up, heat pump upgrade, duct sealing, duct insulation, heat pump water heater, ECM fan motors, and cool roof. Table V-1 lists all the energy-efficient measures implemented under this program.

Table V-12. Program energy- efficient measures

End Use	Measure
Lighting	• Direct Install Lighting
Domestic Hot Water	• Hot Water Appliances • Efficient Faucets and Aerators
HVAC	• Heat Pump Tune-Up and Upgrade • Duct Sealing and Duct Insulation
Whole House	• Cool Roof

[1] Appendix E., Evaluation, Measurement, And Verification (EM&V) Plans, Case No. PUR-2020-00274 (Virginia), Docket No. E-22 Sub 604 (North Carolina), VOLUME 2 OF 5, June 15, 2022, Prepared by DNV Energy Insights USA Inc. (DNV),

2 Violette, Daniel M.; Rathbun, Pamela. (2017). Chapter 21: Estimating Net Savings – Common Practices: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68578, 45.; Synapse Energy Economics, Erin Malone, Wendy Ong, Max Chang. State Net-to-Gross Ratios, Research Results and Analysis for Average State Net-to-Gross Ratios Used in Energy Efficiency Savings Estimates. Prepared for the United States Environmental Protection Agency, January 23, 2015, 2.

Evaluation plan

This section details the RHEA EM&V approach. The evaluation approach will be a statistically-adjusted engineering (SAE) billing analysis, with a well-matched representative comparison group. While DNV will endeavor to quantify measure-level impacts, there is a risk that individual impact estimates of small measures will be statistically insignificant.

Table V-2 summarizes the program participation and gross annualized energy savings by year. Measure installation by year is shown in Table V-3 .

Table V-2. Program system-wide participation and gross annualized energy savings by year

Year	Total participants (N)	Gross annualized energy savings (kWh/year)
2020	2,755	4,980,079
2021	9,949	22,671,902
Total	**12,704**	**27,651,981**

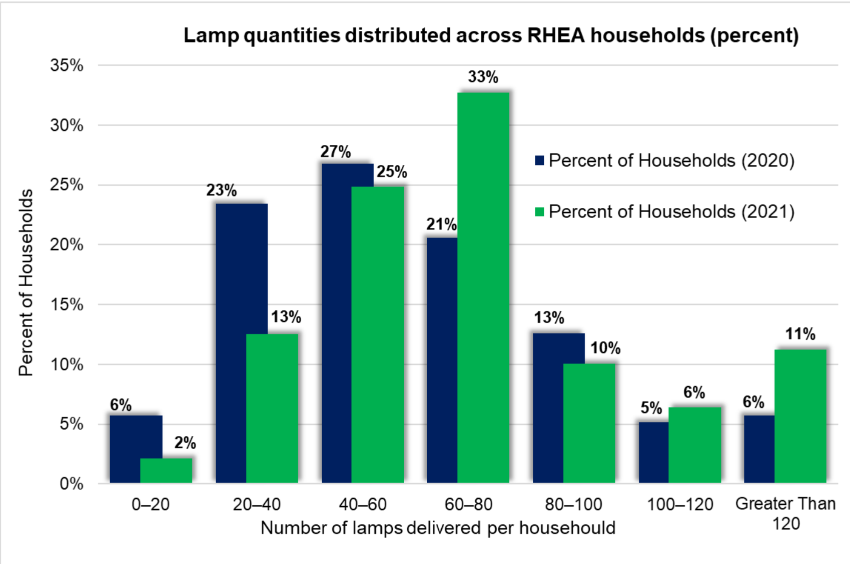
Table V-3. Measure installation system-wide by year

Year	Total Measures (N)	Bathroom Aerator (N)	Duct Insulation (N)	Duct Sealing (N)	ECM Fan Motor (N)	Heat Pump Tune-Up (N)	Heat Pump Upgrade (N)	Hot Water Pipe Insulation (N)	Hot Water Turndown 10º (N)	Kitchen Aerator (N)	LED Lamps (N)	Low-flow Showerhead (N)	Water Heater Replacement (N)
2020	118,757	159	11	62	2	628	21	611	5	66	116,903	289	0
2021	604,763	367	0	95	0	913	21	1164	18	124	601,230	828	3
Total	**723,520**	**526**	**11**	**157**	**2**	**1541**	**42**	**1775**	**23**	**190**	**718,133**	**1117**	**3**

Lighting

The RHEA program is dominated by lighting measures. The impact analysis will attempt to identify statistically significant savings characterized by lamp type, home size, location of installation, or number of lamps installed per household. As an example of characterization, Figure V-1 shows the distribution of lamp quantities across participant households.

Figure V-1. Lamp quantities distributed across households (percent)



Experimental design

The RHEA analysis measures the participant group against a comparison group using a “time-series comparison/cross sectional experimental design.” This design helps the evaluation achieve internal and external validity and reduces concerns about self-selection bias and free-ridership.

An evaluation has internal validity when its design allows the results to isolate the impact of the DSM activity being studied. When other factors are not recognized, changes attributed to the program may be the result of other phenomena. For example, if the research design does not recognize the dynamic nature of a participant’s operational or end-use characteristics, their change in usage could be explained by changes in other participant characteristics.

An evaluation has external validity when its design ensures that the results The RHEA analysis measures the participant group against a comparison group using a “time-series comparison/cross sectional experimental design.” This design helps the evaluation achieve internal and external validity and reduces concerns about self-selection bias and free-ridership.

An evaluation has internal validity when its design allows the results to isolate the impact of the DSM activity being studied. When other factors are not recognized, changes attributed to the program may be the result of other phenomena. For example, if the research design does not recognize the dynamic nature of a participant’s operational or end-use characteristics, their change in usage could be explained by changes in other participant characteristics.

Data requirements

The billing analysis uses program tracking data (BI data), weather data, and monthly usage (billing) data as shown in Table V-4. The RHEA monthly usage data will cover the period from 2019 (pre-installation for earliest program participants) through 2022 (post-installation of the program year 2021 participants). The residential billing data for 2021 through 2ND quarter of 2022 that was recently delivered by the Demand-side Planning (DSP) to DNV will be sufficient to complete the analysis and no additional consumption data is needed at this time.

Table V-4. Billing data requirements for RHEA impact evaluation

Billing data
Electric account number
Electric premise number
Meter read date
Days in the billing cycle
Billing code (i.e., estimated, or actual)
Consumption in kWh
Zip code
Office ID
Rate code
Net metering flag

Impact evaluation approach

This impact evaluation approach will be an SAE model, which incorporates engineering estimates of savings into the analysis.

Research design

The evaluation will use a two-stage billing analysis approach. This approach determines the program impacts by examining the change in participant's usage and demand patterns over time. The impact estimate is further refined by measuring a representative comparison group's change in usage over a similar time frame. This allows DNV to determine how energy usage would have changed among program participants had the program not been offered. Measure level savings will be reported to the extent they are statistically significant. See Appendix A for a detailed description of the research design and methodology.

Communication and reporting

Project schedule

Table V-V shows the evaluation schedule. Dates for each deliverable are listed in bold with 2 weeks for Dominion Energy to review and provide comments.

Table V-13 Schedule

Tasks / Milestones	2022		2023	
	Nov	Dec	Jan	Feb
Planning				
Data Management				
Analysis				
Presentation to DE				
Impact Report Draft				
Impact Report Final				

APPENDIX A. METHODOLOGY

Research design

The evaluation will use a two-stage billing analysis approach. This approach determines the program impacts by examining the change in participant's usage and demand patterns over time. The impact estimate is further refined by measuring a representative comparison group's change in usage over a similar time frame. This allows us to determine how energy usage would have changed among program participants had the program not been offered. Measure level savings will be reported to the extent they are statistically significant.

Develop a Representative Comparison Group

DNV will develop a comparison group for the analysis through the following steps:

Step 1: Establish a comparison group pool

The comparison pool will consist of the residential customers that are not participants in the RHEA program.

Step 2: Eliminate known participation periods or participants

After the initial data cleaning, any known participants will be eliminated from the comparison group pool. This will be done by matching the comparison pool customers against the available RHEA program participant BI tracking data to identify and eliminate program participants.

Step 3: Establish the comparison group

During this step, each comparison pool customer within a characteristic stratum will be compared to each participant in that stratum.

DNV will then calculate the weighted mean square error (MSE) between the annualized usage and seasonalized usage of the participants and the comparison pool members. The two comparison pool customers with the lowest MSE will be designated “the matched comparison group member for that specific participant.” Other characteristics for matching will be geographics, presence of AMI, and net metering.

The comparison group will be chosen with replacement. Selecting a sample with replacement allows a customer to have the potential of being designated a comparison group member for more than one participant. This redundancy is addressed in the second stage regression with weighting to mitigate standard error estimates.

Temperature normalization

One of the most important steps in assessing the program impacts is the pre-installation to post-installation comparison of energy usage. By controlling for other non-program influences, such as weather, the programs’ effects can be isolated and quantified. The process of controlling for weather is called “temperature normalization.”

DNV uses a temperature normalization procedure derived from the Princeton Scorekeeping Method (PRISM®). PRISM develops a mathematical model that represents the relationship between temperature and energy consumption.[3] This model represents a customer's energy usage as some base level βo, and a linear function between a reference temperature τ , and the outside temperature. The constant proportionality, β, represents a customer’s effective heat-loss or heat-gain rate.

PRISM recognizes that each customer has unique space conditioning operating characteristics. To capture these unique characteristics, PRISM examines a range of heating and cooling reference temperatures. The model chosen to represent a customer's energy use is the model that best linearizes the relationship between usage and degree days (HDD or CDD). For each customer, an optimal model based on a unique reference temperature (τ1 and τ2) are identified by the minimum mean squared error (MSE) of the regression. The PRISM approach to consider heating and cooling loads uses Equation 4-1.

Equation 4-1. The PRISM heating and cooling model

$$U_i = \beta_0 + \beta_1 * HDD_i(\tau_1) + \beta_2 * CDD_i(\tau_2) + e_i$$

Where:

U_i	=	The electric usage during cycle i.
$HDD_i(\tau_1)$	=	The heating degree days based on reference temperature τ_1, during cycle i.
$CDD_i(\tau_2)$	=	The cooling degree days based on reference temperature τ_2, during cycle i.
β_i	=	The coefficients to be estimated to minimize the error term.
e_i	=	The error in predicting U.

The optimal heating and cooling model is determined by calculating the regression models assuming various reference temperature values (τ1 1 and τ2). Expected annual degree days are applied to the optimal model to calculate a normalized annual consumption (NAC). The results of the model can be interpreted as:

- β_o is an estimate of the average base load for a cycle
- β_1 represents the heating slope, or the increase in electric usage for each incremental increase in heating degree days
- β_2 represents the cooling slope, or the increase in electric usage for each incremental increase in cooling degree days

Models are developed to allow for the temperature normalization of each individual participant and comparison group member for both the pre-installation and the post-installation periods.

Once the optimal parameters have been established, NAC is estimated applying normal or historical degree-days to each model.

[3] Fels, Margaret F. 1986. "PRISM: An introduction". *Energy & Buildings*. 9 (1): 5-18; Agnew, K.; Goldberg, M. 2017. Chapter 8: Whole- Building Retrofit with Consumption Data Analysis Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68564.

Regression analysis approach

DNV will develop an initial regression model using ordinary least squares (OLS). This simple model determines the effect of one important change variable (i.e., participants engineering estimate of savings) on energy while controlling for all other changes. The basic form of this model is shown in Equation 4-2. Comparison group customers chosen multiple times in the matching process only enter the model once but with a weight associated with the number of times they were chosen. This addresses the potential for downwardly biasing the parameter standard errors.

Equation 4-2. The Statistically Adjusted Engineering regression model

$$NAC_{post,i} = \beta_0 + \beta_1 * NAC_{pre,i} + \beta_2 * P_i + \beta_3 * TS_i + \varepsilon_i$$

Where:

$NAC_{post,i}$	=	Post installation NAC for customer i
$NAC_{pre,i}$	=	Pre-Installation NAC for customer i
P_i	=	Dummy variable for participation
$TS_{,i}$	=	Tracking estimate of total savings for customer i
$\beta_0, \beta_1, \beta_2, \beta_3$	=	Coefficients to be estimated to minimize the prediction error
B_2	=	Realization rate of tracking estimate savings
ε_i	=	Prediction error

The residual standard deviation is related to the size of the customer's electric usage or demand. As a result, the regression assumption most often violated is that the standard deviation of the error terms (or "residuals") has a constant variance across the range of predicted values. When the standard deviation residuals are related to the predicted values, the model is said to be "heteroscedastic." Heteroscedasticity can often be detected in cross-sectional models used to analyze program impacts. During this step, a verification is performed to check that the regression assumptions are valid. If the initial regression model is found to be "heteroscedastic," it could result in the misspecification of mathematical relationships. If this occurs, further multivariate regression analysis will be performed under a weighted least squares ("WLS") approach.

Estimate of total savings

The final step in the analysis is to estimate the energy savings by using the resultant models. Since there are only two implementation years, the evaluation will report an overall savings estimate rather than savings by program year.

Estimate of measure savings

Due to the natural variation of residential consumption, it is difficult to obtain statistically significant estimates associated with small (less than 5%) influences. Accordingly, Equation 4-2 uses the total tracking savings as an independent variable. While adding additional variables to define individual measures should provide the same estimate of total savings, the individual estimates of small measures could be statistically insignificant. Accordingly, the estimate of individual measures would need to be ex-post. The analysis will attempt to disaggregate the savings using a number of techniques, including ratio allocation of savings and prediction models featuring the total estimate of savings for a site as the dependent variable and the individual tracking estimates of savings as independent variables.

About DNV

DNV is a global quality assurance and risk management company. Driven by our purpose of safeguarding life, property and the environment, we enable our customers to advance the safety and sustainability of their business. We provide classification, technical assurance, software and independent expert advisory services to the maritime, oil & gas, power and renewables industries. We also provide certification, supply chain and data management services to customers across a wide range of industries. Operating in more than 100 countries, our experts are dedicated to helping customers make the world safer, smarter and greener.

Appendix I
Residential Customer Engagement Program Impact Evaluation (2021-2022)

Dominion Energy

Date: June 5, 2023

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DNV

EXECUTIVE SUMMARY

The Residential Customer Engagement Program aims to motivate no- and low-cost energy conservation actions, participation in other Dominion Energy (DE) demand side management programs, or increased installation rates of energy efficiency measures by providing customers educational insights into their energy consumption through monthly digital or paper home energy reports (HERs). The five-year Residential Customer Engagement Program officially launched on January 1, 2021.

The Program employs a randomized control trial (RCT) experimental design. In designing and implementing this Program, the implementer selects the population of program-eligible customers that DNV randomly assigned into either a treatment or control group. The objectives of the evaluation are to:

- Measure the reduction in electric consumption for the Customer Engagement recipient group using historical energy consumption data.
- Quantify joint savings from HER-related increased uptake of other Dominion Energy DSM programs.
- Provide an estimate of 2021 and 2022 HER credited savings for adjusted joint savings resulting from participation in Dominion Energy's DSM programs.

The evaluation employed three types of analyses: an energy savings impact analysis using consumption data, a joint savings impact analysis that used program tracking and load shape data, and a customer survey that informed the joint savings analysis and provides a descriptive analysis of customer behaviors, attitudes, and satisfaction.

Key findings

- Total Dominion Energy Customer Engagement 2021 and 2022 electric savings are 4.6 million kWh and 9.4 million kWh, respectively.
- The survey included a set of questions for the recipient group about their experience with the reports, including measuring awareness of the report, the depth of their review, and the report's usefulness. The results show that most HER report recipients recalled the reports, read some or all of the reports, and liked features of the reports.
- Email report recipients showed lower savings compared to paper report recipients. While email recipient savings are not statistically significant in either year, paper recipient savings increased by 160% in 2022 compared to 2021 and were statistically significant in both years.
- The customer engagement program performance was negatively impacted due to (1) a pause in the program, (2) digital report distribution interruption, and (3) several other unrelated IT issues. These issues have since been resolved or are near resolution.
- In general, behavior programs ramp up over the first three years of a program. Multiple factors could combine to explain lower than typical first- and second-year behavioral program savings. They include: the periods of enforced inactivity early in the implementation period, decreasing novelty of HER type programs, and ongoing effects of covid or other changes in customer response to conservation messaging. There has always been variation across programs based on consumption levels, region, fuel type, etc. Recently, it has appeared that variation in timing may also be a factor with older programs (ten years or more) starting to see diminishing savings as well as more recent starts during and after Covid performing less well.
- Both email and paper report recipients saved more in the second year of the program suggesting the program will generate increased savings year over year.

- This impact evaluation included a customer survey. Of the representative group of report recipients, 81% read the reports, 67% liked the reports, 55% said it helped them make better decisions to use and save energy, and 67% said the energy usage graph over the past 12 months is helpful.
- The response rates (and subsequent attitudes about energy efficiency) of recipients and non-recipients were similar. The willingness of non-recipients to complete the survey at the same rate as recipients is a positive indication of Dominion Energy's overall level of customer engagement.

1 INTRODUCTION

1.1 Background

The Residential Customer Engagement Program (Customer Engagement program or the Program) aims to motivate no- and low-cost energy conservation actions, participation in other Dominion Energy demand side management (DSM) programs, or increased installation rates of energy efficiency measures by providing customers educational insights into their energy consumption through monthly digital or paper home energy reports (HERs). APPENDIX A contains an example of an HER report.

The Program employs a randomized control trial (RCT) experimental design.[1] In designing and implementing this Program, the implementers select the population of Dominion Energy (DE) program eligible customers that DNV randomly assigns into either a treatment group that receives the reports (recipients) or a control group that does not receive the reports (non-recipients), such that the customers are alike in all important ways except whether they receive the reports. The reports sent to customers in the recipient group equip them with information about their household's energy use including a comparison of similar neighbors' energy use and the Program's customized tips for saving energy.

The five-year Residential Customer Engagement Program officially launched on January 1, 2021.[2] Following testing in January 2021, the implementer began sending email reports in February, and paper reports in April. The customer engagement program performance was negatively impacted due to (1) a pause in the program, (2) digital report distribution interruption, and (3) several other unrelated IT issues. These issues have since been resolved or are near resolution.

At launch, the Program had 207,379 customers in the treatment group who received HERs via email and a corresponding 51,896 in the control group.[3] A parallel wave included 120,521 customers in the treatment group that received paper HERs and a corresponding 30,190 customers in the control group.

1.2 Report structure

This report provides a brief discussion of the methodology and the results of the evaluation. A sample, report, the survey, survey results, and a more in-depth discussion of methods are provided as appendices.

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[1] The EM&V Plan is included as Appendix E-12 to the Residential Customer Engagement Program EM&V Plan. Evaluation, Measurement, and Verification Report for Virginia Electric and Power Company (Dominion Energy), Case No. PUR-2020-00274 (Virginia), Docket No. E-22 Sub 604 (North Carolina), Volume 1 of 4, June 15, 2022, Prepared by DNV Energy Insights USA Inc. (DNV). The evaluation workplan is included in Appendix IV of this report.

[2] The SCC approved this program as part of the DSM Phase VII programs on May 2, 2019 (Case No. PUR-2018-00168). Following additional review, the program was refiled in Virginia at the end of 2019 and re-approved on July 30, 2020, as part of the DSM Phase VIII programs (Case No.PUR-2019-00201). As a result, the planned implementation schedule was delayed a year.

[3] Bidgely Dominion Program Design. 2020. Digital & Paper Home Energy Report,

1.3 Research objectives

The main goal of the impact evaluation is to estimate net energy savings for the HER recipient (treatment group) and non-recipient (control group) for the program years 2021 and 2022. DNV's evaluation used monthly household energy billing data to calculate the reduction in energy consumption of the recipient group relative to the non-recipient group. Consumption reduction is the full measure of savings caused by receipt of HERs and is referred to here as measured savings. We used a pooled fixed-effects model to estimate savings. Specifically, the objectives are to:

1. Measure the reduction in electric consumption for the Program recipient group using historical energy consumption data.
2. Quantify joint savings from HER-related increased uptake of other Dominion DSM programs, which may be present in the measured consumption reduction, including an increase in the number of participants and/or extent of participation in rebate programs due to HER. Lighting savings were based on a survey that asked Dominion Energy customers in both the recipient and non-recipient groups about their lighting purchase history, while all other types of savings were based on the recipient and non-recipient tracking data from 2021 and 2022.
3. Provide an estimate of 2021 and 2022 HER credited savings for adjusted joint savings resulting from participation in Dominion Energy's DSM programs.

2 METHODOLOGY

The evaluation employed three types of analyses: an energy savings impact analysis using consumption data, a joint savings impact analysis that used program tracking and load shape data, and a customer survey which informed the joint savings analysis and provides a descriptive analysis of customer behaviors, attitudes, and satisfaction.

2.1 Impact analysis

The fixed-effects methodology is a flexible way to characterize the effect of the HER on household consumption while controlling for household and time-specific characteristics. This approach results in more precise estimates while allowing us to estimate savings from partial-year participants.

The fixed-effects methodology estimates program savings by comparing the consumption of the recipient and non-recipient groups before and after program implementation. The change that occurs in the recipient group is adjusted to reflect any change that occurred in the non-recipient group to isolate changes attributable to the program. A more detailed description of the fixed-effects model is attached as APPENDIX D.

2.2 Joint program savings analysis

The Customer Engagement Program has a secondary objective of promoting other Dominion Energy DSM programs. If the Customer Engagement Program is successful in achieving this objective, the measured consumption reduction will include the savings from any increased uptake of these other DSM programs. We refer to this as joint program savings since credit for these savings is shared by both the Customer Engagement program and other Dominion Energy rebate programs. Joint savings can occur when Customer Engagement recipients:

- Install rebated program measures in greater numbers
- Install rebated program measures generating greater savings
- Install any rebated program measures earlier than non-recipient households, regardless of the level of savings

Since the rebate programs claim the savings, we deduct joint savings from the Customer Engagement measured savings to avoid double counting. The measured savings with joint savings removed are referred to as “credited savings” in this report. The following two sections go into further detail about how DNV calculated the downstream rebate and upstream lighting joint savings. Information about the installation or planned installations of energy efficiency measures for both recipients and non-recipients is reported in the customer survey described in Section 3.4, but the descriptive survey results about energy conserving behaviors, other than upstream lighting purchases, are not used in the impact analysis.

2.2.1 Downstream rebate analysis

DNV used Dominion Energy’s tracking and end-use load shape data to quantify energy savings for Customer Engagement participants through Dominion Energy rebate programs. HERs generate a flow of savings throughout a program year that increases or decreases as the consumption of the recipient group changes compared to the non-recipient group. By contrast, rebate savings are generally reported on an annual basis and do not account for when measures were installed, how long they last, or when the year savings accrue from such measures. To account for rebate program savings in a way that is consistent with the measured Customer Engagement program savings, we considered

- When savings started (installation dates for downstream, rebate year for upstream)
- When during the year savings occurred (load shape of yearly savings)
- How long the savings will last (persistence of savings or measure life)

Savings for all measures start on the day of installation (or rebate date) and are projected forward from that day based on daily load shapes and measure life. At present, the measure lives for the majority of installed measures are greater than the two years the Customer Engagement program has been in place.

DNV calculated the stream of savings from Dominion Energy rebate programs for Customer Engagement recipient and non-recipient group households by summing the savings achieved in 2021 and 2022, including measures installed in prior years (in the case of 2022) that are expected to be still in use. The rebate portion of joint savings is the difference between the recipient and non-recipient groups' savings. We removed this difference from the Customer Engagement measured savings.

2.2.2 Upstream lighting analysis

DNV administered an online survey to collect information from program participants about the purchase and installation of LED screw-based bulbs, LED flood reflectors, LED Decorative and specialty bulbs, and LED fixtures from March 2022 to March 2023. We used survey results to calculate the number of purchased LEDs incentivized by the upstream program for the Customer Engagement recipient and non-recipient groups over the one-year period. These results were used to estimate joint savings associated with DE's upstream LED lighting programs.

In particular, the difference in the average number of LEDs purchased by the recipient and non-recipient households provided the uplift in efficient lighting due to the Customer Engagement program. We multiplied savings per LED by the estimated uplift to generate upstream joint savings in 2021 and 2022.

Upstream joint savings calculated in this manner were used to generate credited savings per household.

2.3 Survey analysis

2.3.1 Sample design

The survey sample was developed from the population of HER recipients and non-recipients. Customers were removed from the sample frame if they had inactive accounts or missing emails, if they overlapped with the market characterization study currently in progress, if they had HER type indicated, or if they were subscribed to a community solar program.[4]

Of the 24,000 customers in the eligible samples across recipient and non-recipient group eligible samples, 821 HER report recipients and 767 non-recipient responses are reported here. The HER recipients completed 665 surveys with an additional 102 surveys that were substantially completed. Non-recipients completed 718 surveys with an additional 103 surveys substantially completed. Accounting for undelivered emails, no response, and eligibility to complete the survey, the response rate was 6% for both the non-recipient group and the recipient group (Table 2-1). The response rates (and subsequent attitudes about energy efficiency) of recipients and non-recipients were similar. The willingness of non-recipients to complete the survey at the same rate as recipients is a positive indication of Dominion Energy's overall level of customer engagement.

Table 2-1. Survey sample disposition

Category	Non-recipient	Recipient
Survey Sample	12,000	12,000
Failed emails	501	472
Surveys not started	10,756	10,844
Not eligible	25	19

[4] In this case, 1424 participants are enrolled in https://www.arcadia.com/for-homes. The email addresses for these customers are associated with Arcadia, and not to the customer, sz-786572356@a.arcadiapower.com.

Category	Non-recipient	Recipient
Survey started but not finished	103	102
Total surveys completed	718	665
Surveys reported	821	767
Response rate	6%	6%

2.3.2 Fielding the survey

The evaluation specified a goal of 600 survey completes for both the recipient and non-recipient groups. DNV prepared an online survey using the Qualtrics web-based platform.[5] A survey invitation was emailed to 24,000 customers beginning on March 17, 2023, and the survey closed approximately 10 days later. The survey invitation, instrument, and results are shown in APPENDIX B and APPENDIX C, respectively.

DNV applied a two-phase survey deployment. Ten percent of the sample received the survey invitation on March 17, 2023, and the remaining 90% received invitations by March 21. This two-phase deployment approach allowed DNV to review preliminary results and amend the survey for clarity as warranted. Non-responders received up to two reminder emails to encourage participation.

[5] Qualtrics XM

3 RESULTS

3.1 Impact evaluation results

Table 3-1 through Table 3-3 show the number of customers as of February 2021, the beginning of the program, the number of customers with billing data in DNV's possession, and the number of customers with enough billing data in both the pre- and post-period to be included in the impact analysis.

Table 3-1. Program participants at start of program (February 2021)

Recipient group	February 2021	
	Recipients	Non-recipients
Email report	207,379	51,896
Paper report	120,521	30,190
Total	327,900	82,086

Table 3-2. Customers with billing data as of February 2021 and January 2022

	2021		2022	
Recipient group	Recipients	Non-recipients	Recipients	Non-recipients
Email report	186,386	46,619	186,386	46,619
Paper report	108,636	27,190	108,636	27,190
Total	295,022	73,809	295,022	73,809

Table 3-3. Customers with enough billing data in both the pre-and post-period

	2021		2022	
Recipient group	Recipients	Non-recipients	Recipients	Non-recipients
Email report	151,008	37,760	151,008	37,760
Paper report	94,094	23,497	94,094	23,497
Total	245,102	61,257	245,102	61,257

3.2 Credited electric savings

The estimated credited savings have two components. The first is the Customer Engagement program's measured savings that reflect the program's impact on average household consumption. It is the average reduction in energy consumption of Customer Engagement recipient households. The second component is the joint savings, which is comprised of downstream rebate and upstream lighting savings. To avoid double counting, we calculated credited savings by removing the downstream rebate joint savings and upstream lighting savings from the Customer Engagement measured savings. The downstream rebate joint savings are calculated from Dominion Energy tracking data. The upstream lighting savings are calculated from a customer survey while also incorporating the savings from the previous four years (lighting savings are assumed to have a 5-year lifespan). The survey results can be found in Section 2.3.

3.2.1 Credited electric savings per household

Table 3-4 and Table 3-5 provide the summary of credited savings per household by report type and total electric savings estimates for program years 2021 and 2022, respectively. Because the program paused for several months in 2021, the

2021 estimates are partial year estimates, while the 2022 estimates are for the full year. Email report recipients showed positive, yet statistically insignificant electric savings in both 2021 and 2022. Paper report recipients showed positive and statistically significant electric savings in both years. Overall, Customer Engagement customers saved 4.6 million kWh in 2021 and 9.4 million kWh in 2022.

Table 3-4. Summary of per household and total savings for the Customer Engagement Program, 2021 (kWh)

Recipient group	Per household				Total		
	Measured savings kWh	Joint savings kWh	Claimed savings kWh	No. in group	Total savings kWh	Lower limit 90% CI kWh	Upper limit 90% CI kWh
Email reports	1.36	0.82	0.54	151,008	82,234	0	4,124,332
Paper reports	47.79	0.00	47.79	94,094	4,496,935	486,464	8,507,407
TOTAL			**18.68**	**245,102**	**4,579,169**	**0**	**10,273,240**

Table 3-5. Summary of per household and total savings for the Customer Engagement Program, 2022 (kWh)

Recipient group	Per Household				Total		
	Measured savings kWh	Joint savings kWh	Claimed savings kWh	No. in group	Total savings kWh	Lower limit 90% CI kWh	Upper limit 90% CI kWh
Email reports	15.71	1.30	14.41	151,008	2,176,354	0	6,096,424
Paper reports	76.63	0.00	76.63	94,094	7,210,606	2,499,301	11,921,911
TOTAL			**38.30**	**245,102**	**9,386,960**	**3,258,066**	**15,515,855**

3.2.2 Total credited electric savings

This section provides a summary of total credited savings for program years 2021 and 2022. The email report group produced credited 2021 and 2022 electric savings of 0.5 kWh or 0.0% and 14.4 kWh or 0.1%, respectively. These savings are not statistically significant. By contrast, the paper report group had statistically significant average reductions of 47.8 kWh (0.3%) savings per household in 2021 and 76.6 kWh (0.3%) savings per household in 2022.

The discrepancy between the email and paper recipient group results could be explained by differences in the way customers handle email vs. paper correspondence. Customers may inadvertently miss email reports due to automatic spam filters or overwhelmingly full inboxes. By contrast, paper reports must pass through the hands of the recipients, even if ultimately disposed of without being opened.

Table 3-6 and Table 3-7 provide a summary of total credited savings per household for program years 2021 and 2022.

DNV

Table 3-6. Total credited savings for the Customer Engagement Program (kWh), 2021

Recipient group	Annual consumption	HER measured savings	Downstream joint savings	Upstream joint savings	Credited savings	Percent credited savings
Email reports	13,042	1.4	0.8	0.0	0.5	0.0%
		(-25.4, 28.1)	(-0.7, 2.0)		(-26.2, 27.3)	
Paper reports	17,280	47.8*	-0.4	0.0	47.8*	0.3%
		(5.2, 90.3)	(-2.8, 2.0)		(5.2, 90.4)	

*Indicates statistically significant at 90% confidence level. Values in parentheses show upper and lower bounds at 90% confidence level.

Table 3-7. Total credited savings for the Customer Engagement Program (kWh), 2022

Recipient group	Annual consumption	HER measured savings	Downstream joint savings	Upstream joint savings	Credited savings	Percent credited savings
Email reports	17,245	15.7	1.3	0.0	14.4	0.1%
		(-10.1, 41.6)	(-1.2, 3.8)		(-11.5, 40.4)	
Paper reports	23,080	76.6*	-1.4	0.0	76.6*	0.3%
		(26.7, 126.6)	(-5.1, 2.3)		(26.6, 126.7)	

*Indicates statistically significant at 90% confidence level. Values in parentheses show upper and lower bounds at 90% confidence level.

Figure 3-1 and Figure 3-2 provide a side-by-side comparison of 2021 and 2022 measured savings for email, paper, and all recipients. Recipients of both report types show increased savings in 2022 compared to 2021. While email recipient savings are not statistically significant in either year, paper recipient savings increased by 160% in 2022 compared to 2021 and were statistically significant in both years. Overall program savings doubled in 2022 compared to 2021 and achieved statistical significance in 2022. These results suggest that the observed savings increases are not due solely to 2021 savings having come from a partial year, but rather that there is a true year-over-year increase in savings.

Table 3-8 provides a summary of downstream joint savings (kWh) per household for program years 2021 and 2022 while Table 3-9 summarizes upstream joint savings (kWh) per household for program year 2022.

Figure 3-1. Measured customer engagement, electric savings per household by year[6]

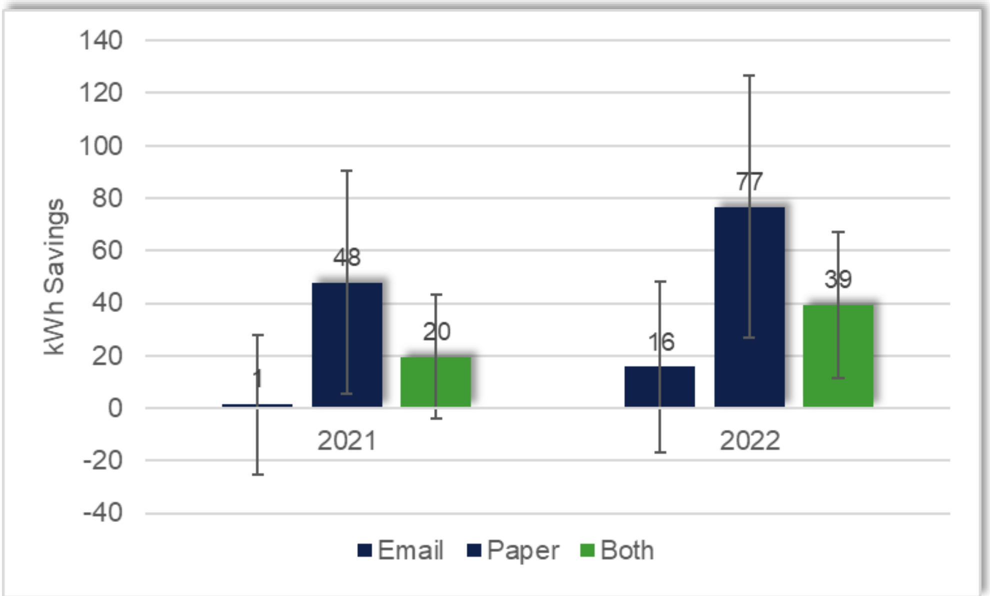
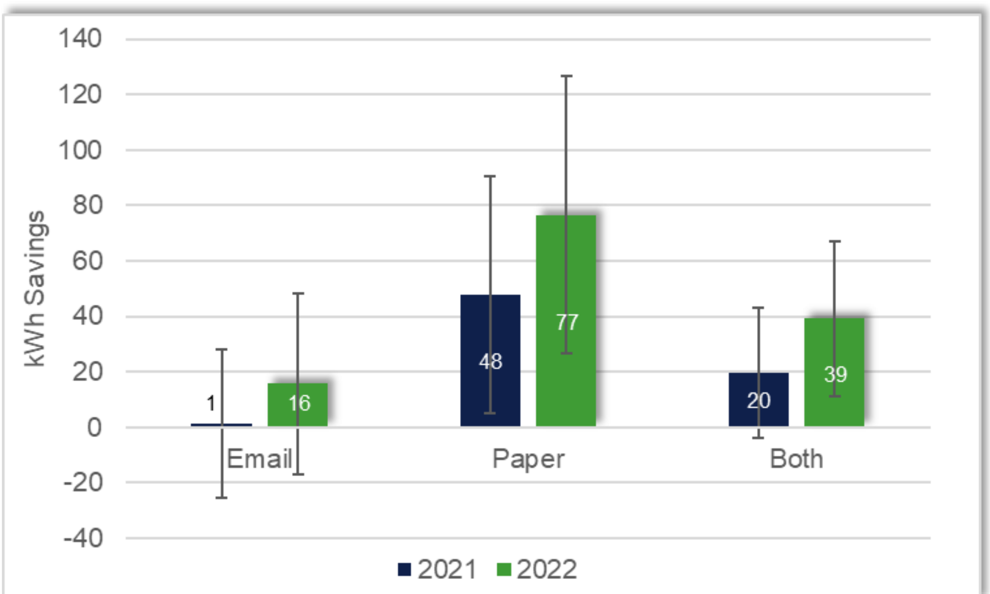


Figure 3-2. Measured customer engagement, electric savings per household by report type, 2021–2022[7]



[6] The vertical lines show the upper and lower bounds at the 90% confidence level.
[7] The vertical lines show the upper and lower bounds at the 90% confidence level.

Table 3-8. Summary of downstream joint savings (kWh) per household, 2021 and 2022

Recipient group	2021 Downstream savings			2022 Downstream savings		
	Average recipient savings	Average non-recipient savings	Difference	Average recipient savings	Average non-recipient savings	Difference
Email reports	10.06	9.24	0.82	22.18	20.89	1.30
Paper reports	11.07	11.98	-0.41	23.57	25.00	-1.44

Table 3-9. Summary of upstream joint savings (kWh) per household, 2022

Upstream lighting measures	Difference in number of bulbs (T-C)		Average deemed savings (kWh per unit)	Email report upstream savings (kWh)	Paper report upstream savings (kWh)
	Email	Paper			
LED Screw-based	0.14	-1.25	5.75	0.78	-7.20
	(-0.7, 0.9)	(-2.6, 0.1)		(-3.8, 5.4)	(-15.0, 0.6)
LED Flood reflector	-0.07	0.16	8.27	-0.55	1.36
	(-0.3, 0.2)	(-0.2, 0.6)		(-2.6, 1.5)	(-1.9, 4.6)
LED Decorative/specialty	0.17	-0.55	7.95	1.32	-4.33
	(-0.1, 0.5)	(-1.0, -0.1)		(-1.1, 3.7)	(-7.6, -1.1)
LED Fixture	-0.14	0.17	16.15	-2.30	2.70
	(-0.3, 0.0)	(-0.2, 0.6)		(-4.7, 0.1)	(-3.8, 9.2)
Total upstream lighting savings				**-1.53**	**-7.48**

3.3 Discussion

HER programs are turnkey programs. Once the experimental design is set, the program's success is fully determined by the reports' ability to nudge the identified customers toward energy-efficient behaviors. Because of the RCT, the savings estimates, the key measure of program effectiveness, are both standardized and rigorous. DNV's estimates will likely be very close to Bidgely's as would any other evaluator's results. However, the customers' willingness to be motivated through behavioral messaging varies. HER programs across the country have demonstrated variation across programs based on consumption levels, income level, region, fuel-type, etc. Variation in timing may also be a factor with older programs (i.e., ten years older or more) starting to see diminishing savings, as well as programs that started during and after COVID-19 performing less well. There is little variation in the reporting vehicles across vendors.

The standard RCT experimental design makes it possible to get highly precise unbiased estimates of the small percentage savings that are typical of behavioral programs. The RCT also means that there is limited evaluator discretion in the evaluation process. That is, DNV's results should be roughly the same as Bidgely's or any other evaluators.

The Customer Engagement Program is a turnkey behavioral program. Once the experimental design is set, the program success is fully determined by the success of the reports at nudging the identified customers toward energy efficient behaviors. There are multiple factors that can affect behavioral program savings. Customers' willingness to be motivated through behavioral messaging varies. HER programs across the country have demonstrated variation across programs based on consumption levels, income level, region, fuel-type, etc. It is hypothesized that behavioral savings are related to what can be referred to as discretionary energy usage. That is, customers are more likely to reduce unnecessary or wasted consumption as opposed to reducing consumption related to, for example, comfort. This conforms with general tendencies for lower savings among lower consumption and/or lower income populations.

Recently, it has appeared that variation in timing may also be a factor. Some older programs (ten years or more) have started to see diminishing savings and recently started programs, during and after Covid, also appear to be performing less well. This could reflect lower inclination to take seriously these kinds of behaviorally oriented programs. Alternatively, customers may have already picked up on less targeted messaging and improved their consumption characteristics such that less savings are available from this better baseline. HER-type programs are always just trying to get their customers a little ahead of the existing, typical energy consumption habits.

The behavioral program market used to be dominated by Opower/Oracle. More recently at least three competitors have entered more widely into the market. Recent declines have affected Opower programs as well as others. Because of all the other possible sources of variation that may affect programs, it is impossible to know if there is any difference in performance across vendors.

Finally, there are two Dominion specific occurrences that may have affected results for this specific program. Reports were suspended for a multi-month period shortly after the commencement of the program. There is academic research that illustrates this initial ramping period with daily consumption data. It is possible to see treatment group consumption reduction shortly after the report has been received and then start to return to normal slowly over the next couple weeks. The early repetition of reports repeats this cycle multiple times, each time reducing consumption to a lower level. After some number of reports, the post report backsliding moderates and it appears that a new normal is achieved. The suspension of reports interrupted this process, and it is possible there could be long term effects to that interruption.

There have also been delivery inconsistencies throughout the implementation. If these inconsistencies led to missed reports, then the effects could be similar to but less widespread than the report suspensions. On the other hand, if some control group customers received messaging to reduce consumption, this would have a more direct negative effect on savings.

3.4 Survey results

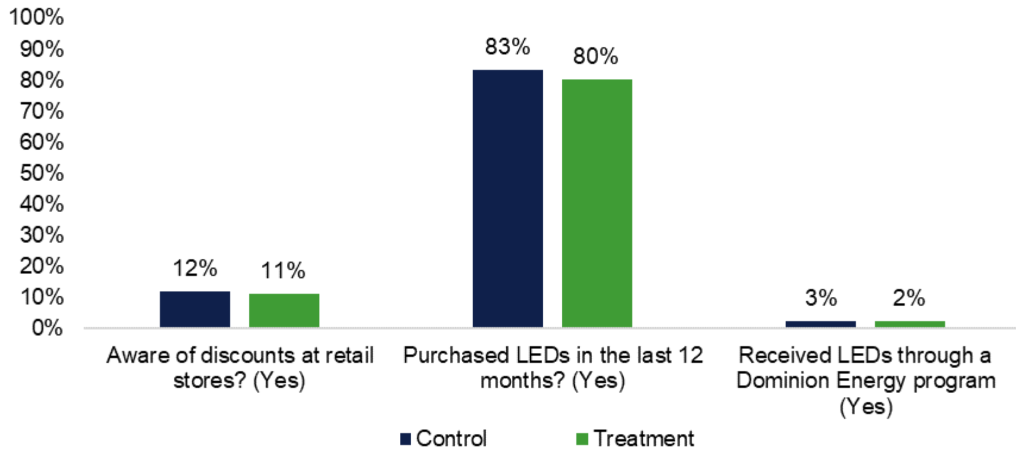
The primary purpose of the HER survey is to inform the efficient lamp uptake for the HER impact evaluation savings. The survey includes questions on LED purchases (type, location, and installation). Among the recipient group, it measures satisfaction with the HER reports and aims to understand customers' adoption of home energy upgrades and any potential differences between the recipient and non-recipient group. In this section, we present the survey findings.

3.4.1 LED purchases

The survey included a set of questions on awareness and purchases of LED light bulbs in the last 12 months. In this section, we present the findings and compare responses among the non-recipient and recipient group. Overall, there was minor variability among the two groups for all LED-related purchase questions.

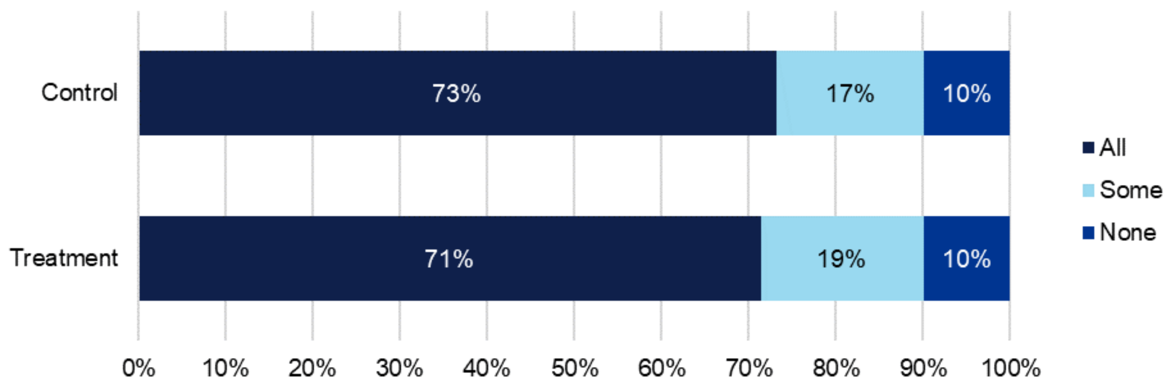
DNV first asked respondents if they were aware that Dominion Energy discounts LED lights in retail stores. We then asked if they had purchased any LEDs in the last 12 months, and if they had received any LEDs through a Dominion Energy program. Figure 3-3 displays the range of responses for the three questions. As shown, both the recipient and non-recipient groups were near identical for all questions. About 10 % of both groups demonstrated an awareness of the discounts, 80% had purchased LEDs in the past year, and less than 5% received any LEDs through a DE program.

Figure 3-3. Non-recipient and recipient groups that are aware of discounts, purchased LEDs, and received LEDs from a Dominion Energy program



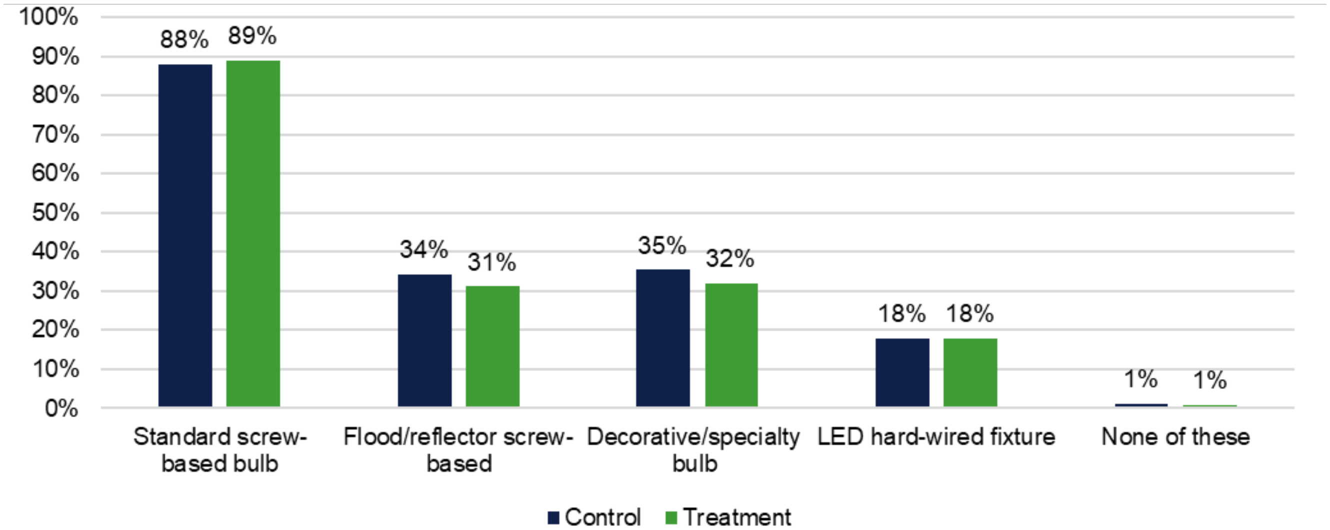
For respondents who purchased LEDs, we asked if they purchased them at stores where Dominion Energy discounts LEDs. The survey presented the list of retail and home improvement stores and asked if all, some, or none of their LED purchases were made at these stores. Figure 3-4 displays the range of responses. As in the above figure, there is little variability among the recipient and non-recipient group with 71% and 73% having made "all" purchases at the discounted stores.

Figure 3-4. Percentage of LEDs purchased at discounted retailer stores by non-recipients and recipients



The survey included a set of questions about the type of LED bulbs purchased (Figure 3-5). The most common type of bulb is the standard screw-based type. The types of bulb purchases among the recipient and non-recipient groups mirrored one another with only minor differences of less than 3% by bulb type.

Figure 3-5. Percentage of non-recipient and recipient, percent of bulb types purchased



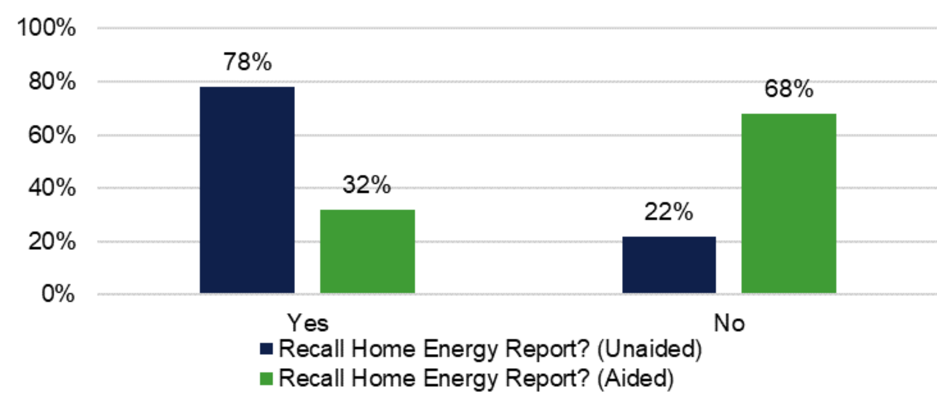
3.4.2 Home Energy Reports

The HER program draws from specific segments of Dominion Energy's residential customer base with high levels of energy consumption. The survey included a set of questions for the recipient group about their experience with the reports, including measuring awareness of the report, the depth of their review, and the report's usefulness. The results show that most HER report recipients recalled the reports, read some or all of the reports, and liked the features of the reports.

3.4.2.1 Home Energy Report survey results

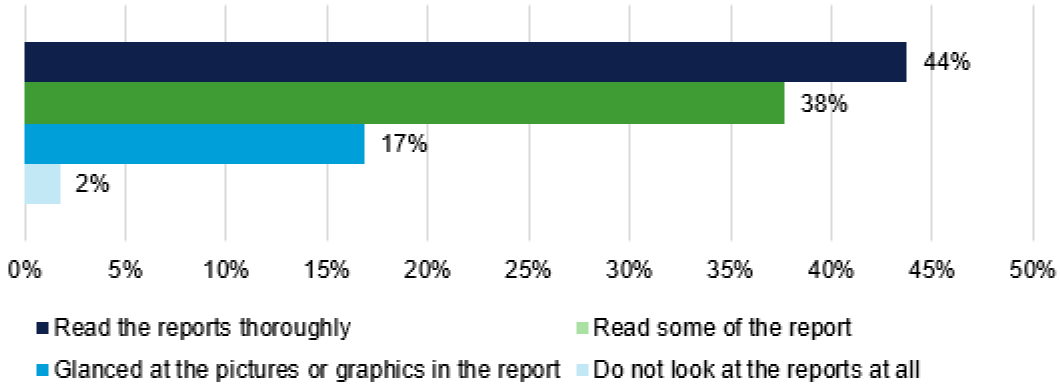
The survey asked respondents among the recipient group if they recalled receiving the HERs in the past 12 months. To measure the awareness of the HER reports the survey contained both an aided question and an unaided question among those who did not initially recall the report. The aided question contained an image of the report. From a combination of these two questions, some 85% of respondents could recall the HER report; 78% could recall it without support and another 32% could recall it after seeing the image of an HER report (Figure 3-6).

Figure 3-6. Percentage of recipient group who recall receiving the HER (aided and unaided)



The survey asked the recipient group customers who recalled receiving HERs about their thoroughness in reviewing the HERs report. As shown in Figure 3-7, the majority (82%) of recipient group customers read the report; others read it "thoroughly" (44%) or read "some of it" (38%) while 17% glanced at it. These results illustrate that the program succeeded in providing content worth customers' time to review.

Figure 3-7. Recipient engagement with the Home Energy Reports (n=576)



The survey asked the recipient group, "Thinking about the Home Energy Reports you have received; how much do you agree or disagree" with five independent statements measuring the benefits of HERs (Figure 3-8 and Figure 3-9). As illustrated in Figure 3-9, respondents were most agreeable about liking the HER report (88%) and finding the energy use graph helpful (86%). About 3 in 4 customers agreed with other features of the HER report, including the top appliance section of the report (74%). The lowest ranking agreement (71%) was in response to the statement that the HER succeeded in helping customers make better decisions and providing a comparison to other similar nearby homes.

Figure 3-8. Survey aid to illustrate components of the HER reports

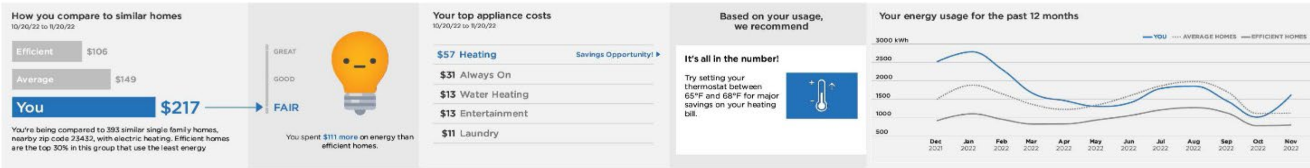
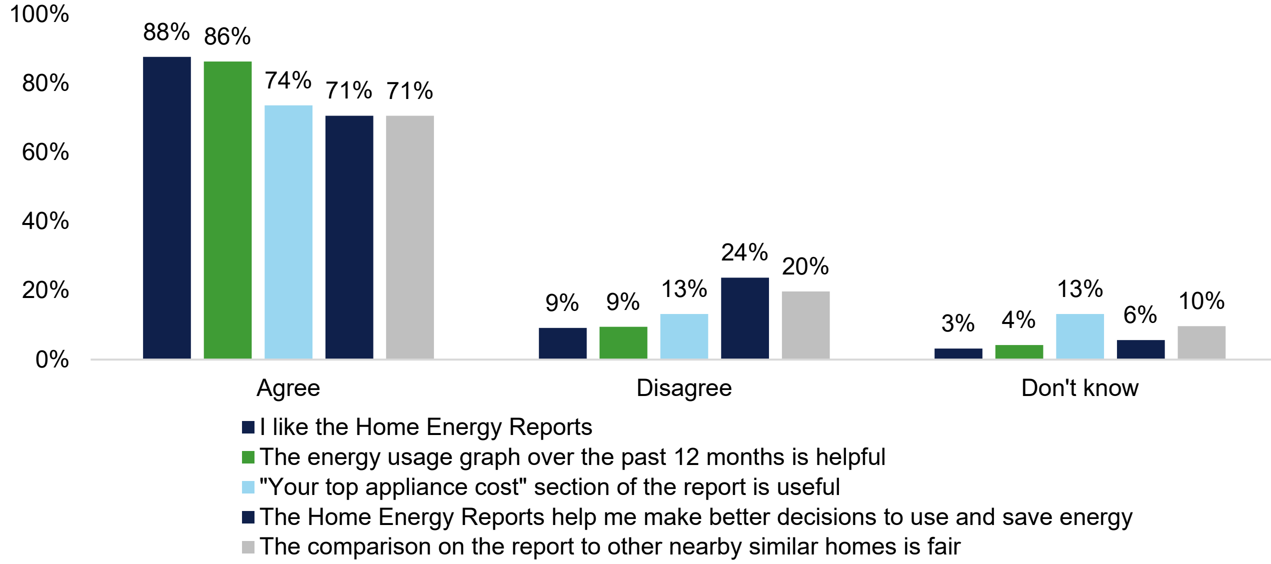


Figure 3-9. Recipient group, level of agreement on features and benefits of the HER reports (n=576)

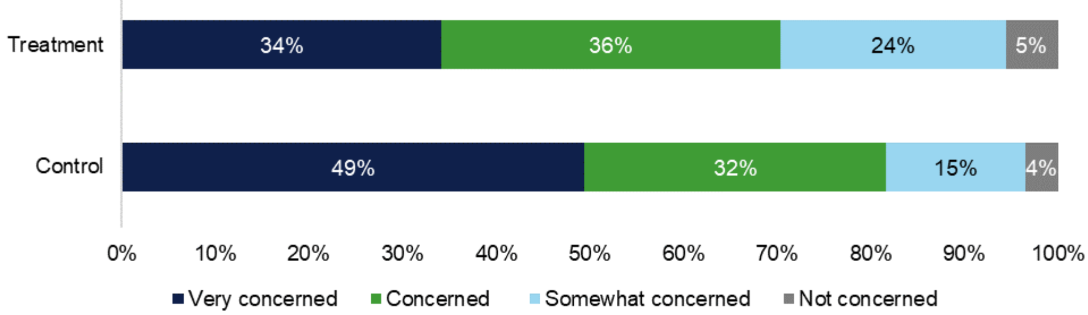


3.4.3 Saving energy

The survey included a series of questions on the importance of saving energy that aimed to understand customers' planned adoption of home energy upgrades and any potential differences between the recipient and non-recipient group.

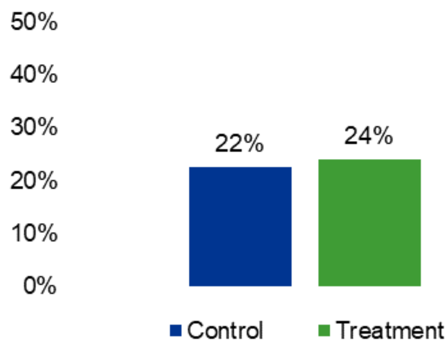
As shown in Figure 3-10, all respondents were asked, "How concerned are you with reducing your home's energy use?" Results show the level of "concern," with the top three being nearly identical, 94% for recipients and 95% for non-recipients); however, as we break out the results into the varying levels of concern, we see that the recipient group is less concerned, with only 34% stating "very" compared to the 49% of non-recipients stating "very."

Figure 3-10. Percent of treatment (n=681) and control group (n=782) concerned with reducing home energy use



The survey asked respondents whether they had plans to undertake any energy efficiency actions recommended by the HERs such as installing LEDs or caulking windows and doors to reduce leakage. Figure 3-11 illustrates that approximately 1 in 4 respondents in both the recipient and non-recipient groups plan to make energy efficiency upgrades to their homes this year. While the results are collectively and independently near identical, the analysis indicated a statistically significant difference between the recipient group and non-recipient group (24% and 22%, respectively) on plans to upgrade.

Figure 3-11. Percentage of customers in the control (n=752) and treatment (n=681) groups with planned home upgrades



We asked the one quarter of respondents who have plans to upgrade, "What types of upgrades are you considering?" among the list presented.

When comparing the sum of all upgrades, we calculated that the recipient group was 11% more likely to have an upgrade planned than the non-recipient group. This modest difference may suggest the HER reports are a motivation to perform home upgrades. The analysis indicated a statistically significant difference between the non-recipient group and recipient group for nearly all measures as indicated in bold font. The three most common measures planned are lighting, insulation/weatherization, and building shells such as windows, doors, or roof.

Figure 3-12. Percentage of recipients and non-recipients, by type of planned home energy upgrades

Upgrades	Recipient	Non-recipient
Light bulbs or fixtures	50%	**45%**
Insulation or building weatherization improvements	**38%**	28%
Replace windows, doors, or roof	31%	**36%**
Heating or cooling	**28%**	26%
New kitchen appliances	20%	**25%**
Smart thermostats	20%	22%
Water heating	**19%**	15%
Small appliances (e.g., dehumidifier, air purifier)	**15%**	8%
Renewable energy (e.g., solar or battery storage)	12%	**14%**
Electric vehicle charger	5%	**11%**
Other*	**4%**	4%
Don't know	2%	2%
None of these	**1%**	0%

*Other upgrades included: thermal curtains, large appliances (washer/dryer) monitor usage, variable speed pool pump, attic fan, and others.

The survey asked all respondents about their awareness of the Dominion Energy Marketplace Program and "what would be the best way to inform customers about future program offerings like rebates and other services for in-store purchases at retail/appliance/home improvement stores." The survey found low levels of awareness of the Dominion Energy Marketplace Program at 11% for both the recipient and non-recipient groups.

When asked to describe the most effective way to be informed about Dominion Energy DSM offerings, respondents were most likely to suggest sources from Dominion Energy including emails, website, social media, and energy bills. (Table 3-10).

Table 3-10. Recipient and non-recipient preferred communication channels for receiving information about DSM program offerings (n=538)

Preferred communication channel	Percent
Emails from Dominion Energy	72%
Dominion Energy website or social media	40%
Dominion Energy bill insert	39%
In-store promotions at retail/appliance/home improvement store	37%
Online stores/banner ads online	17%
Phone calls, postal mail, or text message from Dominion	14%
Print media	10%
Community events	4%
Through a contractor	4%

The implementer, Bidgely, also solicits feedback from recipients and reports that 95% of respondents have provided positive feedback.

DNV

APPENDIX A. SAMPLE HOME ENERGY REPORT

Dominion Energy®

600 East Canal Street S 11 Fl
Richmond, VA 23219

Account Number: [redacted]
THIS IS NOT A BILL

[redacted]
SUFFOLK, VA 23432

Your Home Energy Report

10/20/22 - 11/20/22

This report contains ESTIMATED insights into your energy usage and top energy consuming appliances. For improved insights and money-saving tips, convert to DIGITAL. See the back for details.

How you compare to similar homes

10/20/22 to 11/20/22

Efficient	$106
Average	$149
You	$217

GREAT
GOOD
FAIR

You're being compared to 393 similar single family homes, nearby zip code 23432, with electric heating. Efficient homes are the top 30% in this group that use the least energy

You spent $111 more on energy than efficient homes.

Your top appliance costs

10/20/22 to 11/20/22

$57	Heating	Savings Opportunity!
$31	Always On	
$13	Water Heating	
$13	Entertainment	
$11	Laundry	

Based on your usage, we recommend

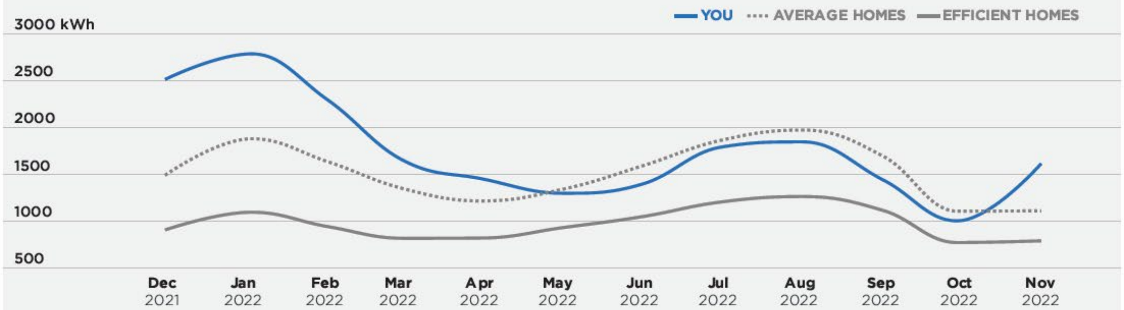
It's all in the number!

Try setting your thermostat between 65°F and 68°F for major savings on your heating bill.

HER_1162905002_20221124124215_0_1.pdf | 10042

DNV

Your energy usage for the past 12 months



Here are a few personalized tips for you

Control temperature while you're away

Programmable thermostats give homeowners more control over their heating and cooling.

Consider a tankless water heater

Tankless water heaters can save homeowners up to 40% on their water heating bill.

Frequently Asked Questions

How do you break down my energy usage?
Appliance itemization is powered by disaggregation, a process that takes the energy usage data from your meter and uses software algorithms to identify the individual appliances that are actually using the energy. The value for each appliance is an ESTIMATE based on consumption.

How do I improve the accuracy of my appliance breakdown?
To improve the accuracy, convert to Digital which gives you access to a Home Profile Survey as well as more insights and recommendations on a web portal.

Who am I being compared to?
Comparison is an ESTIMATE based on grouping similar homes and available third-party property data. Please update your Home Profile to improve accuracy.

How do I stop receiving reports?
If you would like to receive only email reports or stop receiving reports, please call us at 1 (888) 366 8280.

Sign Up Today

Go Digital

Switch to email reports at:
DominionEnergyReports.Bidgely.com
Use Access Code: **HZW9SC**

Improve your experience - Go DIGITAL!
· Home Profile Survey for more accurate insights
· More money-saving tips & offers on the web
· Be green by reducing paper

Still have questions?

· Call: 1 (888) 366 8280
· Press 3 for Residential, then option 4

Dominion Energy®

APPENDIX B. SURVEY INSTRUMENT

Email survey invitation

From: Dominion Energy LED Lights <DominionEnergyCustomerResearch@qemailserver.com>
Sent: Monday, April 3, 2023 5:02 PM
To: John Smith
Subject: Help Us. Help You. Programs Designed with You in Mind

Dear John Smith,

Dominion Energy is committed to providing our customers with energy-saving products and services to help you lower your energy bill. As part of this effort, we are conducting research to learn about household lighting and energy-saving upgrades. Dominion Energy is working with DNV Energy, a company specializing in energy research, to learn more about energy usage in homes. This information will be used to help us make improvements to existing energy efficiency programs. Today we invite you to participate in a brief online survey. The survey should take only five minutes.

We value your help. Your participation is very important as only a limited number of customers were selected to take this survey.

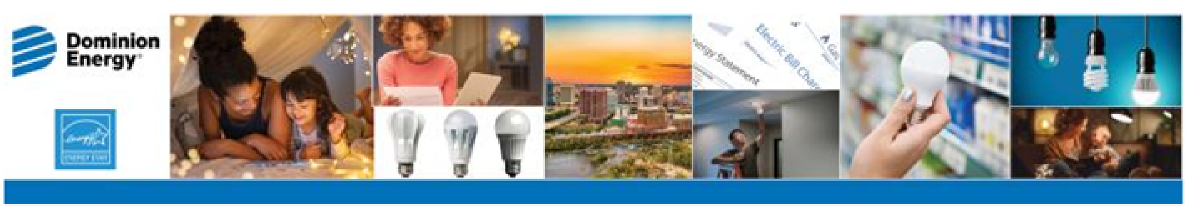
To get started click on this link: Take the Survey

Your answers will be held in the strictest confidence. The information you provide will be combined with information from other households that complete the survey. Individual household data will not be published. The results are reported in summaries such as group averages, percentages, and other general statistics. If you would like to validate the authenticity of this request, you may call Dominion Energy's customer service line.

Thank you for helping to improve Dominion Energy's efficiency programs.

Chelsea L. Dyer
Dominion Energy
600 Canal Place 11th Floor
Richmond, VA 23219

Dominion Energy



Follow the link to opt out of future emails:
Click here to unsubscribe

Survey Questions

Q1
Date: Time
Q2
Customer Name
Q3
Address
Q4
City
Q5
Email
Q6
Site ID
Q7
Is your home address [Q3], [Q4]?
Yes
No
Q8
Does anyone in your household currently work for a gas or electric utility company, including Dominion Energy?
Yes
No

Q9
Are you familiar with your household's purchases of energy-saving light bulbs bought in 2020?
Yes
No
Don't know

Q10
We would like to learn more about your past purchases of light-emitting diode (LED) and light bulbs.

Q11
Lamp images

Q12
LED light bulbs are the most efficient light bulbs available on the market and come in many shapes and sizes. In this section we would like to learn about your LED purchases made in 2020 for your home.

Q13
Did you or anyone in your household purchase LED light bulbs in 2020?
Yes
No
Don't know

Q14
Approximately, how many LED bulbs did your household purchase? If you purchased any multi-packs, enter the total number of bulbs included in all packages. For example, two multi-packs with three bulbs each would count as six. Your best estimate is fine.

Q15
How many of the [L2] LED bulbs that you purchased in 2020 are currently installed in or around your home?
All of them (100%)
Most of them (75%)
Some of them (50%)
A few of them (25%)
None of them (0%)
Don't know

Q16
What type of bulb did the majority of these LED bulbs replace? Was it...
CFL
LED
Incandescent
Halogen
A mix of CFL and other bulbs
Don't know
If other, specify

Q17
What did you do with the bulbs you did NOT install? Did you….?
Store them in your home
Gave them away
Return them to the store
Don't know
Did something else with them (describe):

Q18
Home Energy Survey - Program Experience

Q19
How familiar are you with Dominion Energy's energy efficiency or conservation programs that are designed to help you identify ways to use less energy and lower your bill?
Not at all familiar
Not very familiar
Somewhat familiar
Very familiar

Q20
Are you aware that Dominion Energy offers discounts on energy-efficient lighting in retail stores?
Yes
No

Q21
Has your household received Dominion Energy Home Energy Report that rates your home's energy use and compares it with similar homes in your area?
Yes
No
Don't know

Q22
Do you recall seeing any of the following advertisements or messages in your Home Energy Report? Check all that apply
Appliance replacement - "Upgrade your fridge or clothes washer for free"
Fridge recycle - "Old fridges can help feed families"
Heating upgrade - "Get a warmer home and a hot deal"
Outage App - "Be prepared, stay connected"
"Start saving today"
Upgrade - "Last chance to score an upgrade"
Welcome - "Say hello to your first eHER"
None of these

Q23
Taking into consideration all aspects of the Home Energy Report, please rate your satisfaction with the report. Rate your level of satisfaction on a 1 to 5 scale where 1 represents "very unsatisfied" and 5 represents "very satisfied".

Q24
Please rate your interest in receiving the following information from Dominion Energy. Rate your level of interest on a 1 to 5 scale where 1 represents "very uninterested" and 5 represents "very interested".
Response percent
Receive Home Energy Reports by email
Receive bill notifications by email
Receive email notice when the home has unusual high energy usage
Receive emails bi-annually with seasonal tips on how make your home more efficient
Response total
Receive Home Energy Reports by email
Receive bill notifications by email
Receive email notice when the home has unusual high energy usage
Receive emails bi-annually with seasonal tips on how make your home more efficient

Q25
Do you have any suggestions to improve the delivery of Dominion Energy's Home Energy Report Program or any other energy efficiency programs? If so, describe below:

Q26
Thank you very much for your time and opinions. Please click on the "submit" button when finished.

Q27
About Your Home & Household

Q28
Do you own or rent?
Own
Rent

Q29
Which of the following building types best describes your home?
Single-family detached home (home not attached to another home)
Townhouse, duplex, or row house (shares exterior walls with neighboring unit, but not roof or floor)
Apartment or condominium (2–4 units)
Apartment or condominium (5 or more units)
Mobile home
Other

Q30
Approximately how many square feet of living space is there in your home, including bathrooms, foyers and hallways? Exclude garages, basements or unheated porches.
Less than 250 SQFT
250–500
501–750
751–1,000
1,001 – 1,250
1,251 – 1,500
1,501 – 2,000
2,001 – 2,500
2,501 – 3,000
3,001 – 4,000
4,001 – 5,000
More than 5,000 SQFT
Don't know

DNV

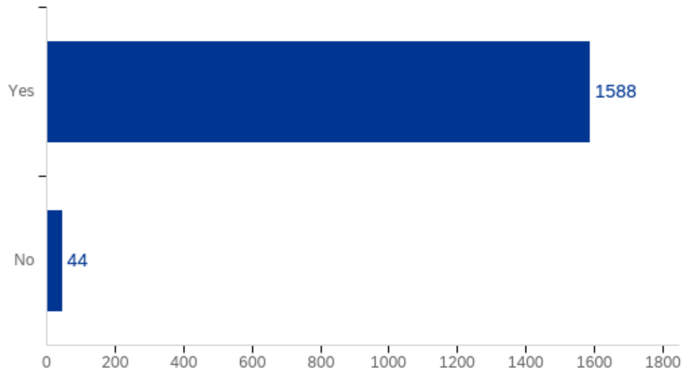
Q31
Approximately what year was this property built?
Before 1940
1940-1969
1970-1979
1980-1989
1990-1999
2000-2009
2010-2020
Don't know
Q32
For each of the following age groups, how many people, including yourself, live in this home year-round? Please select one response for each age category.
Response percent
Age category
5 and under
6–18
19–34
35–54
55–64
65 and over
Response total
Age category
5 and under
6–18
19–34
35–54
55–64
65 and over
Q33
What is the highest degree or level of school you have completed? If you're currently enrolled in school, please indicate the highest degree you have received.
Less than a high school diploma
High school degree or equivalent
Vocational/trade school or associate degree
Bachelor's degree (e.g., BA, BS)
Master's degree (e.g., MA, MS, MEd)
Doctorate (e.g., PhD, MD, EdD)
Prefer not to say
Other (please specify)

Q34
What is the primary household language?
English
Spanish
Chinese (including Mandarin and Cantonese)
Tagalog
Vietnamese
Korean
Prefer not to say
Other (please specify)

Q35
This information is collected for internal purposes only and remains confidential. Please check the range that best describes your household's 2019 total annual income.
Less than $10,000
$10,000 – $19,999
$20,000 – $24,999
$25,000 – $49,999
$50,000 – $74,999
$75,000 – $99,999
$100,000 – $149,999
$150,000 – $174,999
$175,000 – $199,999
$200,000 – $249,999
$250,000 or more
Prefer not to say

APPENDIX C. SURVEY RESULTS

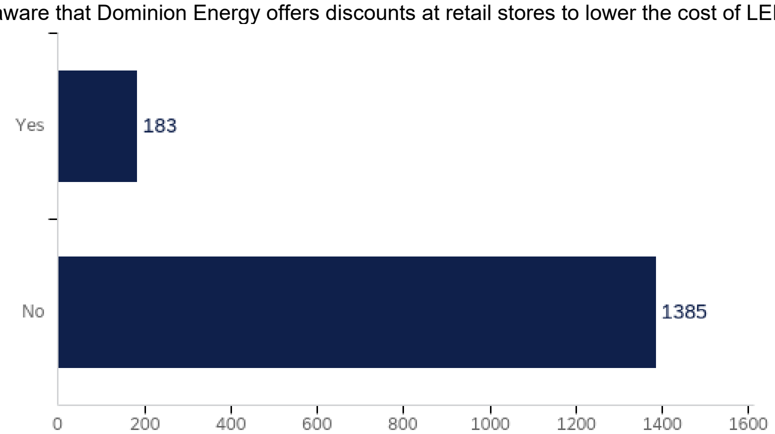
Q1 - Do you currently have an active account with Dominion Energy at [Field-PREMISE_ADDRESS_LINE1]?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Do you currently have an active account with Dominion Energy at [Field-PREMISE_ADDRESS_LINE1]?	1.00	2.00	1.03	0.16	0.03	1632

#	Answer	%	Count
1	Yes	97.30%	1588
2	No	2.70%	44
	Total	100%	1632

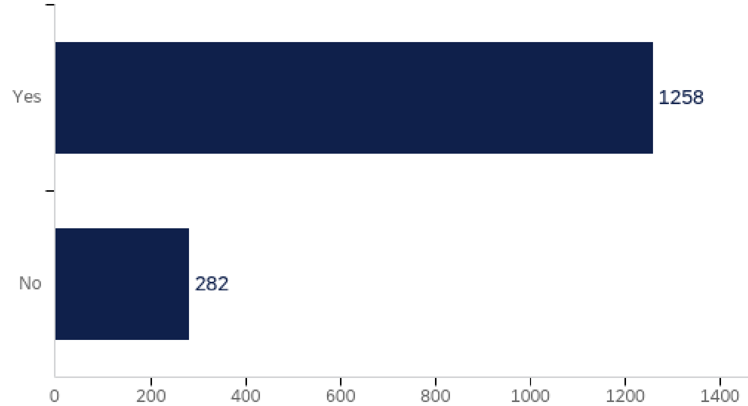
Q2 - Are you aware that Dominion Energy offers discounts at retail stores to lower the cost of LED light bulbs for our customers?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Are you aware that Dominion Energy offers discounts at retail stores to lower the cost of LED light bulbs for our customers?	1.00	2.00	1.88	0.32	0.10	1568

#	Answer	%	Count
1	Yes	11.67%	183
2	No	88.33%	1385
	Total	100%	1568

Q3 - In the past 12 months, did anyone in your household purchase LED light bulbs or LED fixtures?



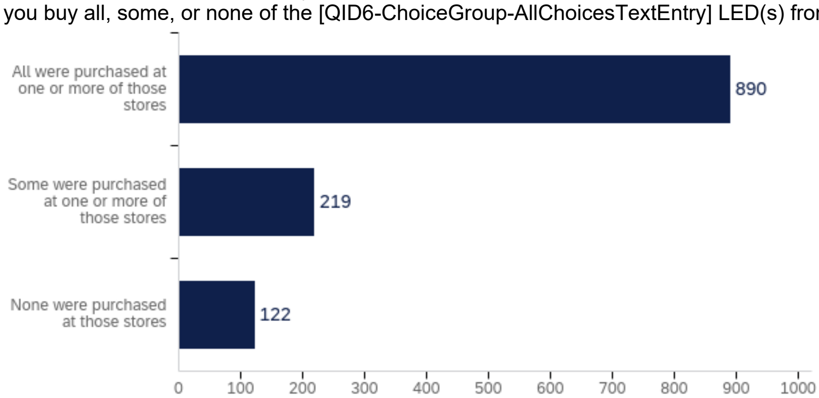
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	In the past 12 months, did anyone in your household purchase LED light bulbs or LED fixtures?	1.00	2.00	1.18	0.39	0.15	1540

#	Answer	%	Count
1	Yes	81.69%	1258
2	No	18.31%	282
	Total	100%	1540

Q4 - Approximately how many total LED light bulbs and/or LED fixtures did your household purchase in the past 12 months? In the case of multi-pack purchases, please list the total number of bulbs purchased. For example, two multi-packs with three bulbs each would count as six bulbs. Your best estimate is fine.

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Quantity:	1.00	250.00	12.19	14.02	196.51	1237

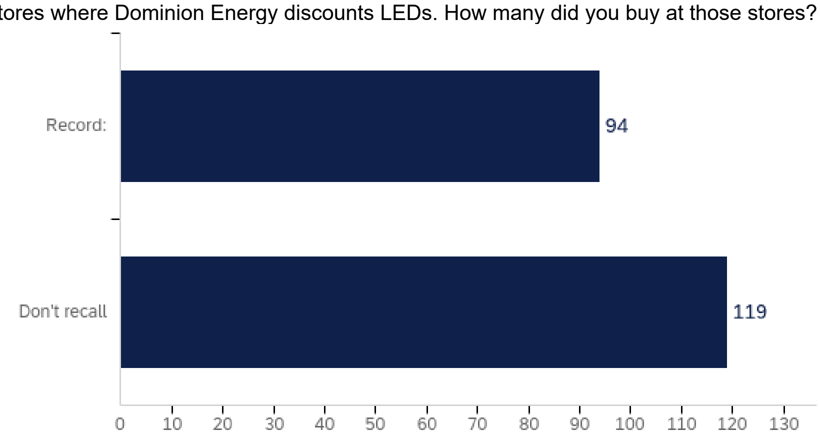
Q5 - Dominion Energy discounts LEDs at stores like: Costco Home Depot Lowes Walmart Target Ace Hardware True Value Batteries Plus Habitat ReStore Goodwill Family Dollar General Dollar BJs Wholesale Club Giant Foods Dominion Energy's Online Retail Marketplace Did you buy all, some, or none of the [QID6-ChoiceGroup-AllChoicesTextEntry] LED(s) from one or more of those stores?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Dominion Energy discounts LEDs at stores like: Costco Home Depot Lowes Walmart Target Ace Hardware True Value Batteries Plus Habitat ReStore Goodwill Family Dollar General Dollar BJs Wholesale Club Giant Foods Dominion Energy's Online Retail Marketplace Did you buy all, some, or none of the [QID6-ChoiceGroup-AllChoicesTextEntry] LED(s) from one or more of those stores?	1.00	3.00	1.38	0.66	0.43	1231

#	Answer	%	Count
1	All were purchased at one or more of those stores	72.30%	890
2	Some were purchased at one or more of those stores	17.79%	219
3	None were purchased at those stores	9.91%	122
	Total	100%	1231

Q5.1 - You indicated in the previous question some of the [QID6-ChoiceGroup-AllChoicesTextEntry] LED(s) were purchased at one or more of the stores where Dominion Energy discounts LEDs. How many did you buy at those stores?

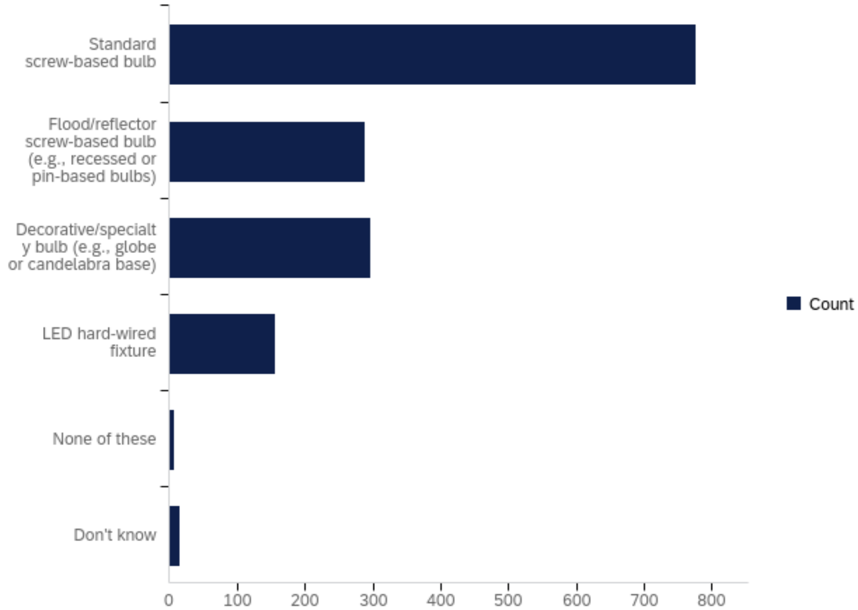


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	You indicated in the previous question some of the [QID6-ChoiceGroup-AllChoicesTextEntry] LED(s) were purchased at one or more of the stores where Dominion Energy discounts LEDs. How many did you buy at those stores? - Selected Choice	1.00	2.00	1.56	0.50	0.25	213

#	Answer	%	Count
1	Record:	44.13%	94
2	Don't recall	55.87%	119
	Total	100%	213

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Record: - Text	1.00	32.00	8.61	6.52	42.56	94

Q6 - You mentioned you purchased [QID6-ChoiceGroup-AllChoicesTextEntry] LED(s) from stores that offer LEDs discounted by Dominion Energy. What type of LED(s) did you purchase from those stores? Select all that apply.



#	Answer	%	Count
1	Standard screw-based bulb	88.30%	777
2	Flood/reflector screw-based bulb (e.g., recessed or pin-based bulbs)	32.84%	289
3	Decorative/specialty bulb (e.g., globe or candelabra base)	33.75%	297
4	LED hard-wired fixture	17.84%	157
5	None of these	0.91%	8
6	Don't know	1.82%	16
	Total	100%	880

Q7 - Approximately how many of the [QID6-ChoiceGroup-AllChoicesTextEntry] LED(s) were...

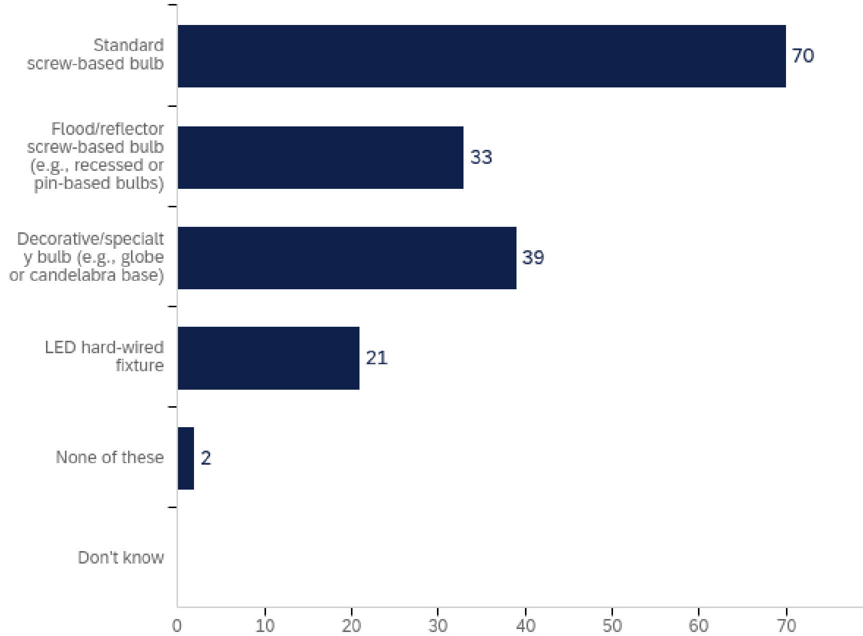
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Standard screw-based bulbs:	1.00	130.00	8.77	9.66	93.39	415

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Flood/reflector screw-based bulbs:	1.00	24.00	4.20	3.77	14.20	246

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Decorative/specialty bulbs:	1.00	36.00	4.72	3.80	14.45	257

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Fixtures:	1.00	38.00	4.50	5.25	27.52	131

Q8 - You mentioned you purchased [QID35-ChoiceTextEntryValue-1] LED(s) from stores that offer LEDs discounted by Dominion Energy. What types of LED(s) did you purchase from those stores? Select all that apply.



#	Answer	%	Count
1	Standard screw-based bulb	75.27%	70
2	Flood/reflector screw-based bulb (e.g., recessed or pin-based bulbs)	35.48%	33
3	Decorative/specialty bulb (e.g., globe or candelabra base)	41.94%	39
4	LED hard-wired fixture	22.58%	21
5	None of these	2.15%	2
6	Don't know	0.00%	0
	Total	100%	93

Q9 - For each type of LED(s) you purchased, please report how many of the [QID35-ChoiceTextEntryValue-1] LED(s) were purchased from stores that offer LEDs discounted by Dominion Energy.

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Standard screw-based bulbs:	0.00	17.00	5.56	4.21	17.69	36

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Flood/reflector screw-based:	0.00	10.00	4.13	2.77	7.69	24

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Decorative/specialty bulbs:	0.00	22.00	5.11	4.64	21.51	27

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Fixtures:	0.00	12.00	3.46	3.30	10.86	13

Q10 - Please report how many of the [QID6-ChoiceGroup-AllChoicesTextEntry] LED(s) are currently installed in light sockets?

Q10_1_4 - No Name

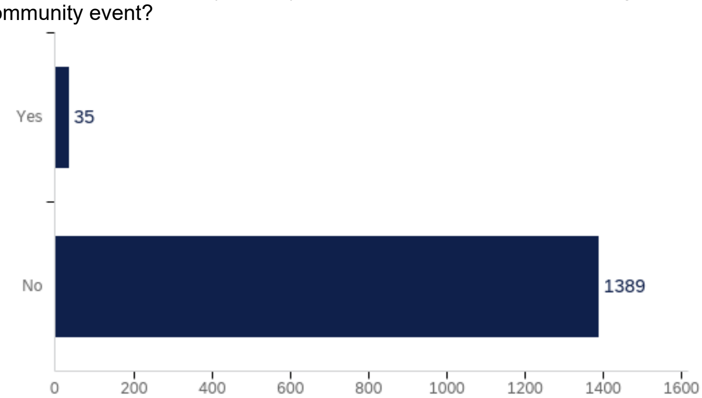
Q10_1_4 - No Name

Q10_1_4 - No Name

Q10.1 - Please report how many of the [QID35-ChoiceTextEntryValue-1] LED(s) you purchased from stores that offer LED(s) discounted by Dominion Energy are currently installed in light sockets.

Q10.1_1_4 - No Name

Q11 - In the past 12 months, did anyone in your household receive LEDs through a Dominion Energy program or at a Dominion Energy supported community event?



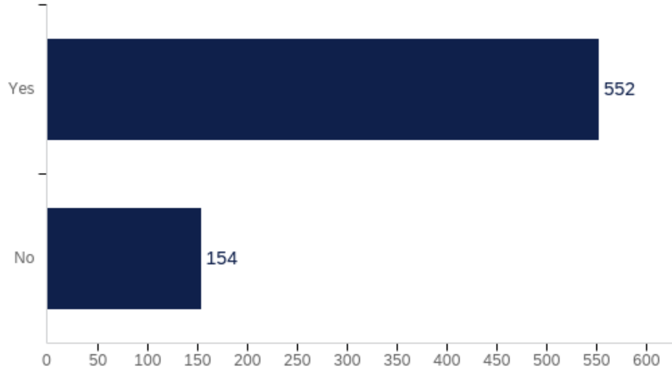
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	In the past 12 months, did anyone in your household receive LEDs through a Dominion Energy program or at a Dominion Energy supported community event?	1.00	2.00	1.98	0.15	0.02	1424

#	Answer	%	Count
1	Yes	2.46%	35
2	No	97.54%	1389
	Total	100%	1424

Q12 - Please report how many of those bulbs are currently installed in light sockets.

Q12_1_4 - No Name

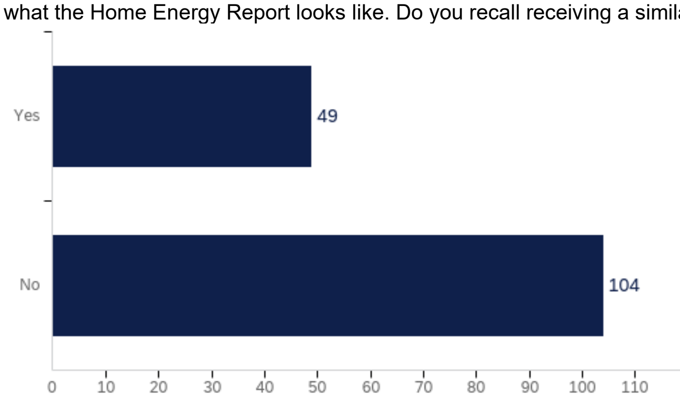
Q13 - In the past 12 months, do you recall receiving a Home Energy Report from Dominion Energy that rates your home's energy use and compares it with similar homes in your area?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	In the past 12 months, do you recall receiving a Home Energy Report from Dominion Energy that rates your home's energy use and compares it with similar homes in your area?	1.00	2.00	1.22	0.41	0.17	706

#	Answer	%	Count
1	Yes	78.19%	552
2	No	21.81%	154
	Total	100%	706

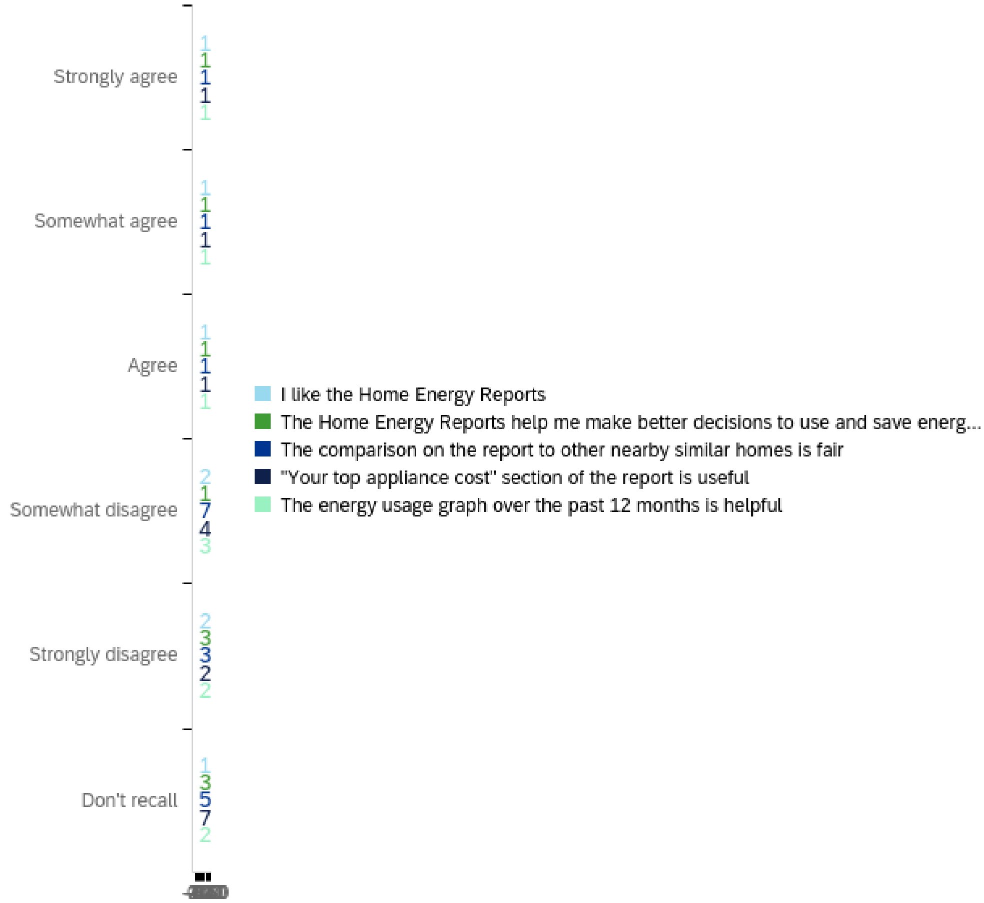
Q14 - This is what the Home Energy Report looks like. Do you recall receiving a similar report from Dominion Energy?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	This is what the Home Energy Report looks like. Do you recall receiving a similar report from Dominion Energy?	1.00	2.00	1.68	0.47	0.22	153

#	Answer	%	Count
1	Yes	32.03%	49
2	No	67.97%	104
	Total	100%	153

Q15 - Thinking about the Home Energy Reports you have received, how much do you agree or disagree with each of the following statements? Please indicate your level of agreement or disagreement with each statement.

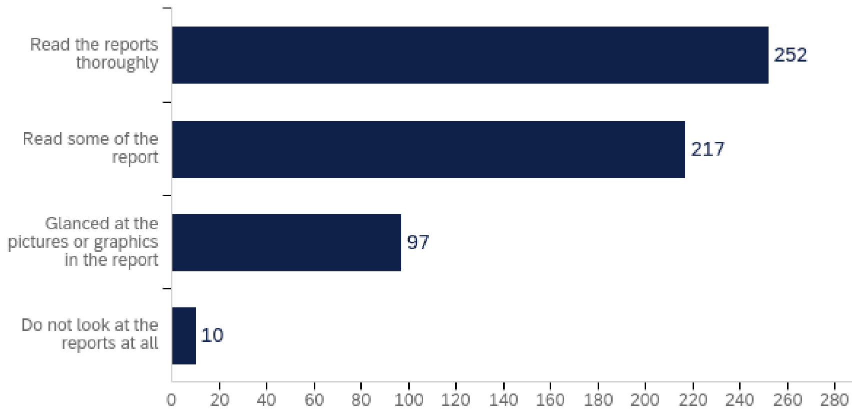


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I like the Home Energy Reports	1.00	6.00	2.38	1.27	1.62	567
2	The Home Energy Reports help me make better decisions to use and save energy	1.00	6.00	2.84	1.39	1.92	565
3	The comparison on the report to other nearby similar homes is fair	1.00	6.00	2.96	1.49	2.23	568
4	" Your top appliance cost" section of the report is useful	1.00	6.00	2.91	1.61	2.60	561
5	The energy usage graph over the past 12 months is helpful	1.00	6.00	2.44	1.30	1.68	570

#	Question	Strongly agree		Somewhat agree		Agree		Somewhat disagree		Strongly disagree		Don't recall	
1	I like the Home Energy Reports	26.43%	185	18.34%	113	22.46%	199	9.96%	28	16.55%	24	8.87%	18
2	The Home Energy Reports help me make better decisions to use and save energy	15.86%	111	21.10%	130	17.83%	158	35.59%	100	23.45%	34	15.76%	32
3	The comparison on the report to other nearby similar homes is fair	14.71%	103	21.75%	134	18.51%	164	26.33%	74	26.21%	38	27.09%	55

#	Question	Strongly agree		Somewhat agree		Agree		Somewhat disagree		Strongly disagree		Don't recall	
4	"Your top appliance cost" section of the report is useful	18.57%	130	18.99%	117	18.74%	166	16.01%	45	20.00%	29	36.45%	74
5	The energy usage graph over the past 12 months is helpful	24.43%	171	19.81%	122	22.46%	199	12.10%	34	13.79%	20	11.82%	24
	Total	Total	700	Total	616	Total	886	Total	281	Total	145	Total	203

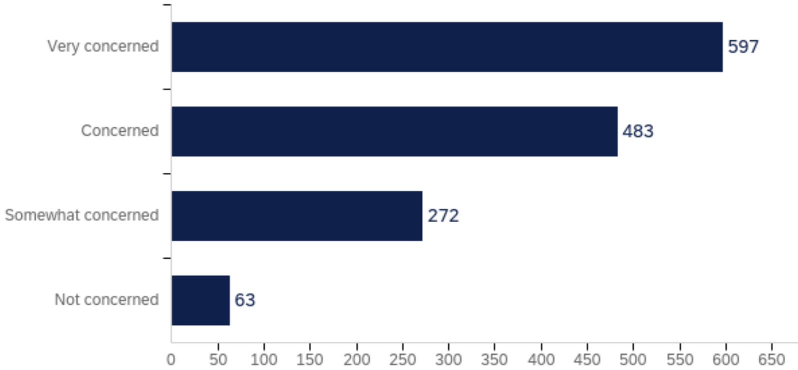
Q16 - Thinking of all the Home Energy Reports you have received, in general, what have you done with them?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Thinking of all the Home Energy Reports you have received, in general, what have you done with them?	1.00	4.00	1.77	0.79	0.62	576

#	Answer	%	Count
1	Read the reports thoroughly	43.75%	252
2	Read some of the report	37.67%	217
3	Glanced at the pictures or graphics in the report	16.84%	97
4	Do not look at the reports at all	1.74%	10
	Total	100%	576

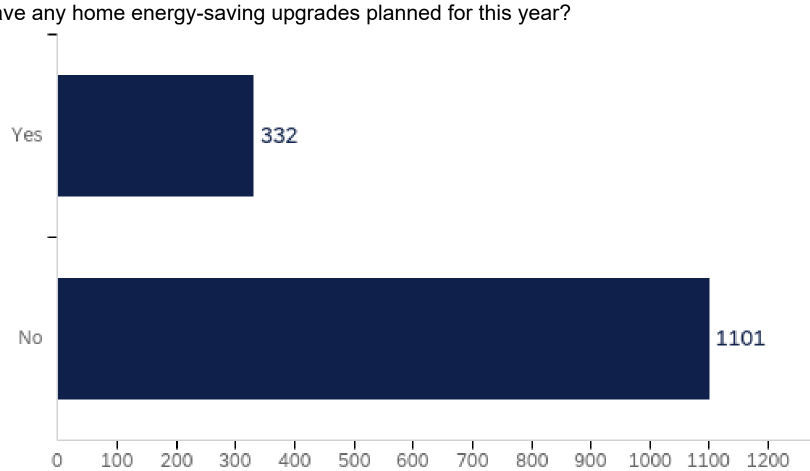
Q17 - How concerned are you with reducing your home's energy use?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	How concerned are you with reducing your home's energy use?	1.00	4.00	1.86	0.88	0.77	1415

#	Answer	%	Count
1	Very concerned	42.19%	597
2	Concerned	34.13%	483
3	Somewhat concerned	19.22%	272
4	Not concerned	4.45%	63
	Total	100%	1415

Q18 - Do you have any home energy-saving upgrades planned for this year?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Do you have any home energy-saving upgrades planned for this year?	1.00	2.00	1.77	0.42	0.18	1433

#	Answer	%	Count
1	Yes	23.17%	332
2	No	76.83%	1101
	Total	100%	1433

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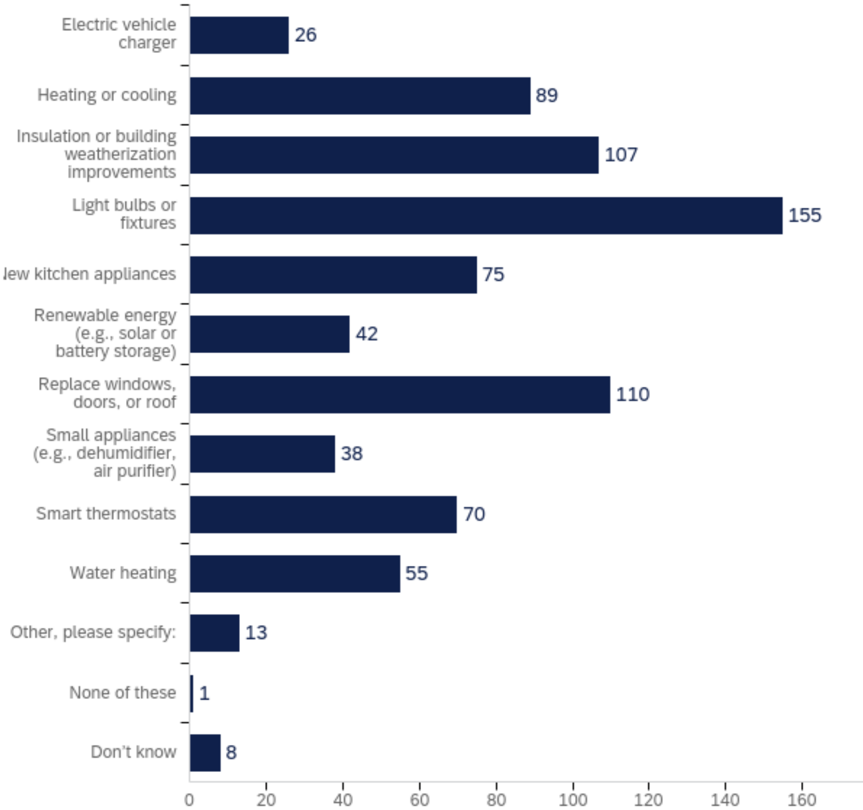
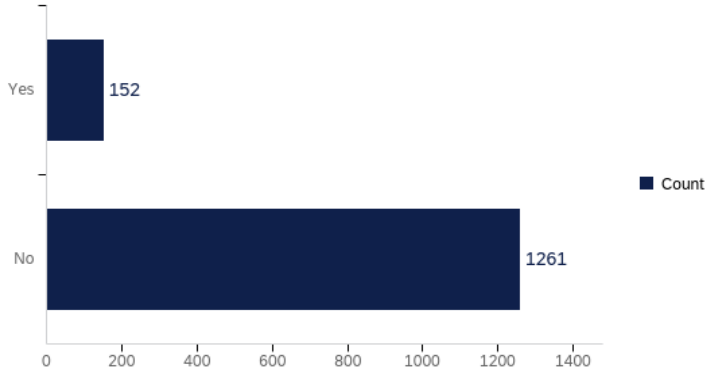
Q19 - What types of upgrades are you considering?



#	Answer	%	Count
1	Electric vehicle charger	7.95%	26
2	Heating or cooling	27.22%	89
3	Insulation or building weatherization improvements	32.72%	107
4	Light bulbs or fixtures	47.40%	155
5	New kitchen appliances	22.94%	75
6	Renewable energy (e.g., solar or battery storage)	12.84%	42
7	Replace windows, doors, or roof	33.64%	110
8	Small appliances (e.g., dehumidifier, air purifier)	11.62%	38
9	Smart thermostats	21.41%	70
10	Water heating	16.82%	55
11	Other, please specify:	3.98%	13
12	None of these	0.31%	1
13	Don't know	2.45%	8
	Total	100%	327

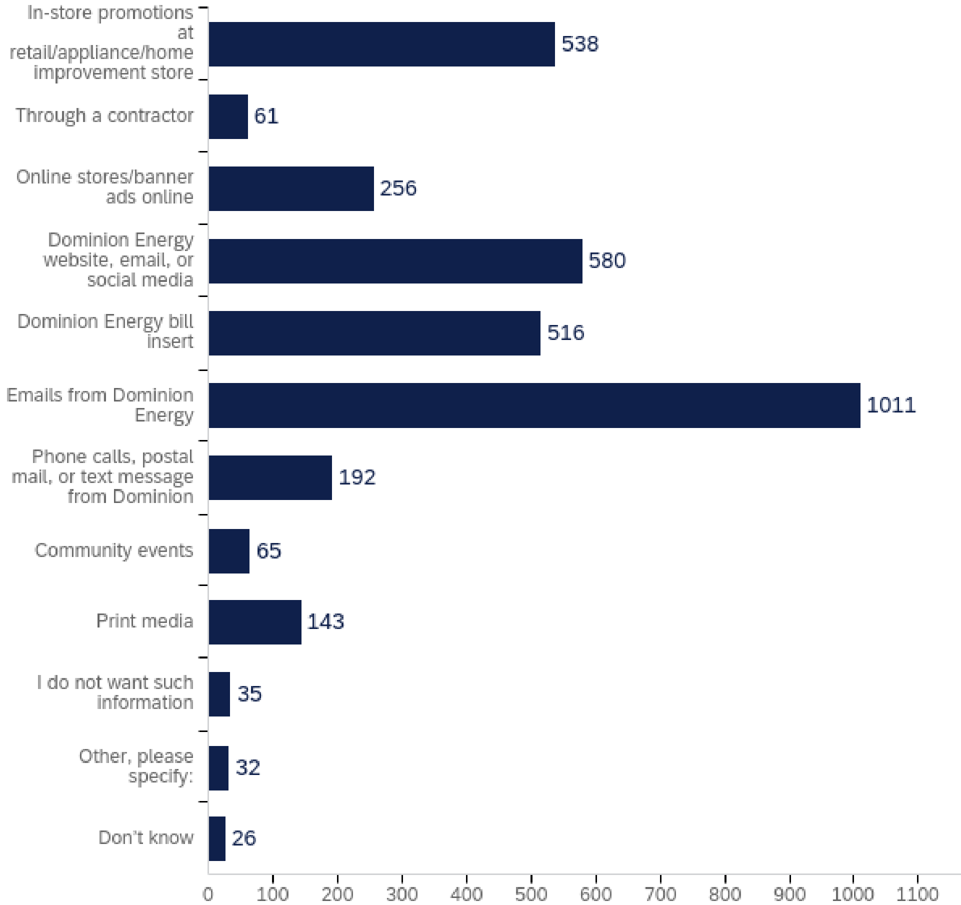
Q20 - Are you aware that the Dominion Energy Marketplace Program offers discounts for various products such as thermostats, air purifiers, LEDs, power strips and smart plugs, weatherization kits, etc.?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Are you aware that the Dominion Energy Marketplace Program offers discounts for various products such as thermostats, air purifiers, LEDs, power strips and smart plugs, weatherization kits, etc.?	1.00	2.00	1.89	0.31	0.10	1413

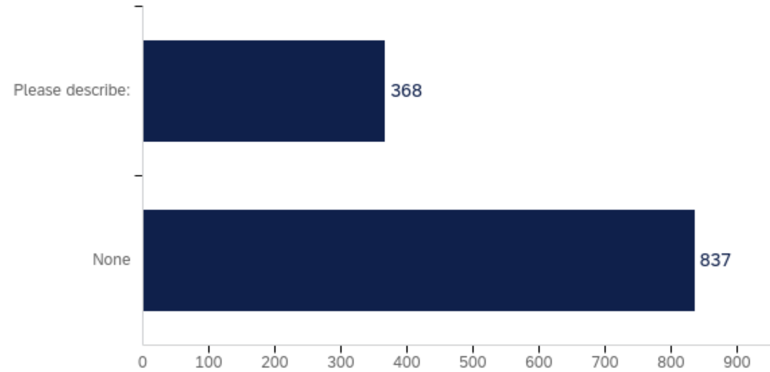
#	Answer	%	Count
1	Yes	10.76%	152
2	No	89.24%	1261
	Total	100%	1413

Q21 - If Dominion Energy wanted to inform customers like you about the future program offerings like rebates and other services, how would you like to receive this information? Select all that apply.



#	Answer	%	Count
1	In-store promotions at retail/appliance/home improvement store	38.43%	538
2	Through a contractor	4.36%	61
3	Online stores/banner ads online	18.29%	256
4	Dominion Energy website, email, or social media	41.43%	580
5	Dominion Energy bill insert	36.86%	516
6	Emails from Dominion Energy	72.21%	1011
7	Phone calls, postal mail, or text message from Dominion	13.71%	192
8	Community events	4.64%	65
9	Print media	10.21%	143
10	I do not want such information	2.50%	35
11	Other, please specify:	2.29%	32
12	Don't know	1.86%	26
	Total	100%	1400

Q25 - Is there anything specific that Dominion Energy can do to improve your experience? If yes, what can we do?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Is there anything specific that Dominion Energy can do to improve your experience? If yes, what can we do? - Selected Choice	1.00	2.00	1.69	0.46	0.21	1205

#	Answer	%	Count
1	Please describe:	30.54%	368
2	None	69.46%	837
	Total	100%	1205

APPENDIX D. IMPACT EVALUATION FIXED EFFECTS MODEL

We estimated monthly savings using a fixed-effects (FE) regression model that is standard for evaluating behavioral programs like Customer Engagement. The FE model estimates program savings by comparing consumption of the recipient group to the non-recipient group before and after program implementation. The change that occurs in the recipient group is adjusted to reflect any change that occurred in the non-recipient group, to isolate changes attributable to the program.

The fixed effects equation is:

$$E_{it} = \mu_i + \lambda_t + \beta_t P_{it} + \varepsilon_{it}$$

Where:

E_{it}	=	Average daily energy consumption for account i during month t
P_{it}	=	Binary variable: one for households in the recipient group in the post period month t, zero otherwise
λ_t	=	Monthly effects
μ_i	=	Account level fixed effect
ε_{it}	=	Regression residual

This model produces estimates of average monthly savings using the following equation:

$$S_t = \beta_t$$

Where:

$\bar{S_t}$	=	Average recipient related consumption reduction during month t
β_t	=	Estimated parameter measuring the recipient group difference in the post period month t

The model also includes site-specific and month/year fixed effects. The site-specific effects control for mean differences between the recipient and non-recipient groups that do not change over time. Baseline energy use is captured by estimates of λt in post-treatment period months. The month/year fixed effects control for change over time that is common to both recipient and non-recipient groups. The monthly post-program dummy variables pick up the average monthly effects of the treatment.

During post-treatment months, the energy use of non-recipient households is estimated by λ while those of the non-recipient households are estimated by $\lambda + \beta$; the latter is a negative term that indicates reduction due to Customer Engagement. This model is consistent

t t

with best practices as delineated in State and Local Energy Efficiency Action Network's (SEE Action) Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations.[3]

[3] https://www.energy.gov/sites/default/files/2021-08/emv_behaviorbased_eeprograms.pdf

APPENDIX E. CUSTOMER ENGAGEMENT PROGRAM EXPERIMENTAL DESIGN

Introduction

Dominion Energy engaged Bidgely to implement the Customer Engagement program, or Home Energy Reports (HER). A fundamentally important aspect of HER program design is the randomized controlled trial (RCT) experimental design. The RCT provides the strongest basis for internal validity and the unbiased estimates of savings expected for these programs. DNV GL recommended that DNV GL, as an independent party, should randomize the two experiments for two reasons:

1. Removes any possibility of a strategic assignment of customers to groups that would still appear random given easily available data.
2. Allows for randomization in a stratified framework which improves the likelihood of balance at the overall level while also facilitating analysis at the stratum level.

Bidgely provided DNV GL a list of customers they consider eligible for the two HER waves. This memo describes the process by which DNV GL randomly assigned eligible customers to the treatment and control groups.[8]

Data Used in the Randomization Process

The randomization utilized the following data:

1. Customer lists to be randomized
2. Residential billing data, comprised of electricity usage and customer characteristics available in the billing system, such as geographical characteristics and dwelling characteristics

Customer Lists

Bidgely provided two lists totaling 413,625 customers:

1. dominion_emailwave_user_list_new.csv
   261,588 records
2. dominion_paperwave_user_list_new.csv
   152,037 records

Each record consists of unique combination of electric account ID, customer ID, and service point ID. There are no duplicates in any of the fields (i.e., the IDs in each record do not appear in any other record.)

Residential Billing Data

DNV GL considered data elements available in the consumption dataset. The strata definitions will facilitate subgroup analysis of the savings. DNV GL chose to use three elements from the Billing data:

1. Dwelling type
2. Geographical location
3. Monthly energy consumption

[8] The terms "treatment" (for recipients) and “control” (non-recipients) are used when referring to the RCT experimental design.

Dwelling Type

The billing data contains six types of premises:

Condo, garden apartment, mid/high rise, and townhouse were combined as multifamily (Multi).

1. Single Family Home, Mobile Home, and premises with usage data but no premise type was classified as single family (Single).
2. Customers with no premise type but with billing data were classified as Single for two reasons: (1) their consumption was comparable to that of single family, and (2) probabilistically, they are more likely to be single family than multifamily.

Geographical Location

DNV GL explored several geographical variables available, including city and assigned weather station. We selected Dominion Energy's regions, which are consistent with other energy savings analyses that Dominion performs.

Monthly Energy Consumption

Measuring change in energy consumption is the ultimate purpose of the RCT. Stratifying by consumption levels both improves the overall balance and also facilitates understanding savings across customers with different consumption characteristics. Rather than stratify by annual consumption bins we chose an approach that that may looks at summer and winter usage separately.

DNV GL used residential billing data for the period January 2018 to April 2019. A calendar year contains data for one summer and two winters (January and February from one winter and December from the following winter.) In order to use billing data that corresponds to one full summer and one full winter, we opted to use billing data from May 2018 to April 2019.[9]

The usage data was classified into three periods: billing periods ending in months June through September were classified as "summer"; November through February were classified as "winter", and the remaining months were classified as "neither winter nor summer". In order to make the data more comparable among customers, we calculated the average daily use for each of these periods (the sum of total kWh divided by the sum of days in the corresponding billing months.)

We tested several options to group average daily use. We picked terciles, separate for winter and summer. This resulted in nine groups, defined by the combinations of low use, medium use, and high use for each season.

Customers with Insufficient or No Billing Data

Some customers could not be classified according to average daily use because they had insufficient billing data in the 15-month billing data file. We required 9 periods or more of billing data in order to classify customers based on daily use. Customers that appeared in the billing data but had an insufficient number of billing months were classified based on region and dwelling type only. Customers with no billing data were assigned to a no-characteristics group.

Randomization Methodology and Verification

After conducting data exploration to select the variables described above, the randomization exercise consisted of assigning customers into 201 strata defined by the characteristics described above, and then randomly assigning the customers in

[9] A stratification using the HER program pre-period consumption data for all customers would produce more up-to-date consumption bins. However, the earlier consumption data do not affect the quality of the randomization. The primary goal is a balanced experiment at the overall level and this stratified approach will provide that.

each stratum into the control group (20% of customers) or treatment group (80%). The strata are defined so that the customers grouped into them are as uniform as possible. Each list (paper and email) was stratified separately.

The following tables detail the number of customers in each classification. The tables also provide treatment and control group mean daily consumption during the 12-month period and the 90% confidence interval of the control group. If the mean of the treatment group is within the confidence interval of the control group, then the difference at that level is not statistically different than zero. All of the groups with available consumption data are balanced at the individual stratum levels.

The list of the 201 strata is presented below.

Table E-1. Region (E=EMAIL, P=PAPER)

List	Region	Treatment Group			Control Group			Difference	Conf. Interval	Difference > 0
		Customer	Mean Daily Use	Std Error	Customer	Mean Daily Use	Std Error			
					Summer					
E	Central	47,400	50.96	0.09	11,860	50.97	0.19	-0.01	0.35	No
E	Eastern	64,590	56.28	0.09	16,158	56.44	0.18	-0.16	0.34	No
E	Northern	67,678	52.38	0.08	16,930	52.21	0.16	0.17	0.30	No
E	Southern	6,278	48.91	0.26	1,581	49.22	0.53	-0.31	0.97	No
E	Western	13,521	45.63	0.16	3,388	45.86	0.33	-0.24	0.61	No
E	_null_	9,759			2,445					
P	Central	30,091	65.32	0.13	7,534	65.28	0.26	0.04	0.48	No
P	Eastern	32,336	76.50	0.15	8,093	76.49	0.29	0.00	0.54	No
P	Northern	41,868	69.57	0.12	10,475	69.50	0.24	0.06	0.44	No
P	Southern	4,120	60.71	0.34	1,041	60.28	0.67	0.43	1.24	No
P	Western	9,420	58.93	0.21	2,361	58.89	0.42	0.04	0.78	No
P	_null_	3,754			944					
	TOTAL	**330,815**			**82,810**					
					Winter					
E	Central	47,400	60.43	0.12	11,860	60.28	0.24	0.15	0.44	No
E	Eastern	64,590	48.11	0.09	16,158	48.01	0.18	0.10	0.33	No
E	Northern	67,678	53.58	0.10	16,930	53.48	0.20	0.10	0.38	No
E	Southern	6,278	64.43	0.34	1,581	64.76	0.68	-0.33	1.25	No
E	Western	13,521	61.44	0.22	3,388	61.55	0.45	-0.11	0.83	No
E	_null_	9,759			2,445					
P	Central	30,091	82.93	0.14	7,534	82.87	0.29	0.06	0.54	No
P	Eastern	32,336	70.07	0.14	8,093	70.08	0.28	-0.01	0.51	No
P	Northern	41,868	78.70	0.13	10,475	78.92	0.27	-0.22	0.49	No
P	Southern	4,120	84.93	0.42	1,041	84.82	0.84	0.12	1.55	No
P	Western	9,420	86.06	0.27	2,361	85.96	0.52	0.10	0.97	No
P	_null_	3,754			944					No
	TOTAL	**330,815**			**82,810**					

Table E-2. Dwelling Type (E=EMAIL, P=PAPER)

List	Dwellin g Type	Treatment Group			Control Group			Difference	Confidenc e Interval	Difference > 0
		Customer s	Mean Daily Use	Std Error	Customer s	Mean Daily Use	Std Error			
					Summer					
E	Multi	33,902	41.51	0.09	8,500	41.37	0.17	0.15	0.32	No
E	Single	165,565	55.04	0.05	41,417	55.10	0.11	-0.06	0.20	No
E	_null_	9,759			2,445					
P	Multi	5,718	58.65	0.30	1,451	58.11	0.58	0.53	1.07	No
P	Single	112,117	69.76	0.07	28,053	69.74	0.15	0.02	0.27	No
P	_null_	3,754			944					
	TOTAL	**330,815**			**82,810**					
					Winter					
E	Multi	33,902	45.66	0.11	8,500	45.53	0.22	0.12	0.40	No
E	Single	165,565	56.08	0.07	41,417	56.02	0.13	0.07	0.24	No

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List	Dwelling Type	Treatment Group Customers	Mean Daily Use	Std Error	Control Group Customers	Mean Daily Use	Std Error	Difference	Confidence Interval	Difference > 0
E	_null_	9,759			2,445					
P	Multi	5,718	75.52	0.34	1,451	75.34	0.66	0.18	1.22	No
P	Single	112,117	78.36	0.08	28,053	78.43	0.16	-0.07	0.29	No
P	_null_	3,754			944					
	TOTAL	**330,815**			**82,810**					

Table E-3. Daily Use Level

List	Daily Use Level	Treatment Group			Control Group			Difference	Confidence Interval	Difference > 0
			Mean Daily Use	Std Error	# Account	Mean Daily Use	Std Error			
Summer										
EMAIL	High Summer High Winter	28,752	77.76	0.12	7,193	77.90	0.24	-0.14	0.45	No
EMAIL	High Summer Low Winter	19,130	71.12	0.11	4,789	71.16	0.22	-0.04	0.40	No
EMAIL	High Summer Med Winter	19,287	76.12	0.14	4,828	75.79	0.27	0.33	0.50	No
EMAIL	Low Summer High Winter	17,753	33.28	0.07	4,442	33.22	0.13	0.06	0.24	No
EMAIL	Low Summer Low Winter	22,131	32.89	0.07	5,538	33.11	0.13	-0.22	0.24	No
EMAIL	Low Summer Med Winter	25,596	33.07	0.05	6,404	33.05	0.10	0.01	0.19	No
EMAIL	Med Summer High Winter	20,609	50.42	0.05	5,157	50.51	0.10	-0.09	0.18	No
EMAIL	Med Summer Low Winter	24,226	50.49	0.05	6,063	50.47	0.09	0.02	0.16	No
EMAIL	Med Summer Med Winter	20,448	49.38	0.05	5,116	49.43	0.10	-0.04	0.19	No
EMAIL	_null_	11,294			2,832					
PAPER	High Summer High Winter	11,494	94.34	0.18	2,879	93.80	0.33	0.54	0.63	No
PAPER	High Summer Low Winter	17,616	96.06	0.14	4,408	95.84	0.27	0.22	0.50	No
PAPER	High Summer Med Winter	10,730	95.02	0.19	2,687	95.59	0.38	-0.57	0.70	No
PAPER	Low Summer High Winter	16,003	44.82	0.09	4,005	44.79	0.17	0.03	0.32	No
PAPER	Low Summer Low Winter	8,461	43.81	0.14	2,121	43.63	0.28	0.18	0.52	No
PAPER	Low Summer Med Winter	14,376	47.16	0.08	3,597	47.29	0.17	-0.13	0.31	No
PAPER	Med Summer High Winter	12,338	66.87	0.07	3,089	66.96	0.14	-0.10	0.26	No
PAPER	Med Summer Low Winter	12,749	67.76	0.07	3,193	67.61	0.14	0.15	0.26	No
PAPER	Med Summer Med Winter	13,528	66.40	0.07	3,386	66.32	0.13	0.09	0.25	No

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List	Daily Use Level	Treatment Group			Control Group			Difference	Confidence Interval	Difference > 0
			Mean Daily Use	Std Error	# Account	Mean Daily Use	Std Error			
PAPER	_null_	4,294			1,083					
TOTAL		**330,815**			**82,810**					
Winter										
EMAIL	High Summer High Winter	28,752	86.34	0.14	7,193	85.92	0.26	0.43	0.49	No
EMAIL	High Summer Low Winter	19,130	30.20	0.06	4,789	30.21	0.11	-0.01	0.20	No
EMAIL	High Summer Med Winter	19,287	50.25	0.06	4,828	50.16	0.13	0.10	0.23	No
EMAIL	Low Summer High Winter	17,753	77.42	0.14	4,442	77.55	0.29	-0.13	0.53	No
EMAIL	Low Summer Low Winter	22,131	30.59	0.07	5,538	30.76	0.13	-0.18	0.25	No
EMAIL	Low Summer Med Winter	25,596	50.33	0.05	6,404	50.26	0.10	0.07	0.19	No
EMAIL	Med Summer High Winter	20,609	80.08	0.14	5,157	80.15	0.28	-0.08	0.52	No
EMAIL	Med Summer Low Winter	24,226	29.54	0.05	6,063	29.60	0.10	-0.06	0.19	No
EMAIL	Med Summer Med Winter	20,448	50.87	0.06	5,116	50.73	0.12	0.13	0.23	No
EMAIL	_null_	11,294			2,832					
PAPER	High Summer High Winter	11,494	107.35	0.19	2,879	107.50	0.36	-0.15	0.67	No
PAPER	High Summer Low Winter	17,616	50.52	0.08	4,408	50.48	0.17	0.03	0.31	No
PAPER	High Summer Med Winter	10,730	75.70	0.08	2,687	75.68	0.16	0.02	0.29	No
PAPER	Low Summer High Winter	16,003	106.07	0.15	4,005	106.10	0.31	-0.03	0.57	No
PAPER	Low Summer Low Winter	8,461	52.38	0.16	2,121	52.50	0.31	-0.12	0.58	No
PAPER	Low Summer Med Winter	14,376	76.48	0.07	3,597	76.44	0.13	0.04	0.24	No
PAPER	Med Summer High Winter	12,338	105.56	0.17	3,089	106.02	0.36	-0.47	0.66	No
PAPER	Med Summer Low Winter	12,749	53.48	0.10	3,193	53.35	0.20	0.13	0.38	No
PAPER	Med Summer Med Winter	13,528	75.87	0.07	3,386	75.94	0.14	-0.07	0.25	No
PAPER	_null_	4,294			1,083					
TOTAL		**330,815**			**82,810**					

Stratification

Table E-3. Full Stratification

Stratum	List	Region	Daily Use Level	Number of Customers	
				Control	Treatment
1	EMAIL	Central	High_Summer/High_Winter	480	121
2	EMAIL	Central	High_Summer/Low_Winter	344	87
3	EMAIL	Central	High_Summer/Med_Winter	293	74
4	EMAIL	Central	Low_Summer/High_Winter	324	81
5	EMAIL	Central	Low_Summer/Low_Winter	405	102
6	EMAIL	Central	Low_Summer/Med_Winter	370	93
7	EMAIL	Central	Med_Summer/High_Winter	317	80
8	EMAIL	Central	Med_Summer/Low_Winter	345	87
9	EMAIL	Central	Med_Summer/Med_Winter	423	106
10	EMAIL	Central	_null_	52	13
11	EMAIL	Central	High_Summer/High_Winter	6,979	1,745
12	EMAIL	Central	High_Summer/Low_Winter	4,156	1,039
13	EMAIL	Central	High_Summer/Med_Winter	3,667	917
14	EMAIL	Central	Low_Summer/High_Winter	3,215	804
15	EMAIL	Central	Low_Summer/Low_Winter	5,582	1,396
16	EMAIL	Central	Low_Summer/Med_Winter	5,631	1,408
17	EMAIL	Central	Med_Summer/High_Winter	4,589	1,148
18	EMAIL	Central	Med_Summer/Low_Winter	4,721	1,181
19	EMAIL	Central	Med_Summer/Med_Winter	5,120	1,281
20	EMAIL	Central	_null_	387	97
21	EMAIL	Eastern	High_Summer/High_Winter	1,546	387
22	EMAIL	Eastern	High_Summer/Low_Winter	969	243
23	EMAIL	Eastern	High_Summer/Med_Winter	896	225
24	EMAIL	Eastern	Low_Summer/High_Winter	866	217
25	EMAIL	Eastern	Low_Summer/Low_Winter	1,316	329
26	EMAIL	Eastern	Low_Summer/Med_Winter	1,137	285
27	EMAIL	Eastern	Med_Summer/High_Winter	983	246
28	EMAIL	Eastern	Med_Summer/Low_Winter	1,053	264
29	EMAIL	Eastern	Med_Summer/Med_Winter	1,290	323
30	EMAIL	Eastern	_null_	140	35
31	EMAIL	Eastern	High_Summer/High_Winter	7,561	1,891
32	EMAIL	Eastern	High_Summer/Low_Winter	5,381	1,346
33	EMAIL	Eastern	High_Summer/Med_Winter	5,385	1,347
34	EMAIL	Eastern	Low_Summer/High_Winter	5,012	1,253
35	EMAIL	Eastern	Low_Summer/Low_Winter	5,351	1,338
36	EMAIL	Eastern	Low_Summer/Med_Winter	7,448	1,863

Stratum	List	Region	Daily Use Level	Number of Customers	
				Control	Treatment
37	EMAIL	Eastern	Med_Summer/High_Winter	5,734	1,434
38	EMAIL	Eastern	Med_Summer/Low_Winter	7,083	1,771
39	EMAIL	Eastern	Med_Summer/Med_Winter	4,998	1,250
40	EMAIL	Eastern	_null_	441	111
41	EMAIL	Northern	High_Summer/High_Winter	2,129	533
42	EMAIL	Northern	High_Summer/Low_Winter	2,670	668
43	EMAIL	Northern	High_Summer/Med_Winter	1,525	382
44	EMAIL	Northern	Low_Summer/High_Winter	2,066	517
45	EMAIL	Northern	Low_Summer/Low_Winter	1,357	340
46	EMAIL	Northern	Low_Summer/Med_Winter	2,729	683
47	EMAIL	Northern	Med_Summer/High_Winter	2,106	527
48	EMAIL	Northern	Med_Summer/Low_Winter	2,128	532
49	EMAIL	Northern	Med_Summer/Med_Winter	1,914	479
50	EMAIL	Northern	_null_	85	22
51	EMAIL	Northern	High_Summer/High_Winter	6,772	1,693
52	EMAIL	Northern	High_Summer/Low_Winter	4,060	1,016
53	EMAIL	Northern	High_Summer/Med_Winter	5,696	1,425
54	EMAIL	Northern	Low_Summer/High_Winter	4,793	1,199
55	EMAIL	Northern	Low_Summer/Low_Winter	5,419	1,355
56	EMAIL	Northern	Low_Summer/Med_Winter	5,947	1,487
57	EMAIL	Northern	Med_Summer/High_Winter	4,972	1,243
58	EMAIL	Northern	Med_Summer/Low_Winter	6,648	1,663
59	EMAIL	Northern	Med_Summer/Med_Winter	4,404	1,101
60	EMAIL	Northern	_null_	258	65
61	EMAIL	Southern	High_Summer/High_Winter	51	13
62	EMAIL	Southern	High_Summer/Low_Winter	21	6
63	EMAIL	Southern	High_Summer/Med_Winter	27	7
64	EMAIL	Southern	Low_Summer/High_Winter	26	7
65	EMAIL	Southern	Low_Summer/Low_Winter	43	11
66	EMAIL	Southern	Low_Summer/Med_Winter	29	8
67	EMAIL	Southern	Med_Summer/High_Winter	23	6
68	EMAIL	Southern	Med_Summer/Low_Winter	34	9
69	EMAIL	Southern	Med_Summer/Med_Winter	40	10
70	EMAIL	Southern	_null_	5	2
71	EMAIL	Southern	High_Summer/High_Winter	1,008	253
72	EMAIL	Southern	High_Summer/Low_Winter	400	101
73	EMAIL	Southern	High_Summer/Med_Winter	600	151
74	EMAIL	Southern	Low_Summer/High_Winter	435	109
75	EMAIL	Southern	Low_Summer/Low_Winter	904	227

Stratum	List	Region	Daily Use Level	Number of Customers Control	Number of Customers Treatment
76	EMAIL	Southern	Low_Summer/Med_Winter	622	156
77	EMAIL	Southern	Med_Summer/High_Winter	568	143
78	EMAIL	Southern	Med_Summer/Low_Winter	649	163
79	EMAIL	Southern	Med_Summer/Med_Winter	733	184
80	EMAIL	Southern	_null_	60	15
81	EMAIL	Western	High_Summer/High_Winter	202	51
82	EMAIL	Western	High_Summer/Low_Winter	123	31
83	EMAIL	Western	High_Summer/Med_Winter	126	32
84	EMAIL	Western	Low_Summer/High_Winter	119	30
85	EMAIL	Western	Low_Summer/Low_Winter	165	42
86	EMAIL	Western	Low_Summer/Med_Winter	155	39
87	EMAIL	Western	Med_Summer/High_Winter	131	33
88	EMAIL	Western	Med_Summer/Low_Winter	153	39
89	EMAIL	Western	Med_Summer/Med_Winter	155	39
90	EMAIL	Western	_null_	16	4
91	EMAIL	Western	High_Summer/High_Winter	2,024	506
92	EMAIL	Western	High_Summer/Low_Winter	1,006	252
93	EMAIL	Western	High_Summer/Med_Winter	1,072	268
94	EMAIL	Western	Low_Summer/High_Winter	897	225
95	EMAIL	Western	Low_Summer/Low_Winter	1,589	398
96	EMAIL	Western	Low_Summer/Med_Winter	1,528	382
97	EMAIL	Western	Med_Summer/High_Winter	1,186	297
98	EMAIL	Western	Med_Summer/Low_Winter	1,412	354
99	EMAIL	Western	Med_Summer/Med_Winter	1,371	343
100	EMAIL	Western	_null_	91	23
101	EMAIL	_null_	_null_	9,759	2,445
102	PAPER	Central	High_Summer/High_Winter	57	15
103	PAPER	Central	High_Summer/Low_Winter	56	15
104	PAPER	Central	High_Summer/Med_Winter	52	14
105	PAPER	Central	Low_Summer/High_Winter	63	16
106	PAPER	Central	Low_Summer/Low_Winter	52	14
107	PAPER	Central	Low_Summer/Med_Winter	48	12
108	PAPER	Central	Med_Summer/High_Winter	44	12
109	PAPER	Central	Med_Summer/Low_Winter	55	14
110	PAPER	Central	Med_Summer/Med_Winter	62	16
111	PAPER	Central	_null_	8	2
112	PAPER	Central	High_Summer/High_Winter	3,295	824
113	PAPER	Central	High_Summer/Low_Winter	4,044	1,012
114	PAPER	Central	High_Summer/Med_Winter	2,672	668

Stratum	List	Region	Daily Use Level	Number of Customers	
				Control	Treatment
115	PAPER	Central	Low_Summer/High_Winter	3,658	915
116	PAPER	Central	Low_Summer/Low_Winter	2,524	632
117	PAPER	Central	Low_Summer/Med_Winter	3,583	896
118	PAPER	Central	Med_Summer/High_Winter	3,052	764
119	PAPER	Central	Med_Summer/Low_Winter	3,158	790
120	PAPER	Central	Med_Summer/Med_Winter	3,462	866
121	PAPER	Central	_null_	146	37
122	PAPER	Eastern	High_Summer/High_Winter	142	36
123	PAPER	Eastern	High_Summer/Low_Winter	148	37
124	PAPER	Eastern	High_Summer/Med_Winter	126	32
125	PAPER	Eastern	Low_Summer/High_Winter	159	40
126	PAPER	Eastern	Low_Summer/Low_Winter	130	33
127	PAPER	Eastern	Low_Summer/Med_Winter	120	30
128	PAPER	Eastern	Med_Summer/High_Winter	114	29
129	PAPER	Eastern	Med_Summer/Low_Winter	128	33
130	PAPER	Eastern	Med_Summer/Med_Winter	160	41
131	PAPER	Eastern	_null_	15	4
132	PAPER	Eastern	High_Summer/High_Winter	2,838	710
133	PAPER	Eastern	High_Summer/Low_Winter	4,944	1,237
134	PAPER	Eastern	High_Summer/Med_Winter	2,737	685
135	PAPER	Eastern	Low_Summer/High_Winter	4,388	1,098
136	PAPER	Eastern	Low_Summer/Low_Winter	2,032	508
137	PAPER	Eastern	Low_Summer/Med_Winter	3,820	955
138	PAPER	Eastern	Med_Summer/High_Winter	3,288	822
139	PAPER	Eastern	Med_Summer/Low_Winter	3,279	820
140	PAPER	Eastern	Med_Summer/Med_Winter	3,623	906
141	PAPER	Eastern	_null_	145	37
142	PAPER	Northern	High_Summer/High_Winter	308	78
143	PAPER	Northern	High_Summer/Low_Winter	559	140
144	PAPER	Northern	High_Summer/Med_Winter	339	85
145	PAPER	Northern	Low_Summer/High_Winter	506	127
146	PAPER	Northern	Low_Summer/Low_Winter	312	78
147	PAPER	Northern	Low_Summer/Med_Winter	360	90
148	PAPER	Northern	Med_Summer/High_Winter	392	98
149	PAPER	Northern	Med_Summer/Low_Winter	305	77
150	PAPER	Northern	Med_Summer/Med_Winter	480	120
151	PAPER	Northern	_null_	8	2
152	PAPER	Northern	High_Summer/High_Winter	3,284	822
153	PAPER	Northern	High_Summer/Low_Winter	6,164	1,541

Stratum	List	Region	Daily Use Level	Number of Customers	
				Control	Treatment
154	PAPER	Northern	High_Summer/Med_Winter	3,509	878
155	PAPER	Northern	Low_Summer/High_Winter	5,546	1,387
156	PAPER	Northern	Low_Summer/Low_Winter	2,186	547
157	PAPER	Northern	Low_Summer/Med_Winter	4,901	1,226
158	PAPER	Northern	Med_Summer/High_Winter	4,143	1,036
159	PAPER	Northern	Med_Summer/Low_Winter	4,293	1,074
160	PAPER	Northern	Med_Summer/Med_Winter	4,131	1,033
161	PAPER	Northern	_null_	142	36
162	PAPER	Southern	High_Summer/High_Winter	11	3
163	PAPER	Southern	High_Summer/Low_Winter	14	4
164	PAPER	Southern	High_Summer/Med_Winter	15	4
165	PAPER	Southern	Low_Summer/High_Winter	17	5
166	PAPER	Southern	Low_Summer/Low_Winter	13	4
167	PAPER	Southern	Low_Summer/Med_Winter	9	3
168	PAPER	Southern	Med_Summer/High_Winter	12	4
169	PAPER	Southern	Med_Summer/Low_Winter	12	4
170	PAPER	Southern	Med_Summer/Med_Winter	16	4
171	PAPER	Southern	High_Summer/High_Winter	456	115
172	PAPER	Southern	High_Summer/Low_Winter	503	126
173	PAPER	Southern	High_Summer/Med_Winter	387	97
174	PAPER	Southern	Low_Summer/High_Winter	514	129
175	PAPER	Southern	Low_Summer/Low_Winter	368	93
176	PAPER	Southern	Low_Summer/Med_Winter	431	108
177	PAPER	Southern	Med_Summer/High_Winter	371	93
178	PAPER	Southern	Med_Summer/Low_Winter	442	111
179	PAPER	Southern	Med_Summer/Med_Winter	489	123
180	PAPER	Southern	_null_	40	11
181	PAPER	Western	High_Summer/High_Winter	32	8
182	PAPER	Western	High_Summer/Low_Winter	32	8
183	PAPER	Western	High_Summer/Med_Winter	34	9
184	PAPER	Western	Low_Summer/High_Winter	36	9
185	PAPER	Western	Low_Summer/Low_Winter	28	8
186	PAPER	Western	Low_Summer/Med_Winter	31	8
187	PAPER	Western	Med_Summer/High_Winter	30	8
188	PAPER	Western	Med_Summer/Low_Winter	35	9
189	PAPER	Western	Med_Summer/Med_Winter	30	8
190	PAPER	Western	_null_	3	1
191	PAPER	Western	High_Summer/High_Winter	1,071	268
192	PAPER	Western	High_Summer/Low_Winter	1,152	288

Stratum	List	Region	Daily Use Level	Number of Customers	
				Control	Treatment
193	PAPER	Western	High_Summer/Med_Winter	859	215
194	PAPER	Western	Low_Summer/High_Winter	1,116	279
195	PAPER	Western	Low_Summer/Low_Winter	816	204
196	PAPER	Western	Low_Summer/Med_Winter	1,073	269
197	PAPER	Western	Med_Summer/High_Winter	892	223
198	PAPER	Western	Med_Summer/Low_Winter	1,042	261
199	PAPER	Western	Med_Summer/Med_Winter	1,075	269
200	PAPER	Western	_null_	33	9
201	PAPER	_null_	_null_	3,754	944
	TOTAL			**330,815**	**82,810**

APPENDIX F. EM&V WORKPLAN

Program Year 2021-2022

Residential Customer Engagement Program
Impact Evaluation Work Plan

Dominion Energy

Introduction

The following workplan describes the annual impact evaluation of the Residential Customer Engagement Program (CEP) administered by the Virginia Electric and Power Company (Dominion Energy). The 2022 CEP evaluation covers program years (PY) 2021 and 2022 and follows the timing and methods specified in the CEP EM&V Plan (Appendix B).1 PY' 2021 and 2022 are being combined into one evaluation because report delivery was interrupted for several months in 2021. The evaluation will take these program interruptions into account and impacts will be reported separately for PY2021 and PY2022.

Program background

The Phase VIII Residential Customer Engagement Program provides educational insights to customers about their energy consumption via periodic digital or paper home energy reports (HER). The HER provides suggestions and "nudges" on how to save energy. HERs include information such as a customer's energy usage, a personalized savings plan, energy saving tips, usage comparisons to nearby homes, and information about other Dominion Energy demand side management (DSM) programs.

Evaluation approach

The CEP is structured as a randomized controlled trial (RCT). The CEP impact analysis will produce gross and net program energy savings using consumption data analysis by estimating changes in energy use of the RCT treatment group relative to the control group using a pooled fixed-effects model (Appendix A). An objective of CEP is to encourage participation in Dominion Energy's DSM programs. Energy impacts of increased program participation for CEP participants (and influenced by HERs) rates is also estimated and reported.

Uplift estimation

The evaluation explores whether the HERs result in increased participation rates (or uplift) in other DSM programs. DNV reviewed the downstream participation of the treatment and control groups (~16%) and there are no significant differences between the groups. Uplift is typically 3% of gross savings for other utility behavior programs but based on the comparison of CEP , will likely be lower for CEP.

The study will report the aggregate savings from the uplift of the added program measures attributed to participation in CEP. The combined (joint) savings from the CEP and other DSM programs is accounted for by calculating the "uplift" attributed to CEP. For example, if on average the control group purchased 5 LED lamps and the treatment group purchased 7 LED lamps, the savings from the additional 2 lamps are considered "program uplift" and reported as such.

From an accounting standpoint, because the DSM program impacts have already been claimed by the other programs (in the case of lamps, the Residential Efficient Products Marketplace program) the savings attributed to the uplift are reported in the CEP evaluation but are claimed by the associated DSM programs to avoid double counting.

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[1] Appendix to the Dominion Energy Evaluation, Measurement, And Verification (EM&V) Plans, Case No. PUR-2020-00274 (Virginia), Docket No. E-22 Sub 604 (North Carolina), VOLUME 2 OF 5, June 15, 2022, Prepared by DNV Energy Insights USA Inc. (DNV).

Uplift can occur when the treatment group:

- Install more program measures than the control group
- Install rebate program measures generating higher savings than the control households, and/or
- Install program measures earlier than control households, regardless of the level of savings.

Evaluation plan

Experimental design

The eligible CEP population of Dominion Energy customers, as identified by the program implementers was randomly assigned to the treatment and control group (by DNV) before the program's launch in 2021. The RCT design results in an unbiased estimates of savings per household because the only systematic difference between randomly assigned treatment and control households is the treatment, or the HERs.

Eighty percent of the eligible population were assigned to the treatment group, and 20% to the control group.2 Group assignment were stratified by customer energy usage in three billing periods for three usage bins for each season: summer, winter, and neither summer or winter (low usage, medium usage, and high usage). Other strata included housing type (single family and multifamily) and region (Office ID).

Impact analysis

The evaluation approach will be broken into two components:

1. Program impacts are calculated for the treatment group relative to the control group.
2. Uplift savings impacts from CEP-inspired activities in other Dominion Energy DSM programs There are two types of uplift:

    a. **Incentive program uplift.** All non-upstream savings that are calculated for the 2021 and 2022 tracking da

    b. **Upstream program uplift.** Upstream refers to the program that produce energy savings by incentivizing markets actors upstream of the end-customer (such as LEDS sold at retail outlets). In the Dominion Energy case these savings are taken by the Residential Energy Efficient Marketplace Program or prior iterations of this program, where incentives are offered to lighting manufacturers, and the discounts are passed to customers in stores.[3] Because LED sales are not tracked at the customer level, uplift for lamp sales are determined from a short customer survey (Appendix B). The survey asks customers in the treatment and control group about their lighting purchase history over the past five years.[4]

[2] "Dominion DSM7 RCEB Experimental Design Randomization" memo. From Paula Ham-Su, Ken Agnew, DNV GL. December 21, 2020.

[3] Dominion Energy's Residential Efficient Products Marketplace program has been in place since 2019. Prior to this program Dominion Energy also offered the Residential Retail LED program as part of the Phase IV DSM programs.

[4] A five-year estimate is selected because the measure life of CFL and LEDs is five years or more

Incentive program uplift estimation

The evaluation will develop an incentive program uplift adjustment that also makes use of the CEP RCT. All incentive program activity by CEP treatment and control group participants will be aggregated and compared on an average per-customer basis. If the average cumulative incentive program-related savings stream of treatment group customers is greater than control group customers incentive program-related savings, then that estimate is deducted from CEP's overall measured savings to produce net savings.

The incentive program uplift adjustment will use Dominion Energy's tracking and end-use load shape data, produced by DNV, to quantify net energy savings for CEP participants. HERs generate a flow of savings throughout a program year that increases or decreases as the consumption of the treatment group changes compared to the control group. However, rebate savings are generally reported on an annual basis and do not account for when measures were installed, how long they last, or when during the year savings from such measures happen. To account for rebate program savings in a way that is consistent with the measured CEP savings, this evaluation will consider:

- When savings started to accrue (installation date for downstream measures and rebate year for upstream measures
- The time frame of accrued savings (taken from existing program load shapes)
- Measure life

Upstream program uplift estimation

Upstream uplift will be estimated using data from surveys that are conducted by DNV with both treatment and control groups. Survey data will indicate whether lighting products supported by Dominion Energy's upstream program (e.g., Residential Energy Efficient Product Program) have been purchased. Dominion Energy's tracking data the lighting measures in this program does not contain customer-specific data that can link CEP participants to these upstream programs directly through tracking data.

DNV will assess whether to conduct the uplift survey on a sample or a census of customers. If a sampling methodology is employed, sampling will use a stratified ratio estimation method. The sample design approach first will place participants into groups of interest (e.g., treatment status – control or participant) and stratify customers by energy usage.)

Upstream and downstream program activity by the treatment and control group participants is aggregated on a per-customer basis. If the average cumulative upstream program-related savings stream of treatment group customer is greater than control group customers upstream program-related savings, then that estimate is used to adjust overall CEP savings estimates for the treatment group. Table F-1 summarizes the program participation and gross annualized energy savings for the CEP in 2021 and 2022.

CEP participation

Table F-11. CEP participation by year

Year	Treatment Participants (N)	Control Participants (N)	Total Participants (N)
2021	313,542	82,086	395,628
2022	365,226	82,086	447,312

Data requirements

The impact evaluation will use data from the following sources shown in Table F-2 through Table F-5.

Table F-2. Data types used in the analysis

Data type	Data description	Data source	Status
Customer information	Customer data from Table 3-3	CEP BI data matched to implementer report delivery tracking data and participant email addresses	From Bidgely only, to be requested immediately, for delivery two weeks following request
Billing data	Monthly energy usage from Table 3 4 (2021–2022)	Dominion Energy DSP	DNV to request Q4 2022 only (DSP)
Program tracking data	BI data specified in Table 3-4	Dominion Energy BI team	Data is already in DNVs possession
Upstream Lighting Survey data	See Appendix A for sample survey	DNV	To be collected by DNV

Table F-3. Customer data requirements (provided by Bidgely)

Customer Information
Electric account number
Electric premise number
Customer name
Customer address
Customer phone
Customer email
Service point ID
Deployment wave
Report type
Recipient status
Account inactive date (closed account)
Account opt-out date (customer requested no report)
Report sent date(s)

DNV will make a data request to Bidgely for the tracking data that details the dates that reports were sent to participants. Table F-4 lists the minimum required fields. Bidgely does not need to create a new dataset for the analysis, the existing format of their tracking data is sufficient. DNV will extract the required fields from their existing format.

Table F-4. Billing data fields

Billing Data
Electric account number
Electric premise number
Meter read date
Billing code (i.e., estimated, or actual)
Consumption in kWh

Table F-5. Tracking data fields (from BI data)

Billing Data
Program
Measure name
Install date
Total savings
Unit of measure

Project management and reporting

Table F-6 shows the high-level evaluation schedule.

Table F-6. Evaluation and reporting schedule

Tasks / Milestones	December 2022	January 2023	February 2023
Planning			
Data Management			
Analysis			
Presentation to Dominion Energy			
Impact Report Draft			
Impact Report Final			

Fixed effects model

The evaluation will use a two-stage billing analysis approach. This approach determines the program impacts by examining the change in participant's usage and demand patterns over time. The impact estimate is further refined by measuring a representative comparison group’s change in usage over a similar time frame. This allows us to determine how energy usage would have changed among program participants had the program not been offered. Measure level savings will be reported to the extent they are statistically significant.

The evaluation will use a fixed-effects (FE) regression model that is standard for evaluating behavioral programs like HER. The FE model estimates program savings by comparing consumption of the treatment group to the control group before and after program implementation. The change that occurs in the treatment group is adjusted to reflect any change that occurred in the control group, to isolate changes attributable to the program.

The fixed effects equation is:

$$EE_{iiii} = \mu\mu_{ii} + \lambda\lambda_{ii} + \beta\beta_{ii} PP_{iiii} + \varepsilon\varepsilon_{iiii}$$

Where:

EE_{iiii}	=	Average daily energy consumption for account ii during month tt
PP_{iiii}	=	Binary variable: one for households in the treatment group in the post period month t, zero otherwise
$\lambda\lambda_{ii}$	=	Monthly effects
$\mu\mu_{ii}$	=	Account level fixed effect
$\varepsilon\varepsilon_{iiii}$	=	Regression residual

This model produces estimates of average monthly savings using the following equation:

$$S_{i} = \beta\beta$$

Where:

SS_{ii}	=	Average treatment related consumption reduction during month *t*
$\beta\beta$	=	Estimated parameter measuring the treatment group difference in the post period month *t*

The model also includes site-specific and month/year fixed effects. The site-specific effects control for mean differences between the treatment and control groups that do not change over time. Baseline energy use is captured by estimates of $\lambda\lambda tt$ in post-treatment period months. The month/year fixed effects control for change over time that is common to both treatment and control groups. The monthly post-program dummy variables pick up the average monthly effects of the treatment.

During post-treatment months, the energy use of control households is estimated by λ_t while those of the treatment households is estimated by $\lambda_t + \beta_t$; the latter is a negative term that indicates reduction due to HER. This model is consistent with best practices as delineated in the SEE Action EM&V of Residential Behavior-Based Programs.[5]

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5 State and Local Energy Efficiency Action Network's (SEE Action) Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations https://www.energy.gov/sites/default/files/2021- 08/emv_behaviorbased_eeprograms.pdf

DNV

APPENDIX G. SAMPLE SURVEY

Below is a sample of a typical upstream survey for a behavior program impact analysis.

Q1

We'd like to hear from you! To help improve Dominion Energy's existing energy efficiency programs and rebates, we are requesting your participation in Dominion Energy Residential Energy Survey. This brief survey should take 5 minutes or less to complete and your responses are confidential. Please use the buttons at the bottom of each screen to navigate the survey. If you have any questions about this survey, you may contact, Name, Dominion@email address or Phone number

Q2

Customer Name

Q3

Address

Q4

City

Q5

Email

Q6

Site ID

Q7

Is your home address [Q3], [Q4]?	Response percent
Yes	0.00%
No	0.00%

Q8	
Does anyone in your household currently work for a gas or electric utility company, including Doiminion Energy?	**Response percent**
Yes	0.00%
No	0.00%

Q9	
Are you familiar with your household's purchases of energy-saving light bulbs bought in 2020?	**Response percent**
Yes	0.00%
No	0.00%
Don't know	0.00%

DNV

Q10

We would like to learn more about your past purchases of light-emitting diode (LED) and light bulbs.

Q11

Q12

LED light bulbs are the most efficient light bulbs available on the market and come in many shapes and sizes. In this section we would like to learn about your LED purchases made in 2020 for your home.

Q13

Did you or anyone in your household purchase LED light bulbs in 2020?	Response percent
Yes	0.00%
No	0.00%
Don't know	0.00%

Q14

Approximately, how many LED bulbs did your household purchase? If you purchased any multi-pa	Mean
	---

Q15

How many of the [L2] LED bulbs that you purchased in 2020 are currently installed in or around your home?	Response percent
All of them (100%)	0.00%
Most of them (75%)	0.00%
Some of them (50%)	0.00%
A few of them (25%)	0.00%
None of them (0%)	0.00%
Don't know	0.00%

Q16

What type of bulb did the majority of these LED bulbs replace? Was it...	Response percent
CFL	0.00%
LED	0.00%
Incandescent	0.00%
Halogen	0.00%
A mix of CFL and other bulbs	0.00%
Don't know	0.00%
If other, specify	

Q17

What did you do with the bulbs you did NOT install? Did you....?	Response percent
Store them in your home	0.00%
Gave them away	0.00%
Return them to the store	0.00%
Don't know	0.00%
Did something else with them (describe):	0.00%

Q18

Home Energy Survey - Program Experience

Q19

How familiar are you with Doiminion Energy's energy efficiency or conservation programs that are designed to help you identify ways to use less energy and lower your bill?	Response percent
Not at all familiar	0.00%
Not very familiar	0.00%
Somewhat familiar	0.00%
Very familiar	0.00%

Q20

Are you aware that Doiminion Energy offers discounts on energy-efficient lighting in retail stores?	Response percent
Yes	0.00%
No	0.00%

Q21

Has your household received Doiminion Energy Home Energy Report that rates your home's energy use and compares it with similar homes in your area?	Response percent
Yes	0.00%
No	0.00%
Don't know	0.00%

Q22

Do you recall seeing any of the following advertisements or messages in your Home Energy Report? Check all that apply	Response percent
Appliance replacement - "Upgrade your fridge or clothes washer for free"	0.00%
Fridge recycle - "Old fridges can help feed families"	0.00%
Heating upgrade - "Get a warmer home and a hot deal"	0.00%
Outage App - "Be prepared, stay connected"	0.00%
"Start saving today"	0.00%
Upgrade - "Last chance to score an upgrade"	0.00%
Welcome - "Say hello to your first eHER"	0.00%
None of these	0.00%

Q23

Taking into consideration all aspects of the Home Energy Report, please rate your satisfaction with the report. Rate your level of satisfaction on a 1 to 5 scale where 1 represents "very unsatisfied" and 5 represents "very satisfied".

Q24

Please rate your interest in receiving the following information from Doiminion Energy. Rate your level of interest on a 1 to 5 scale where 1 represents "very uninterested" and 5 represents "very interested".

Response percent	**1. 1-Very uninterested**
Receive Home Energy Reports by email	0.00%
Receive bill notifications by email	0.00%
Receive email notice when the home has unusual high energy usage	0.00%
Receive emails bi-annually with seasonal tips on how make your home more efficient	0.00%

Response total	**1. 1-Very uninterested**
Receive Home Energy Reports by email	0
Receive bill notifications by email	0
Receive email notice when the home has unusual high energy usage	0
Receive emails bi-annually with seasonal tips on how make your home more efficient	0

Q25

Do you have any suggestions to improve the delivery of Doiminion Energy's Home Energy Report Program or any other energy efficiency programs? If so, describe below:

Q26

Thank you very much for your time and opinions. Please click on the "submit" button when finished.

Q27

About Your Home & Household

Q28

Do you own or rent?	**Response percent**
Own	0.00%
Rent	0.00%

Q29

Which of the following building types best describes your home?	**Response percent**
Single-family detached home (home not attached to another home)	0.00%
Townhouse, duplex, or row house (shares exterior walls with neighboring unit, but not roof or floor)	0.00%
Apartment or condominium (2–4 units)	0.00%
Apartment or condominium (5 or more units)	0.00%
Mobile home	0.00%
Other	0.00%

Q30

Approximately how many square feet of living space is there in your home, including bathrooms, foyers and hallways? Exclude garages, basements or unheated porches.	Response percent
Less than 250 SQFT	0.00%
250–500	0.00%
501–750	0.00%
751–1,000	0.00%
1,001 – 1,250	0.00%
1,251 – 1,500	0.00%
1,501 – 2,000	0.00%
2,001 – 2,500	0.00%
2,501 – 3,000	0.00%
3,001 – 4,000	0.00%
4,001 – 5,000	0.00%
More than 5,000 SQFT	0.00%
Don't know	0.00%

Q31

Approximately what year was this property built?	Response percent
Before 1940	0.00%
1940-1969	0.00%
1970-1979	0.00%
1980-1989	0.00%
1990-1999	0.00%
2000-2009	0.00%
2010-2020	0.00%
Don't know	0.00%

Q32

For each of the following age groups, how many people, including yourself, live in this home year-round? Please select one response for each age category.

Response percent	1. None
Age category	0.00%
5 and under	0.00%
6–18	0.00%
19–34	0.00%
35–54	0.00%
55–64	0.00%
65 and over	0.00%

Response total	1. None
Age category	0
5 and under	0
6–18	0
19–34	0
35–54	0
55–64	0
65 and over	0

Q33

What is the highest degree or level of school you have completed? If you're currently enrolled in school, please indicate the highest degree you have received.	Response percent
Less than a high school diploma	0.00%
High school degree or equivalent	0.00%
Vocational/trade school or associate degree	0.00%
Bachelor's degree (e.g., BA, BS)	0.00%
Master's degree (e.g., MA, MS, MEd)	0.00%
Doctorate (e.g., PhD, MD, EdD)	0.00%
Prefer not to say	0.00%
Other (please specify)	0.00%

Q34

What is the primary household language?	Response percent
English	0.00%
Spanish	0.00%
Chinese (including Mandarin and Cantonese)	0.00%
Tagalog	0.00%
Vietnamese	0.00%
Korean	0.00%
Prefer not to say	0.00%
Other (please specify)	0.00%

Q35

This information is collected for internal purposes only and remains confidential. Please check the range that best describes your household's 2019 total annual income.	Response percent
Less than $10,000	0.00%
$10,000 – $19,999	0.00%
$20,000 – $24,999	0.00%
$25,000 – $49,999	0.00%
$50,000 – $74,999	0.00%
$75,000 – $99,999	0.00%
$100,000 – $149,999	0.00%
$150,000 – $174,999	0.00%
$175,000 – $199,999	0.00%
$200,000 – $249,999	0.00%
$250,000 or more	0.00%
Prefer not to say	0.00%

Q36

This concludes our survey. As a thank you for your participation your response will be entered into a drawing for a $100 Amazon e-gift card. If selected as the winning respondent you will be notified by email. Would you like to be included in the incentive drawing?	Response percent
Yes, include my response in the drawing	0.00%
No, exclude my response in the drawing	0.00%

DNV

APPENDIX H. EM&V PLAN-RESIDENTIAL CUSTOMER ENGAGEMENT PROGRAM SECTION E

E5. RESIDENTIAL CUSTOMER ENGAGEMENT PROGRAM EM&V PLAN

E5.1. Program Summary

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

E5.2. Measures

The measures included in the kit offered by the Residential Customer Engagement Program (CEP) are listed inTable 5-1.

Table 5-1. Measures Offered by Residential Customer Engagement Program

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

E5.3. Evaluation, Measurement, and Verification Overview

DNV will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[16] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV's savings evaluation approach is:

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

The evaluation methods described in the following EM&V plan meets the standards of section A of 20 VAC 5-318-40 and the final order of SCC Case No. PUR-2020-00156 ("Final Order").[17]

E5.4. Deemed Savings Approach

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

[16] 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

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

consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

E5.5. Evaluated Savings Approach

The program specific evaluated savings approach is guided by a Value of Information (VOI) framework outlined in the Final Order.[18]

The CEP will be evaluated using billing analysis as recommended by Chapter 17, Residential Behavior Evaluation Protocol of the Uniform Methods Project (UMP).[19]

E5.5.1. Savings Estimation

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

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

Incentive Program Uplift Estimation

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

Upstream Program Uplift Estimation

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

E5.5.2. Sample Design Considerations

DNV will coordinate with the program implementation vendor and Dominion Energy to put in place the RCT experimental design for the program in advance of the implementation of each wave of the program. After the target population is identified, a subset of that population will be randomly allocated to a control group that does not receive the reports. The

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

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

RCT will be developed within strata defined by geography and energy consumption bins. The size of the control group will be determined by the:

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

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

E5.6. Lost Revenue Methodology

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

1. Calculate program savings by applying the realization rate derived from the billing analysis.[20]
2. Apply the evaluated savings to the participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation.
3. Develop cumulative monthly energy savings based on measured and evaluated data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

E5.7. Timeline and Scope of Work

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

E5.8. Residential Customer Engagement Program – Revision History

Table 5-2. Revision History for Customer Engagement Program EM&V Plan

Version	Date	Notes
Version 1	11/26/2019	▪ Initial Release
Version 2	3/22/2021	▪ Added date to revision history and removed "Document" from "Document Revision History." Removed decimal place from version number. Deleted redundant paragraph on program uplift Section L.5.1.

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

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Version	Date	Notes
Version 3	4/22/2022	▪ Updated the title of "STEP Manual" to the "Dominion Energy Virginia and North Carolina Technical Reference Manual" (DE TRM) ▪ Replaced "DNV EM&V approach" to the approach defined in the Final Order of SCC PUR-2020-00156, Ex Parte: In the matter of baseline determination, methodologies for EM&V of existing DSM programs, [etc.] ▪ Removed version number from title ▪ Removed reference to IPMVP Option C (whole facility) because Option C is designed for site level analysis

APPENDIX J

Residential New Construction Program Baseline Study

Dominion Energy

Date: May 12, 2023

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1 EXECUTIVE SUMMARY

This report presents the results of the Residential New Construction Program Baseline Study conducted by DNV for Dominion Energy (DE) and the Virginia State Corporation Commission (SCC). This study explored the extent to which in a "natural" (no-program) market, homes have been and would be built to the ENERGY STAR® standard required by DE's Residential New Construction Program (Program). The study also collected information on several key construction practice parameters, which can be used in setting parameter baselines for future savings calculations.

The Program has increased the number of energy efficient ENERGY STAR certified homes in Virginia.

This study found that prior to Program roll-out, a small percentage (5.4%) of newly constructed homes in Virginia were ENERGY STAR certified. It also found that few homes are built to ENERGY STAR standards outside the Program. The existing minimum ENERGY STAR certified homes requirements exceed aspects of the Virginia building code and therefore these certified homes will use less energy than a large majority of homes built in Virginia today.

This study is based on interviews with Program-participating and non-participating builders in DE's Virginia service territory. The results may be used in conjunction with other sources to triangulate to a baseline that is representative of residential new construction practices in that service territory. In particular, the 2019 Pacific Northwest National Laboratory[1] study included on-site observations of a representative sample of newly constructed homes in Virginia.

ENERGY STAR Certified Homes offer builders competitive advantages with potentially modest incremental costs.

Results from this study should be one of the multiple inputs considered when assigning future baseline for this program.

In conducting this study of Program participants and non-participants, DNV has been able to gather useful insights into both groups of builders' perceptions and motivations relating to Program participation, which should inform future Program implementation and growth.

1.1 Introduction

In a Final Order from Case Number PUR-2020-00156, the SCC determined that baseline studies should be conducted for DE's DSM programs and ordered DE and SCC staff to meet to select at least two demand-side management (DSM) programs for which to perform the studies.[2]

DE and DNV selected the RNC Program as one focus for a baseline study. The SCC approved the Program as part of the DSM Phase VIII programs on July 30, 2020 (PUR-2019-00201) for a five-year period from January 1, 2021, through December 31, 2025. The Program officially launched on January 15, 2021. The Program provides incentives to home builders for the construction of new homes that are ENERGY STAR certified.[3] Certification requires that homes, as a whole, be energy efficient rather than just requiring specific measures to be energy efficient. Eligible homes must be at least 15% more efficient than the state-level minimum code. Eligible homes can be single-family attached, single-family detached, two-over-two condos, or low-rise multifamily. Energy-efficient upgrades include shell improvements, HVAC performance, lighting, appliances, and domestic hot water.

The study leveraged interviews with 20 participating and non-participating builders in Virginia. It assessed the extent of the natural market for ENERGY STAR certified homes in DE's service territory, developed estimates of standard practice for

[1] https://www.energycodes.gov/sites/default/files/2020-06/Virginia_Residential_Field_Study.pdf

[2] For purposes of this case, the SCC defined the "baseline" as "the expected energy or demand usage for an activity absent the DSM program or measure." Initiating Order at 6.

[3] https://www.energystar.gov/partner_resources/residential_new/homes_prog_reqs/national_page

measure-level energy efficiency home components, and characterized builders' motivations and processes for building homes of varying energy performance. The results of this study, along with other evidence, may inform a future effort to determine measure-level baseline values for use in the Program's reference home model.[4]

1.2 Objectives

This study had the following objectives:

1. Determining what the baseline penetration of ENERGY STAR certified homes was in Virginia before the introduction of this Program
2. Assessing whether there is a "natural" market for ENERGY STAR certified homes in Virginia that is growing independently of any Program interventions
3. Measuring the frequency of homes that are built in Virginia with energy efficiency features that are better than energy code requirements, but which do not meet the standards for ENERGY STAR certified homes.
4. Collecting information to identify typical market practices for specific home components. This information can be used, along with other evidence, to determine what the baseline reference home should be for the Program's impact evaluation.

1.3 Methods

In designing this baseline study, the DNV team considered the available existing research in this area and weighted the costs and benefits of the study methodologies to undertake. The 2019 PNNL study was a comprehensive primary research effort that included observations of a representative sample of Virginia homes. Therefore, DNV determined that the best and most cost-effective approach was to conduct in-depth interviews with builders in DE's Virginia territory, rather than repeat the costly onsite research that PNNL conducted.

From September through November 2022, DNV conducted in-depth interviews with builders from 20 companies. The builders all represented companies that had built single-family homes in DE's service territory in 2021. The sample had 10 builders who had participated in the Program as of July 2022, and 10 builders who had never participated in the Program. Interviews occurred over the phone or through video conference. Respondents received $100 Amazon gift cards for completing the interviews. During the interviews, respondents provided information on their company's construction activity, average efficiency levels, marketing approaches, the frequency of ENERGY STAR construction, awareness of the Program, motivations for participating in the Program, and barriers to Program participation. The interview respondents' companies represented about 14% of the single-family homes and about 62% of the ENERGY STAR certified homes built annually in Virginia.[5]

1.4 Conclusions

Conclusion 1: The market for ENERGY STAR certified homes has room for growth. While a small natural market for these homes exists in DE's service territory, there is much room for the Program to help grow it.

- **In 2020, before the start of the Program, ENERGY STAR certified homes comprised only 5.4% of the single-family market in Virginia**. DNV determined this market share by leveraging data on the number of ENERGY STAR

[4] This later study will also rely on the 2019 Virginia Residential Energy Code Field Study by the Pacific Northwest National Laboratory (PNNL) which estimated baseline measure-level efficiency values (https://www.energycodes.gov/sites/default/files/2020-06/Virginia_Residential_Field_Study.pdf).

[5] DNV estimated the population of single-family homes built annually in Virginia using a two-year average from 2020 and 2021 of 1-unit building permits from the U.S. Census Building Permit survey. The share of ENERGY STAR certified homes was estimated by taking the number of ENERGY STAR certified homes built in 2020 as reported by interview respondents and dividing by the number of ENERGY STAR certified homes in 2020 from U.S. Environmental Protection Agency ENERGY STAR data.

certified homes in Virginia from the U.S. Environmental Protection Agency and data on the total number of single-family permits from the U.S. Census Building Permit Survey. This was lower than the national average of 7.9%.

- **Once the Program started in 2021, most ENERGY STAR certified homes in Virginia were built through the Program.** Out of all the ENERGY STAR certified homes built in 2021 by interviewees in DE's service territory, only 6% were built outside of the Program. Respondents indicated that the ENERGY STAR certified homes built outside of the Program did not go through the Program because the builders did not know of the Program in time.
- **Similarly, very few homes built outside of the Program are ENERGY STAR certified homes.** Only 4% of all homes that respondents' companies reported building outside of the Program in DE's Virginia service territory were ENERGY STAR homes. Again, the builders of these homes did not know about the Program during construction.
- **One major county government strongly suggests that certain major new home developers commit to green construction practices.** Fairfax County's Comprehensive Plan has a policy directing all new homes in multi-home developments to incorporate sufficient green-building practices to achieve LEED, ENERGY STAR, or some other equivalent designation.[6] During interviews, builders of multi-home developments referred to this policy as a "requirement" and cited it as a major driver for their decision to build ENERGY STAR certified homes in Fairfax County and elsewhere. These builders reported that in Fairfax, building to the ENERGY STAR standard is the price of doing business, and for large builders, it is easiest to build all their homes the same way (e.g., adhering to the most stringent code) regardless of home location to achieve economies of scale. The only non-participant builder who reported building any ENERGY STAR certified homes said they had done so because it was "required" by Fairfax County. However, it is important to note that the ENERGY STAR qualified homes mentioned in the Fairfax plan are not the same thing as ENERGY STAR certified homes because the plan does not specify any requirements for verification and testing.

Conclusion 2: The Program has helped drive a shift by some participating builders toward building only ENERGY STAR homes thereby increasing the number of ENERGY STAR certified homes in Virginia. It also influenced builders that had not built ENERGY STAR Homes before to start building them.

- **Participating builders indicated they would have built 40% fewer ENERGY STAR certified homes in DE's service territory in 2021 without the Program**. This drop was driven mostly by one large builder who said they would have built no ENERGY STAR certified homes without the program. Three other participating builders indicated they would have built fewer ENERGY STAR certified homes in 2021 without the program but would have still built some. Another three builders said they would have built the same number of ENERGY STAR certified homes in 2021 without the Program. Lastly, two participating builders reported learning about the program and then staring to build ENERGY STAR homes in 2022; and therefore, had no ENERGY STAR homes in 2021.[7]
- **Two participating builders are shifting towards building only ENERGY STAR certified homes and most of the other participating builders are demonstrating business models that build only ENERGY STAR certified homes**. Two participating builders reported they have built better than code historically but started building ENERGY STAR certified homes in 2022 partially due to the Program. Six of the remaining eight participating respondents said they only build ENERGY STAR certified homes. These builders mentioned incorporating energy efficiency as part of their brand and building all their homes the same way to reduce costs.

[6] Objective 13, Policy c in the Fairfax County Comprehensive Plan reads: "Ensure that zoning proposals for residential development that are not otherwise addressed in Policy b above [addressing multifamily residential buildings] will incorporate green building practices sufficient to attain certification under an established residential green building rating system that incorporates multiple green building concepts and that includes an ENERGY STAR Qualified Homes designation or a comparable level of energy." Objective 13, Policy a also reads that the plan should "Encourage certification of new homes through an established residential green building rating system that incorporates multiple green building concepts and has a level of energy performance that is comparable to or exceeds ENERGY STAR qualification for homes. Encourage the inclusion of professionals with green building accreditation on development teams." https://www.fairfaxcounty.gov/planning-development/sites/planning-development/files/assets/compplan/policy/environment.pdf. Accessed April 3, 2023

[7] One builder did not respond to this question.

- **The future of the program is in recruiting builders who are new to ENERGY STAR certified construction.** As expected in a newly launched program, most of the interviewed participating builders (6 of 10) were early adopters who reported building ENERGY STAR certified homes in the DE Virginia service territory in 2019 and 2020 before the Program's 2021 launch. However, the other interviewed participating builders were new to ENERGY STAR certified home construction and contributed to the 40% increase in ENERGY STAR certified homes in DE's service territory noted above. It is reasonable to assume that as the program matures, most of the new recruits will be builders that are new to ENERGY STAR certified home construction.

Conclusion 3: ENERGY STAR certified homes exceed the 2018 Virginia Energy Conservation Code and yet sell at similar prices to homes with similar features.

- **ENERGY STAR certified home requirements exceed the 2018 Virginia Energy Conservation Code.**[8] ENERGY STAR Certified Homes Version 3.1 requires higher efficiency and commissioned heating equipment (AFUE of 95 versus AFUE of 80), reduced air infiltration (3.0 ACH50 or less), and ductwork in conditioned space beyond compared to the Virginia Code. In addition, the ENERGY STAR requirements have a history of evolving to stay ahead of improving building codes. Per the US Department of Energy's Office of Energy Efficiency and Renewable Energy, Virginia's implementation of the IECC 2018 code was amended down to be equivalent with the 2009 version of the code.[9]
- **Seven of the 11 builders who said they had built ENERGY STAR certified homes reported that these homes sell at a similar price to homes of a similar size and with similar non-energy related features**. The remaining four builders said that ENERGY STAR certified homes are between 1% and 7% more expensive but that some of that increase might be related to other factors such as the fact that ENERGY STAR certified homes are often built in more expensive locations.

Conclusion 4: The major drivers for building ENERGY STAR certified homes are having a competitive advantage and complying with county policies.

- **Respondents who build ENERGY STAR certified homes said the certification gives them a competitive advantage and makes their brand stand apart from other builders**. One said, "We just feel ENERGY STAR is something in line with our brand."
- **A plurality of ENERGY STAR certified home construction happens in Northern Virginia, where some local policies strongly suggest green building certification**. Respondents indicated that they build more ENERGY STAR certified homes in Northern Virginia than other parts of the state partially because local governmental entities, strongly recommend that newly constructed single-family communities use green building practices. For example, Fairfax County's Comprehensive Plan, Objective 13 Policy b and c require that developments in Fairfax containing multiple single-family homes meet green building standards such as ENERGY STAR.[10] However, as noted above, the ENERGY STAR qualified homes mentioned in the Fairfax plan are not the same thing as ENERGY STAR certified homes because the plan does not specify any requirements for verification and testing. In addition, this policy also does not apply to individual single-family home projects. Notably, participants said most of their construction occurs in Northern Virginia. In contrast, non-participants who do not build ENERGY STAR certified homes were more likely to report building in the Hampton Roads area.

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[8] See Table 3-7

[9] https://www.energycodes.gov/state-portal

[10] See Objective 13, Policy b and c in the Fairfax County Comprehensive Plan at https://www.fairfaxcounty.gov/planning-development/sites/planning-development/files/assets/compplan/policy/environment.pdf. Accessed April 3, 2023

Conclusion 5: Many non-participating builders prioritize reducing upfront costs rather than energy efficiency and thus are not drawn to ENERGY STAR certification.

- **Many non-participants said that they typically build only slightly better than code because they are trying to attract first-time home buyers or buyers that are primarily concerned with upfront cost**. This may be an unfounded barrier, because participant builders indicated that ENERGY STAR certified homes can be built with little additional cost. As noted below, the marginal cost to move from code-compliance to ENERGY STAR certification is roughly $2,000. However, it is likely that many cost-conscious builders might consider this incremental cost to still be a barrier to construction.
- **Unlike participants, non-participants view ENERGY STAR certification as requiring substantial incremental costs.** The ENERGY STAR cost and savings analysis conducted in 2018 estimates the incremental cost of building a home to ENERGY STAR version 3.0 requirements as ranging from $1,828 to $2,154 in Climate Zone 4.[11, 12] As mentioned above, non-participants avoid these costs because they are trying to minimize upfront costs.

Conclusion 6: ENERGY STAR certified homes are marketed to high-income professionals and as "move-up homes." Respondents indicated that ENERGY STAR certified homes are typically marketed to high-income professionals or two-income households. Typical ENERGY STAR certified home buyers are families with young children who are energy conscious and looking to move into a bigger home. Half of the respondents (5 participants and 5 non-participants) said they mention energy efficiency in their marketing materials, saying that homebuyers care more about upfront price, appearance, and location.

Conclusion 7: Builders learn about the program through third-party home energy efficiency professionals such as Home Energy Rating System (HERS) Raters, and builders outside of the program already work with HERS raters.

- **Participating builders most frequently mentioned their HERS raters as their first sources of information about the program.** This corresponds to findings from similar programs in the Northeast and Midwest in which HERS raters are the main pipeline for participation. [13] Builders also highlighted learning about the program through Home Builder Associations or directly from program (i.e., ICF) or DE staff.
- **Eight out of 10 non-participant respondents reported working with third-party energy efficiency professionals even if they do not do full HERS ratings**. The non-participants said they engage subcontractors to conduct blower door and duct leakage testing that is increasingly required by code. Engaging subcontractors such as HVAC professionals to demonstrate compliance through blower door testing does not require doing a full HERS rating. Even companies that provide full HERS rating services often offer two levels of service, including a basic code compliance option and a more thorough HERS modeling option.

1.5 Recommendations

- **Target non-participant builders to expand the Program footprint.** Early adopter builders were highly satisfied with the Program, and some indicated that the Program has contributed to their willingness to build ENERGY STAR certified homes for the first time. Since very few ENERGY STAR certified homes are currently built outside of the Program, bringing new builders into the program could increase the market share of ENERGY STAR certified homes. Since several non-participating builders indicated they have traditionally focused on the starter home market, the Program's messages to them might focus on the benefits of expanding their company's reach to the "upmarket" and the minimal incremental costs of building ENERGY STAR certified homes.

[11] https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Version%203%20Cost%20%20Savings%20Summary.pdf

[12] The incremental cost in Virginia is likely lower though because the ENERGY STAR analysis is based on 2009 IECC baseline which is less efficient than the code in Virginia based on the 2018 IECC.

[13] https://energizect.com/sites/default/files/documents/R1602_Residential%20New%20Construction_Process%20Evaluation_Review%20Draft_5.12.17.pdf

- **Continue promoting the value of the Program to new builders through energy rating companies.** Even some non-participating builders indicated that they are increasingly hiring energy raters to test their homes' air and duct leakage to comply with code. These third-party energy raters can sell the value of the Program to builders, even pitching facilitation of program participation as an added-value service. Of note, the program currently provides $50 per home directly to HERS raters.
- **Promote the value of the Program to new builders through case studies and training materials that show benefits outweigh costs.** Case studies of construction costs of ENERGY STAR-certified and similar standard homes can show that the program incentives can cover a significant portion of the incremental costs to build an ENERGY STAR home. The Program can provide literature for builders to use that explain to potential buyers how ENERGY STAR certified homes are better products than standard homes.

2 METHODS

2.1 Population and recruitment sample

Since the program's inception in January 2021 through the start of this study in July 2022, the program had a total population of 18 participant builders.

To determine the population of non-participant builders in the DE service territory, DNV relied on two sources: residential connection data from DE and ENERGY STAR certified home completions from an EPA database. DNV split the identified non-participant builders into groups based on company size. For companies from the residential connections file, DNV based company size on the count of work requests made by each company (for example, large companies had between 90 and 300 work requests while small companies had between 0 and 26). For the companies identified using the EPA database of ENERGY STAR certified homebuilders, DNV used the number of homes and apartments certified in the last 12 months to determine company size. DNV then sorted the companies based on the number of work orders or certified homes from highest to lowest and assigned them three groups (large, medium, and small), so the number of new construction projects were as close to equally divided as possible between large, medium, and small strata. This resulted in 381 non-participant builders as shown in Table 2-1 below.

DNV targeted completing in-depth interviews over the phone or the computer with 18 participants, which was the population of Program participants as of July 2022. DNV received email addresses and phone numbers for these participants directly from DE. DNV also targeted completing in-depth interviews over the phone or the computer with 20 non-participating builders. To get non-participant contact information, DE provided DNV with a database of builders who had requested electric connections for new construction. DNV supplemented this dataset with contact information from ZoomInfo. In the end, DNV obtained contact information for the full population of 18 participants and for 138 (36%) of the non-participant population.

2.2 Recruitment and interview methods

DNV randomly sorted the list of companies in each of the population groups for recruitment. DNV reached out to participant and non-participant companies via email and phone to schedule 30-minute interviews with respondents. Originally, DNV offered a $50 Amazon gift card to incentivize participation but then increased the incentive to $100 four weeks into outreach to encourage greater response rates.[14] Table 2-1 shows the sample, target, and achieved respondents for each type of builder.

2.3 Sample disposition

The final achieved sample of 20 respondents was lower than the target of 38 respondents. During outreach, DNV heard from potential respondents that builders were atypically busy due to end-of-year responsibilities compounding with impacts from inflation-induced high mortgage rates. Despite difficulties in outreach, DNV attempted to contact sample respondents five times at different times of day before considering a respondent unresponsive. When available, DNV attempted outreach to multiple respondents from the same company. DNV conducted only one interview for each company. The overall response rate was 56% for participants and 7% for non-participants.

[14] Five of the 20 respondents completed the interview for a $50 gift card but then were given an additional $50 gift card once the incentive was increased to $100.

Table 2-1. Builder interview targets and sample

Respondent company type	Population size	Sample	Target	Achieved respondents
Participant	18	18	18	10
Non-participant – Large	12	11	10	5
Non-participant – Medium	32	30	7	3
Non-participant – Small	337	97	3	2

The final sample included presidents/owners, vice presidents, chief financial officers, purchasing managers, and construction managers at 10 participating and 10 non-participating builder companies that had constructed homes in DE's service territory in 2021. Table 2-2 summarizes the size of the companies represented by interview respondents. It shows the average number of employees for companies of each type, the average number of single-family (SF) homes built in Virginia for each type, and the total number of SF homes built in Virginia in the last year for each company type. Overall, the respondents' companies had built 3,499 SF homes in Virginia in the last year representing about 14% of the single-family homes built annually in Virginia.[15]

Table 2-2. Respondent company size

Respondent company type	Respondent count	Average number of employees in Virginia Division	Average number of SF homes built in Virginia in the last year*	Total number of SF homes built in Virginia in the last year
Participant	10	39	199	1,986
Non-participant – Large	5	524	253	1,267
Non-participant – Medium	3	15	72	216
Non-participant – Small	2	6	15	30
Overall	20	154	175	3,499

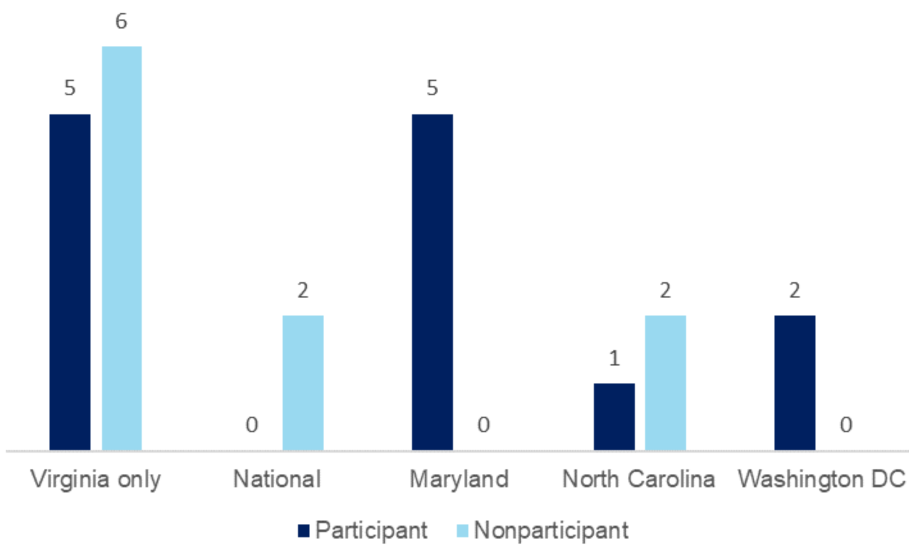
*Since the surveys were completed in 2022, "last year" refers to 2021.

Figure 2-1 shows the count of respondents that indicated their companies work in various regions across the United States. Eleven of the 20 respondents represented companies that only build in Virginia. Another two respondents worked for companies that built nationally. Among the remaining seven respondents, the most frequently mentioned states were Maryland, North Carolina, and Washington, DC.[16]

[15] DNV estimated the population of single-family homes built annually in Virginia using a two-year average from 2020 and 2021 of 1-unit building permits from the U.S. Census Building Permit survey.

[16] While not shown in Figure 2-1, the following states were cited by one respondent each: Arizona, California, Delaware, Florida, Georgia, Illinois, Indiana, Maryland, Nevada, New Jersey, Ohio, South Carolina, Tennessee, and Texas.

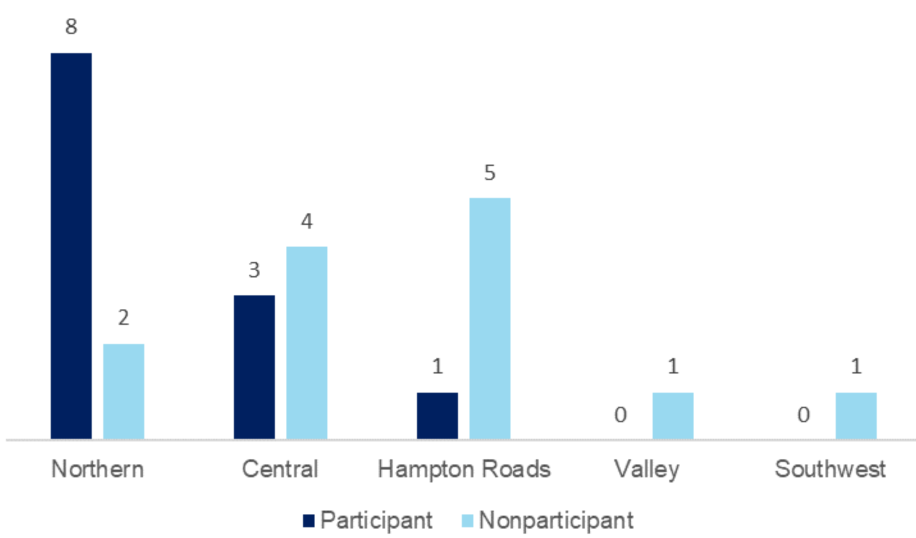
Figure 2-1. Count of respondent companies working in each region (n=20)



When asked specifically about which regions of Virginia they build in, respondents most frequently mentioned Northern Virginia, Central Virginia, and Hampton Roads. Participating builders said that they built mostly in Northern Virginia while non-participants reported building most frequently in Hampton Roads.

Of the 3,499 homes built by respondent companies in 2021 in Virginia, 1,931 (or 55%) were reported to be in DE's service territory. Six of the 10 non-participants and 4 of the 10 participating builders said that all their homes were built in the DE service territory. Participants reported building 1,059 homes and non-participants reported building 872 homes in the DE service territory.

Figure 2-2. Count of respondent companies working in each region of Virginia (n=20)



Most respondents said that their companies only built single-family homes (including town homes). Only two participants and four non-participants reported building multifamily properties. Only two non-participants said they build commercial properties.[17]

2.4 Threats to validity

The following threats to validity are applicable to this research effort:

- **Small sample size:** The respondents' companies represented about 14% of the single-family homes built annually in Virginia. Additionally, the overall sample includes an overrepresentation of companies that focus on ENERGY STAR certified homes. Out of all the single-family homes built by respondents' companies in 2020, 42% were ENERGY STAR certified while in Virginia overall, only 5.4% of single-family homes built in 2020 were ENERGY STAR certified. This overrepresentation of ENERGY STAR builders was a necessary byproduct of seeking insights from builders who were knowledgeable about the Program and ENERGY STAR certified homes.
- **False precision:** Some questions asked respondents to make estimates about characteristics of markets from previous years which could be hard to remember. Additionally, some respondents were specialized more in sales and less in technical characteristics of the homes and thus could speak more knowledgeably about sales trends than baseline efficiency values. For other respondents, the reverse was true, and they could speak more knowledgeably about baseline efficiency values than sales trends. For technical questions used to estimate baseline efficiency values, respondents were given an option to say they "did not know" for each measure. As a result, the number of respondents for each measure varies to exclude respondents who said they "did not know" what the typical efficiency-level was for the homes built by their company. Unfortunately, to limit interview length, the interview guide did not include systematic questions to ask respondents to rate their confidence about their technical estimates beyond providing a "do not know" option.
- **Lack of verification or direct observation:** To limit the budget of this study, the study design does not include any on-site inspection of homes or reviews of building plans. As such, the technical values in this study are based solely on the responses from interviews and are therefore limited to the understanding of the respondent and are not verified. As such, this study is not intended to be the sole input into the determination of baseline values for future iterations of DE's Program. Instead, it should be considered one data point to be used to triangulate a baseline that is generally representative of residential new construction practices in DE's service territory.

2.5 Weighting

For most of this report, all responses are weighted equally, because the individual responses about respondents' decisions are unique to them and should not be extrapolated to represent other non-respondents in the population. For results relating to respondents themselves or the decision-making of their companies as a whole—such as referring to respondents' satisfaction with the program or their company's motivations for building ENERGY STAR certified homes—we weighted all responses equally. One exception is the analysis for baseline efficiency levels (Table 3-4). For that analysis, results were weighted to reflect the state of Virginia as a whole. The weighting scheme has two components so that the weighting scheme accounts for both the size of each respondent company type stratum in the population and the size of each builder in terms of number of homes built in Virginia. The first component is a group weight for each company type in Table 2-3 calculated by dividing the population size by the achieved respondents. The second component was a unique weight for each respondent equal to the share of all respondents' company's homes built in Virginia in the last year that were built by

[17] Multifamily buildings are buildings with more than four units and does not include structures of attached town homes.

each unique respondent's company. The two components were multiplied together to create a unique weight for each respondent. Those weights were then normalized to sum to 1.

Table 2-3. Group weight component

Respondent company type	Population size	Achieved respondents	Group weight component
Participant	18	10	1.8
Non-participant – Large	12	5	2.4
Non-participant – Medium	32	3	10.67
Non-participant – Small	337	2	168.5

3 RESULTS

3.1 Builders' home efficiency tiers

DNV asked builders to describe the tiers of efficiency they offer in the DE service territory. Table 3-1 shows the count of individual respondents who fit into each of the following mutually exclusive categories:

- **ENERGY STAR-level only** refers to companies with only one tier of home efficiency and that tier either meets or exceeds ENERGY STAR requirements. Not all homes in this tier receive official ENERGY STAR certification, but they are all built to the level of efficiency required by ENERGY STAR.
- **Better than code only** refers to companies with only one tier of home efficiency that is better than code but not as efficient as required by ENERGY STAR. Builders who built better than code explained that they did so to help ensure compliance with code. Typically, these builders used better than code insulation in walls, ceilings, and crawl spaces, ENERGY STAR certified appliances, and ENERGY STAR certified HVAC equipment without pursuing ENERGY STAR certification for the home itself.
- **Code minimum only** refers to builders with only one tier of home efficiency that is built to code minimum standards.
- **Code minimum and ENERGY STAR** refers to companies with two tiers of home efficiency with one tier being built to code minimum and the other being built to ENERGY STAR criteria. The base code tier is often marketed to first-time home buyers looking for a very affordable home while the ENERGY STAR homes are marketed toward "move-up" buyers.
- **Code minimum and better than code** refers to companies with two tiers of home efficiency with one being built to code minimum and one being built better than code but not to ENERGY STAR criteria. Again, the code minimum home targets affordability while the better than code home is targeted to "move-up" buyers.
- **Better than code moving to ENERGY STAR only** refers to companies with only one tier of efficiency but who are working to improve the efficiency of that tier. These companies historically have built better than code but not to ENERGY STAR criteria and are now working towards building only ENERGY STAR-level homes with help from the program starting in 2022.

Table 3-1. Builder efficiency tier types

Efficiency tier type	Participant (n=10)	Non-participant (n=10)	Total (n=20)
ENERGY STAR-level only	6	0	6
Better than code only	0	5	5
Code minimum only	0	2	2
Code minimum and ENERGY STAR	2	1	3
Code minimum and better than code	0	2	2
Better than code moving to ENERGY STAR-level only	2	0	2

Overall, most companies reported building all their homes to the same efficiency level. For some companies the single efficiency level was ENERGY STAR homes, and for others the single efficiency level was Code Minimum. While some builders said they build different tiers of houses, this tiering has more to do with home size, finishings, and locations than energy efficiency. Only 5 out of 20 respondent companies had multiple tiers in terms of energy efficiency.

Most participating builders (6 out of 10) reported building only ENERGY STAR-level homes in DE's service territory. These builders represented 77% of the homes that participants reported building in 2021 and they had business models that focused on energy-efficient homes. Of the remaining four participants, two said that they have a single tier that is better than code but that, with support from the Program, they are upgrading this tier to ENERGY STAR-level. These two participants said they just started participating in the Program in 2022 with their first ENERGY STAR-level homes but had previously built homes that were better than code. Lastly, two participating builders reported having two efficiency tiers, with one maximizing affordability and thus being built only to code and the other targeting a higher-budget customer and thus being built to ENERGY STAR standards.

Non-participant builders were more likely than participants to say they maximized affordability rather than energy efficiency, with only one saying that they had an ENERGY STAR-level tier. Half of the non-participant respondents, representing 61% of the non-participant respondent homes that were reported built in 2021, said they had a single tier and that the tier was better than code but not ENERGY STAR-level. They explained that building slightly better than code helps ensure their homes will comply with code without adding much additional cost. Two of the 10 non-participant respondents build only to code minimum requirements and another two have a code minimum tier and a slightly better than code tier.

Table 3-2 and Table 3-3 show the percentages of their home sales that respondents reported to be in each efficiency-level category. The tables show the average response across all respondents for each efficiency-level and then the percent of all homes built by all respondents in DE service territory at each efficiency-level. Participating builders reported that three-fourths of all their homes built in DE's service territory went through the program from 2019 through 2021 and they expected that to increase in 2022 to 84%. A main driver of that increase was two builders who did not participate in 2021 program but started in 2022 and who have since upgraded their "better than code" tier to an ENERGY STAR-level tier. They said that their share of code minimum homes remained relatively constant from 2019 through 2022 since those homes targeted a specific market of homebuyers looking only for the lowest upfront cost. In 2022, there was a slight increase from 2021 in the share of ENERGY STAR-level non-Program homes as one builder chooses to forgo official certification to reduce costs while still building homes to ENERGY STAR efficiency standards.

The non-participating builders reported that the vast majority (84%) of their homes were built slightly better than code but not to ENERGY STAR levels. This strategy helped ensure code compliance without inducing excessive costs. Still, 14% of the homes were built only to code minimum standard to serve homebuyers looking for low-price homes. The non-participating builders reported that only 2% of non-participant homes were built to ENERGY STAR levels. These homes were built in communities that required ENERGY STAR certification.

DNV asked respondents who said they built "better than code" homes that were not ENERGY STAR certified about what energy efficient measures they include in their homes. Respondents indicated they used better than code insulation in walls, ceilings, and crawl spaces. This included the use of "flash and batting," which is a thin layer of spray foam insulation that has air sealing capabilities along with conventional fiberglass batt insulation. Additionally, respondents mentioned ENERGY STAR certified appliances and efficient HVAC equipment. Indeed, as shown in Table 3-2 below, the average reported baseline AFUE, 91.8 was far better than code and approaches ENERGY STAR levels (95). Lastly, better than code builders cited using 100% LED lighting.

Table 3-2. Participant mix of home efficiency levels in DE service territory

	Average response 2019 (n =10)	Average response 2020 (n =10)	Average response 2021 (n =10)	Average response 2022 (n =10)	Percent of homes* 2019 (n =1059)	Percent of homes 2020 (n =1059)	Percent of homes 2021 (n =1059)	Percent of homes 2022 (n =1059)
Code minimum	15%	15%	15%	14%	3%	3%	3%	3%
Better than code	25%	25%	20%	5%	20%	20%	20%	9%
ENERGY STAR level program homes	NA*	NA*	53%	67%	NA*	NA*	74%	84%
ENERGY STAR level non-program homes	60%	60%	13%	15%	77%	77%	3%	4%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

* "Percent of Homes" refers to the percent of all homes built by respondents in DE's service territory and does not represent the full population of homes built in DE's service territory. The survey questions used for this table specifically asked about the shares of homes built to each efficiency level in the DE service territory only.

Table 3-3. Non-participant mix of home efficiency levels in the DE service territory

	Average response (n=10)				Percent of homes* (n =873)			
	2019	2020	2021	2022	2019	2020	2021	2022
Code minimum	30%	30%	30%	30%	14%	14%	14%	14%
Better than code	71%	71%	70%	70%	86%	86%	84%	84%
ENERGY STAR level program homes	NA*	NA*	NA*	NA*	NA*	NA*	NA*	NA*
ENERGY STAR level non-program homes	0%	0%	1%	1%	0%	0%	2%	2%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

* "Percent of Homes" refers to the percent of all homes built by respondents in the DE service territory and does not represent the full population of homes built in the DE service territory. The survey questions used for this table specifically asked about the shares of homes built to each efficiency level in the DE service territory only.

3.2 Standard practice

3.2.1 Reported baseline efficiency

Table 3-4 shows the average baseline values for key efficiency measures that both participating and non-participating builders reported. DNV asked respondents to provide average efficiency values for each efficiency tier of their homes. Most respondents had only one efficiency tier and thus their value for that tier was included. Five respondents had two tiers. For those respondents we included the lowest efficiency tier in the baseline. Overall, the reported baseline values account for 96% of the homes built by respondents in 2021. They include the single tier for respondents that had one tier, and the lower efficiency tier for the five respondents that had two tiers. Note that not all respondents were knowledgeable about all measures, and thus the response rates vary by measure in Table 3-4.

Additionally, respondents with two tiers of efficiency mentioned very few differences between the two tiers. The main difference was that some lower tier homes had a share of LEDs lower than 100% while higher tier homes always had 100% LEDs. Additionally, some lower tier homes did not receive infiltration of duct leakage testing while higher tier homes had this testing done more frequently. Lastly, for companies with two tiers of efficiency, the higher tier homes typically had window U-values that were 7% more efficient than the lower tier for that individual company.[18]

[18] "Higher" tier in this context is only relative to the lower tier within that individual company. An individual company's highest tier may still be less efficient than a tier for another company that builds only ENERGY STAR homes.

Table 3-4. Baseline efficiency values

Measure	Number of respondents who provided estimates	Number of homes from respondents	Average statewide weighted value
Lighting (% LED)	19	3,404	98%
Infiltration (ACH50)	13	2,363	4.17
Duct leakage to outside (cfm25 per 100 sq. ft.)*	11	2,030	3.48
Duct insulation (R-value)	14	1,812	8.10
Window (U-value)	17	2,082	0.31
Window Solar Heat Gain Coefficient (SHGC)	15	2,064	0.28
Furnace Annual Fuel Utilization Efficiency (AFUE)	14	1,747	85.63

* "CFM25 per 100 sq. ft." is a standard unit of measuring duct leakage that stands for cubic feet of air per minute leaking out of ductwork per 100 square feet of conditioned floor area when there is a pressure gradient of 25 pascals between the inside and outside of the ducts.

3.2.1.1 Lighting

On average, respondents reported that 98% of hardwired lighting fixtures have LEDs. Only four respondents (one participant and three non-participants) indicated they had installed less than 100% LED. Of these four respondents, the lowest share of LEDs was 80% while the other three reported using 90% LED or greater. These respondents were also the only respondents who said that they installed CFLs in their hardwired fixtures. Reported CFL use was 5% for three respondents and 20% for the fourth respondent. One non-participant said they install incandescent bulbs in 5% of their fixtures.

3.2.1.2 Infiltration

Infiltration is typically measured by third-party HERS raters doing blower door tests. While respondents indicated that blower door tests historically were not required in every municipality in Virginia, they are mandatory for ENERGY STAR certification. All but three of the respondents (one participant and two non-participants) said they do blower door tests. And even these three respondents indicated that they will conduct blower door tests in their homes more often since codes increasingly require the test. One non-participant said, “We will be doing blower door tests now that its required.” Another non-participant said, “We’re starting to do blower door and duct leakage tests per a new city requirement effective July 1, 2022.” -

Almost all participant and non-participant companies reported hiring a third-party HERS rating company to conduct the blower door tests with only one respondent saying they were not sure who conducted their blower door tests. Eight out of 10 non-participant respondents indicated that they have blower door tests conducted. Three of those eight said they do not do HERS ratings, instead they just have blower door tests conducted without energy modeling.[19]

3.2.1.3 Duct leakage to outside

As was the case with infiltration testing, building codes are increasingly requiring duct leakage testing and so respondents indicated that they are increasingly using duct testing. The respondents said that they often use the HERS raters to perform the duct testing. Respondents also indicated that the results of duct leakage tests “were highly variable.”

3.2.1.4 Duct insulation

Twelve of the 20 respondents said they use duct insulation with an R-value of R-8 which is the minimum level required by code in unconditioned space. Another respondent said they use R-15 insulation while another said they use R-8 in most places but R-13 in attics which is required by code in some municipalities. A final respondent said they use R-8 in the code minimum tier but have all ducts in conditioned space for their ENERGY STAR tier and thus do not need to insulate ducts. The remaining five respondents did not know the average R-values of duct insulation in their homes.

3.2.1.5 Window U-value and Solar Heat Gain Coefficient (SHGC)

The builders reported an average baseline window U-value of 0.31 which is only slightly better than the code required value of 0.32. This average value includes ENERGY STAR homes. The average SHGC of 0.28 was more efficient than code driven down mostly by participant builders.

3.2.1.6 Furnace Annual Fuel Utilization Efficiency (AFUE)

The builders reported an average furnace AFUE of 85.6% which is higher than required by code (80%) and even approaches the ENERGY STAR efficiency level of 95%. Of note, four respondents said they only build all-electric homes and thus only use heat pumps. They said avoiding gas streamlines the bureaucratic processes related to construction

[19] A blower door test and a duct leakage test are only two pieces of creating an energy model of a home. To make an energy model, HERS raters need to collect all data related to the energy performance of a home including but not limited to data about all of the mechanical equipment and building envelope structure data such as insulation levels. Therefore, since blower door tests are just a component of energy modelling, it is possible to have just a blower door test conducted for the sake of demonstrating compliance with air leakage code requirements without going through the process of making an energy model.

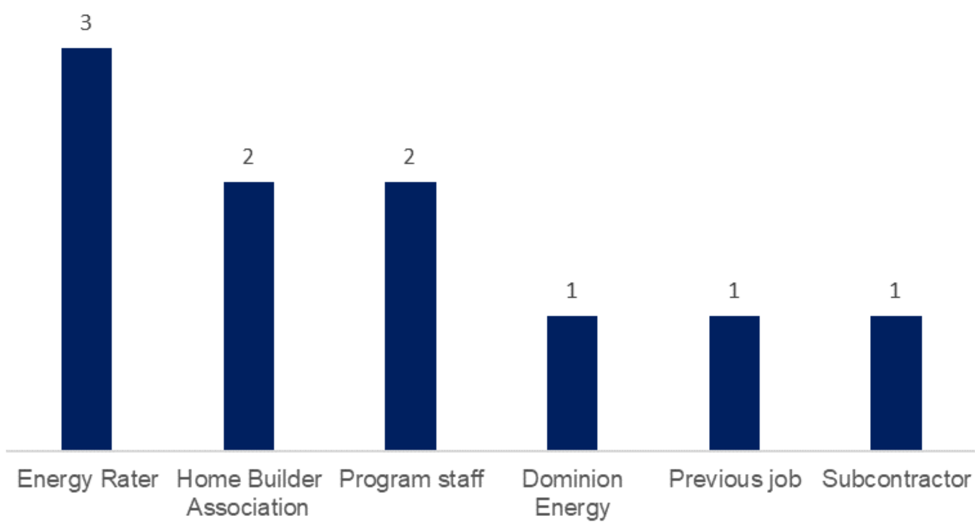
because they only must request service from one energy utility. Avoiding gas also eliminates the costs related to gas piping and fixtures.

3.3 Program market drivers

3.3.1 Program awareness

Participating builders reported a variety of sources through which they first learned about the program (Figure 3-1). They most frequently mentioned their HERS raters as first sources of information, which corresponds to findings from similar programs in the Northeast and Midwest in which HERS raters are the main pipeline for participation. Builders also highlighted learning about the Program through home builder associations or directly from Program (i.e., ICF) or DE staff.

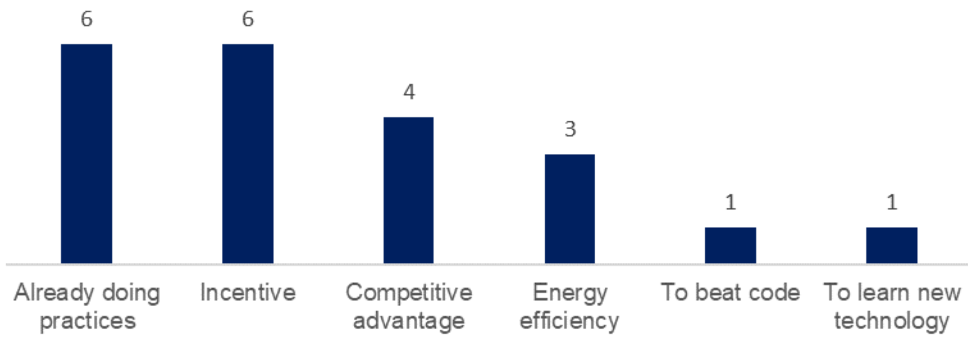
Figure 3-1. First sources of program information (n=10)



3.3.2 Motivations to participate in program

Participant builders indicated that their main motivation for participating in the Program was the incentive for building practices they were already implementing or were mostly implementing (Figure 3-2). Builders indicated that it was easy to meet Program requirements. One builder said: “We've been building the homes of the future for a long time. We saw the program as a way to showcase our homes and show other builders how to build. We wanted to encourage builders by example to get raters involved.” Additionally, four participants mentioned that the Program gave them a competitive advantage. One said: “the rebates help offset the increased cost of building ENERGY STAR homes and helped us find our niche.”

Figure 3-2. Motivations for program participation (n=10)



Three participating builders and one non-participant said they had built ENERGY STAR-level homes in DE's service territory that did not go through the Program. The three participating builders said those homes did not participate because they were either late applying to the Program or because the builder did not want to deal with the extra time and cost associated with ENERGY STAR or Program application processes. One builder said, "It adds time to the schedule and makes getting the occupancy permits difficult as you wait." The non-participant was simply not aware of the Program.

Looking at all 10 non-participants, only three had heard that DE had a Program offering incentives for building ENERGY STAR homes. Those three non-participants indicated they had not participated due to increased costs. One builder said, "The incentive amount was not enough to make the ENERGY STAR certification process worth it. We will practice energy efficiency, we just don't go through the certification process. The only way to make the program worth it would be to either raise the rebate or make the ENERGY STAR certification process easier." A representative from the Program's implementation contractor also observed that the financial incentives from the DE Program were lower than those for other ENERGY STAR certified programs they were involved with.

Four of the 10 participating builders indicated they participate in similar new home construction programs that offer financial incentives for building ENERGY STAR homes in states outside of Virginia. Three cited programs in Maryland with programs in Pennsylvania, Delaware, New York, New Jersey, Nevada, Texas, Arizona, and North Carolina each being mentioned once. Only one participating builder said they participated in another program similar to DE's Program in Virginia but outside of the DE territory. Washington Gas offers this program which requires builders to submit a HERS rating and provides incentives and marketing support.[20]

3.3.3 Program influence

Participating builders estimated that without the Program, they would have built 40% fewer ENERGY STAR certified homes in 2021 than they did with the Program. Table 3-5 compares the number of homes that participants reported having built in 2021 in different energy efficiency bins with their estimates of what they *would have* built in each efficiency level in the absence of the Program. Without the Program, respondents indicated that 325 ENERGY STAR certified homes would have been built better than code but not to ENERGY STAR levels.[21] This drop in ENERGY STAR certified homes is driven mostly by one large builder who said they would have built no ENERGY STAR certified homes without the Program. The builder said that the program "was a huge influence in building ENERGY STAR certified homes. There's an incentive that covers the costs of professional reviews and ENERGY STAR certification."

While this one large builder said the Program had a huge influence, most participants said the Program had only limited influence on their decision to build ENERGY STAR certified homes. When asked to rate the influence of the Program on

[20] See https://wgsmartsavings.com/network/home/builders and https://www.washingtongas.com/builders-contractors/builder-services/small-residential#programs.

[21] One of the ten respondents refused to provide counterfactual estimates.

their decision to build ENERGY STAR certified homes, where 1 is “not at all influential” and 10 is “very influential,” respondents provided an average response of 6.1. Half of respondents gave a rating of 5 or lower, indicating little influence from the Program. One of those builders said, “It’s driven by the code. We don’t do ENERGY STAR certification if it’s not required, and none of the homeowners have been driven enough to ask for it.” Conversely, four respondents gave a rating of 8 or above, indicating that the Program did influence their number of ENERGY STAR certified homes (Table 3-6).

Table 3-5. Participating builder estimates of housing efficiency mix without program (n=9)

Energy Efficiency of Single-Family Homes Newly Constructed	Actual 2021	2021 without program
Code minimum	32	32
Better than code	11	336
ENERGY STAR certified homes	816	491
Total	**859**	**859**

Table 3-6. Participating builder estimates of program influence (on a scale of 1-10)

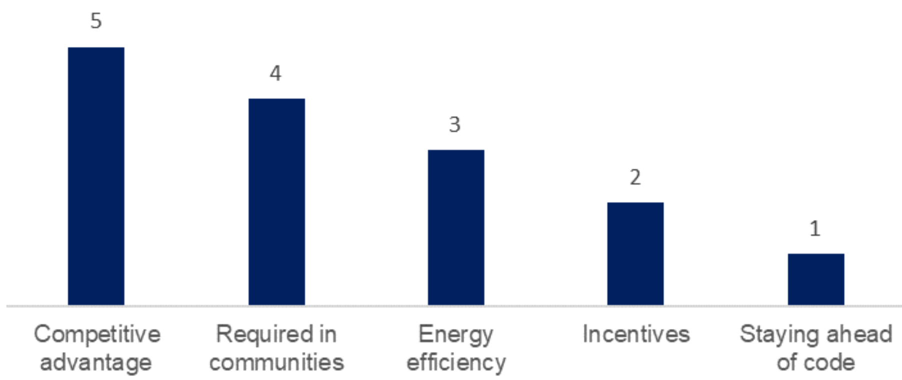
Rating of influence	Count of respondents
Not influential (1 to 5)	5
Neutral (6 to 7)	1
Influential (8 to 10)	4

3.3.4 Motivations to build ENERGY STAR certified homes

DNV asked the 10 participating builders and the one non-participant who built ENERGY STAR certified homes about their motivations for building ENERGY STAR certified homes (Figure 3-3). One of the most frequently cited motivations was that ENERGY STAR provides a competitive advantage for the company. One builder said, “We just feel ENERGY STAR is something in line with our brand.” Another frequently mentioned motivation was that some municipalities, such as Fairfax, require homes to be ENERGY STAR certified when part of a multi-single-family home project such as a subdivision or community. One non-participant cited this requirement as the reason his company had started building ENERGY STAR certified homes. They were not aware of the Program during that project. One large participating builder said that due to ENERGY STAR certification requirements, like the ones in Fairfax, they build all their homes to ENERGY STAR criteria. To keep costs down they build all homes the same way and so they build to the highest code standard so that their homes always comply with code. The builder said, “we’ve just adopted ENERGY STAR outside of the subdivisions. We build to the same specifications in all our homes.”

Respondents also mentioned energy efficiency as a motivation with one saying, “It’s the right thing to do.” Lastly, multiple respondents mentioned financial incentives, including both those through the Program and federal tax credits.

Figure 3-3. Motivations for building ENERGY STAR homes (n=11)



3.3.5 Cost of ENERGY STAR homes

When asked if ENERGY STAR homes sell at different prices than homes with similar sizes and features, 7 of the 11 ENERGY STAR home builders said, "No." One builder said, "ENERGY STAR certified homes can be sold at the same price. It's not hard for us to meet ENERGY STAR. I can make an ENERGY STAR certified home with typical components as long as the construction is managed properly and as long as I am listening to the rater in the beginning." The remaining four builders said ENERGY STAR certified homes sell at price 1% to 7% higher than similar homes that are not ENERGY STAR certified. However, the builder who estimated the highest price difference between ENERGY STAR certified and similar homes said that the price difference was not entirely because of the ENERGY STAR features and could be more the result of location since they said they build ENERGY STAR certified homes in more expensive locations. Specifically, builders indicated that ENERGY STAR certified homes are more likely to be built in Northern Virginia and especially likely in Fairfax. One builder said, "Fairfax is driven to have more efficient codes. There is drive there for more ENERGY STAR certified homes."

The perception among participating builders of small additional costs to building an ENERGY STAR certified home is not surprising when one considers that during the study period (2019 through 2022) the measure-level efficiency values between ENERGY STAR 3.0 and the 2018 Virginia Energy Conservation code were similar for most measures. Table 3-7 compares the 2018 Virginia Energy Conservation Code[22] with the requirements for the ENERGY STAR Single-family New Homes program.[23] The significant differences are that ENERGY STAR 3.0 requires more efficient heating systems, better installation of insulation (i.e., "Grade I insulation"), HVAC commissioning, and ENERGY STAR appliances.[24] Even these small differences in measure-level efficiencies result in energy savings.

In January 2023, the requirements for version 3.1 went into effect in Virginia increasing the efficiencies of ENERGY STAR homes relative to the 2018 Virginia Energy Conservation Code. Version 3.1 has additional efficiencies above the 2018 Virginia Energy Conservation code including a maximum air infiltration value of 3 ACH50 (compared to 5 ACH50 in the Virginia 2018 Energy Conservation Code), a requirement to have all ducts in conditioned space thus eliminating any duct leakage to outside (compared to no requirement in the 2018 Virginia Energy Conservation code for ducts to be in

[22] https://codes.iccsafe.org/content/VECC2018P1/chapter-4-re-residential-energy-efficiency

[23] https://www.energystar.gov/sites/default/files/asset/document/National%20Program%20Requirements%20Version%203.1_Rev%2012.pdf

[24] Notably, the ENERGY STAR 3.0 requirements for insulation level for ceilings are less than those from the Virginia's state level code. This is because ENERGY STAR bases its insulation requirements on the 2009 International Energy Conservation Code (IECC) while the 2018 Virginia Energy Conservation code is based on the 2018 IECC.

conditioned space and to just have a maximum duct leakage to outside of 4 CMF25 / 100 ft2 CFA), and higher insulation R-values.

Table 3-7. Code requirement versus ENERGY STAR 3.0 requirements

Measure	2018 Virginia Energy Conservation Code*	High Efficiency ENERGY STAR v. 3.0**	High Efficiency ENERGY STAR v. 3.1**
Infiltration	5 ACH50	5 ACH50	3 ACH50
Duct leakage to outside	4 CMF25 / 100 ft^2 CFA	4 CMF25 / 100 ft^2 CFA	All ducts in conditioned space
Duct insulation	R-8	R-8	All ducts in conditioned space
Wall insulation	R-15 cavity only OR R-13 cavity and R-1 continuous (No Grade requirement)	R-13 (Grade I required, low thermal bridging)	R-20 (Grade I required, low thermal bridging)
Ceiling insulation	R-49	R-38	R-49
Floor insulation	R-19	R-19	R-19
Basement wall insulation	R-13 cavity or R-10 continuous	R-13 cavity or R-10 continuous	R-13 cavity or R-10 continuous
Slab insulation	R-10	R-10	R-10
Window u-value	0.32	0.32	0.30
Window SHGC	0.40	0.40	0.32
Door insulation	R-1.5	R-4.8	R-5.9
Furnace	80 AFUE	90 AFUE (and commissioning)	95 AFUE (and commissioning)
Central AC	13 SEER	13 SEER	13 SEER
Water heater****	Varies	Varies	Varies
Lighting (% LEDs)	90%	90%	90%
Appliances	Federal standard	ENERGY STAR	ENERGY STAR

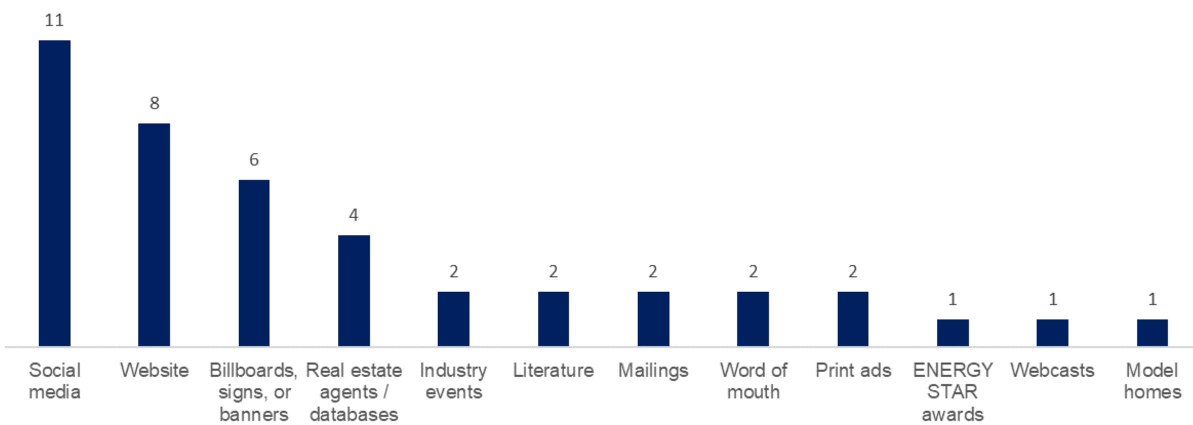
* https://codes.iccsafe.org/content/VECC2018P1/chapter-4-re-residential-energy-efficiency
** https://www.energystar.gov/sites/default/files/asset/document/National%20Program%20Requirements%20Version%203_Rev%2012.pdf
*** https://www.energystar.gov/sites/default/files/asset/document/National%20Program%20Requirements%20Version%203.1_Rev%2012.pdf
**** Water heater efficiencies are not summarized in the table because they vary by fuel and size. However, overall, the ENERGY STAR program does not require water heaters be much more efficient than federal minimum standards.

Builders said that typical ENERGY STAR certified home buyers are people in high-income professions or two-income households. These buyers are often new families with young children or retirees. One builder said, "They are typically families with children because this exemplifies their path to decarbonization, or they are retirees looking for a healthy home and energy efficient homes." Builders also cited that ENERGY STAR certified home buyers are typically environmentally conscious and trying to minimize utility bills.

3.3.6 Marketing and outreach

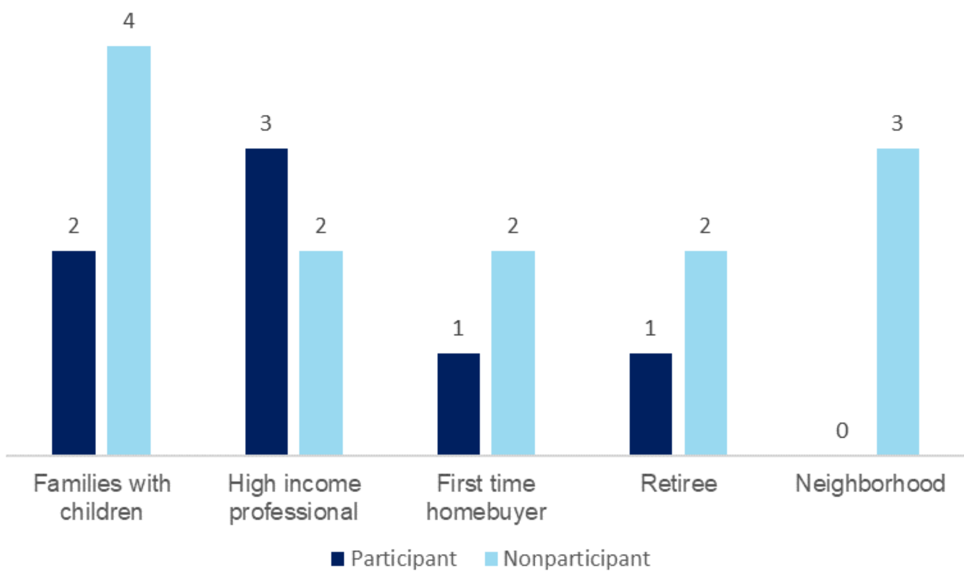
The builders, both participating builders and non-participants, indicated they use a wide variety of marketing methods (Figure 3-4) with social media being mentioned most frequently (11 respondents). Respondents reported personal websites and outdoor signage as their other most common types of marketing. Note that respondents could provide multiple responses, so the total responses sum to more than respondents for this question. One respondent did not know about the marketing practices at their company.

Figure 3-4. Methods of marketing and outreach (n=19)



When asked which types of potential homebuyers they target in their marketing, seven builders (six participants and one non-participants) said they do not target a particular type of buyer. Figure 3-5 shows the responses from the remaining 13 respondents. Participating builders most frequently mentioned families with children or high-income professionals. Non-participants also highlighted families with children or other types of "move-up" buyers looking to buy a bigger home. Non-participants also frequently said that their outreach is often dependent on the neighborhood of the development. For example, one non-participant said a project of theirs near a military base is targeted at military professionals while another non-participant with a project near a university targeted people associated with the school.

Figure 3-5. Targeted home buyers (n=13)



Half the respondents (5 participants and 5 non-participants) said they mentioned energy efficiency in their marketing. Those who mentioned energy efficiency said they use the certifications and logos such as the ENERGY STAR logo and RESNET HERS ratings on their website, advertisements, and literature. They reported discussing utility bill savings with potential homebuyers, and one participant builder even offers a utility bill guarantee. The builder said, "We use the HERS score and utilize the annual savings to show potential homebuyers that we guarantee your utility bill to be no more than $1.50 a day." Builders who did not mention energy efficiency said it was not a priority for homebuyers. One non-participant said, "Energy efficiency is not an important issue to home buyers. Price point and types of materials matter but energy efficiency is not a concern." Participating builders who said that they did not mention energy efficiency to potential homebuyers reported taking a broad approach in their marketing rather than getting into specifics. One participant said, "We don't mention ENERGY STAR or savings in particular, we just say that we build to higher standards."

APPENDIX A. WORK PLAN FOR RESIDENTIAL NEW CONSTRUCTION PROGRAM BASELINE STUDY

Memo to:

Dominion Energy: Jim Browder, Michael Hubbard, Kevin Reza, Edmund Hall, Nathan Frost, Selma Cosic, Jarvis Bates, Matthew Drumheller, Nick Meyers, Brenda Miller

From: DNV

Date: July 19, 2022

Copied to:

DNV: Dan Feng, Dale Tutaj, Sue Haselhorst, Miriam Goldberg

Prep. By: Christopher Dyson, DNV

Background

In the Final Order from the Virginia State Corporation Commission (the Commission) in Case Number PUR-2020-00156, the Commission determined that baseline studies should be conducted for Dominion Energy's (the Company's) DSM programs and ordered the Company and Staff to meet to select at least two DSM programs for which to perform the studies.[25]

The Company and DNV selected, and Staff agreed on conducting, the following baseline studies:

1. DSM Phase VII Non-Residential Lighting Systems & Controls, and
2. DSM Phase VIII Residential New Construction programs

Table 3-8, from DNV's initial letter proposal for these baseline studies, compares the key characteristics of the two Dominion programs that will inform these studies.

Table 3-8. Baseline study program characteristics

Program	Non-Residential Lighting Systems & Controls	Residential New Construction
Sector	Non-Residential	Residential
Event Type/Context	Existing Buildings	New Construction
Measures	Dominated by a single high-impact or high-savings measure type (lighting	Whole-house measures
Savings basis	Prescriptive	Whole-house engineering models

25 For purposes of this case, the Commission defined the "baseline" as "the expected energy or demand usage for an activity absent the DSM program or measure." Initiating Order at 6.

Savings and spending levels	High impacts and spending	Moderate projected savings and spending compared to other programs in the portfolio
Broader applicability	Non-residential lighting is a high-impact measure across several other programs in the portfolio, including the DSM Phase VIII Non-Residential Small Business Improvement Enhanced and the Phase IX Agricultural programs. The results from this study may have broader applicability to other lighting measures across the Dominion Energy non-residential DSM programs.	Because a wide range of measures are included, information may be applicable or informative for other programs outside the new construction context.
Incentivized entities	Non-residential customers who operate the lighting systems and controls	Builders (incentive) and homeowners (indirect – ongoing benefits)

Besides the final order, the Hearing Examiner's report provided some guidance as to the scope of the residential baseline research.

In the 2019 DSM Proceeding, for the Phase VIII Residential New Construction Program, Staff recommended setting the baseline assumption to reflect the level of efficiency the home would have been constructed to achieve without the proposed new construction program instead of at the baseline state minimum energy efficiency level as proposed by the Company. More specifically, Staff recommended, "the Company perform studies to determine the average energy efficiency rating of the homes being built that are the model type(s) built as part of the Phase VIII Residential New Construction Program but that are not incented to be energy efficient, 'which will necessarily be a higher standard than the code minimum energy efficiency requirements.' …I agree with Staff that a more accurate baseline would reflect the level of efficiency that would have been constructed absent the Phase VIII Residential New Construction Program. In keeping with my recommendation for baseline studies, I would leave it to Staff's discretion as to whether this baseline is chosen for a baseline test.

The Virginia SCC approved the Residential New Construction (RNCR) Program as part of the DSM Phase VIII programs, on July 30, 2020, (PUR-2019-00201) for a five-year period of January 1, 2021, through December 31, 2025. The program officially launched on January 15, 2021. The program provides incentives to home builders for the construction of new homes that are ENERGY STAR® certified. [26] Certification requires that the whole home be energy efficient instead of individual measures. Eligible homes must be at least 15% more efficient than the state-level minimum code. Eligible homes can be single-family attached, single-family detached, two-over-two condos, and low-rise multifamily. The program offers incentives that offset the costs of upgrades and rater services. Upgrades include shell improvements, HVAC performance, lighting, appliances, and domestic hot water.

After the submission and approval of the letter proposal in early 2022, DNV began developing a detailed work plan for the residential new construction baseline. After a couple draft versions of the plans with varying work scopes were submitted to Dominion staff for review and discussion in May and June of 2022, on June 18, Dominion approved a revised version of the scope that is captured in this current plan.

One key document that DNV reviewed in preparing this detailed work plan was the Virginia Residential Energy Code Field Study which the Pacific Northwest National Laboratory (PNNL) published in 2019. This report summarized research that the study team—which included PNNL, the Southeast Energy Efficiency Alliance (SEEA), and other stakeholders—conducted in

[26] ENERGY STAR certified homes website: https://www.energystar.gov/newhomes/features_benefits, Accessed March 18, 2022.

Virginia over the 2017-2018 period. The study team visited 138 homes in various stages of construction. Following this data collection, the study conducted three stages of analysis including:

1. Identifying code compliance trends within Virginia based on what was observed in the field,

2. Modeling the energy consumption of the homes observed in the field compared to the quantity of energy these homes would expect to consume if they just met minimum code requirements, and

3. Calculating the potential energy savings, consumer cost savings, and avoided carbon emissions associated with increased code compliance.

The study found that minimizing duct leakage would produce the most total energy savings, total energy cost savings, and total state emission reduction. It also found that reducing building envelope air leakage, increasing lighting efficiency, improving exterior wall insulation, and improving ceiling insulation would also produce significant energy savings and emissions reductions. The study also found that the energy consumption of the sampled Virginia homes (29.42 kBtu/ft^2-yr statewide) was very close to the energy consumption (29.8 kBtu/ft^2-yr) the energy models would have predicted if the homes had been built to the prescriptive energy code requirements.

Since the PNNL study already covered some aspects of a new construction baseline study, such as onsite new construction assessments, and was relatively recent, the DNV study team chose not to repeat these elements for the current study. Instead, it will focus on in-depth interviews with builders to better understand not only current building practices but also future market trends. However, DNV will use information from this PNNL study, along with information from other sources – such as builder interviews and a review of recent Virginia building code changes – to review the parameters for the reference or baseline models used to determine gross energy savings and demand impacts (see discussion below in Section 2.2).

Research objectives

This Dominion residential new construction baseline study has the following research objectives:

1. *Determining what the baseline penetration of ENERGY STAR® certified homes was in Virginia before the introduction of the RNCR Program*

2. *Assessing whether there is a "natural" market for ENERGY STAR certified homes in Virginia that is growing independently of any program interventions:* Part of this market research effort will include learning about the drivers of the construction of ENERGY STAR certified homes in Virginia, whether these are occurring inside or outside the RNCR Program. It will be also useful to understand which factors may discourage the construction of ENERGY STAR certified homes in Virginia, since if the RNCR program is helping to mitigate these market barriers, this information will be useful for the impact and net-to-gross (NTG) evaluations of this program scheduled for 2023.

3. *Measuring the frequency of homes that are built in Virginia with energy efficiency features that are better than energy code requirements, but which do not meet the standards for ENERGY STAR certified homes. Collecting information for determining what the baseline reference home should be for the RCNR impact evaluation:* As noted, the interviews with builders should produce information about current Virginia building practices that will be useful for determining whether any adjustments are needed to the parameters for the reference or baseline models used to determine gross energy savings and demand impacts.

It is important to note that the information the study team collects from the builders for the RNCR impact and NTG evaluations will not be summarized in the report for this baseline study unless the information is also useful for understanding the new construction baselines. There will be a separate report in 2023 that will summarize the RNCR impact and NTG evaluation findings.

The study team was able to realize the first research objective—determining what the baseline level of ENERGY STAR certified homes was in Virginia before the introduction of the RNCR Program—through secondary research. The team looked at data from the U.S. Environmental Protection Agency's (EPA) ENERGY STAR program on the number of ENERGY STAR certified homes which were built in Virginia in 2020, before the RNCR Program started. It then combined these data with data from the U.S. Census on annual building permits to calculate the "market shares" of the ENERGY STAR certified homes. Table 3-9 shows that in 2020 the ENERGY STAR Certified Home market share in Virginia was only 5.4%. It also shows that the market shares of both Virginia and North Carolina were below the U.S. national average. Figure 3-6 shows a map of the ENERGY STAR Certified Home market shares for the whole country.

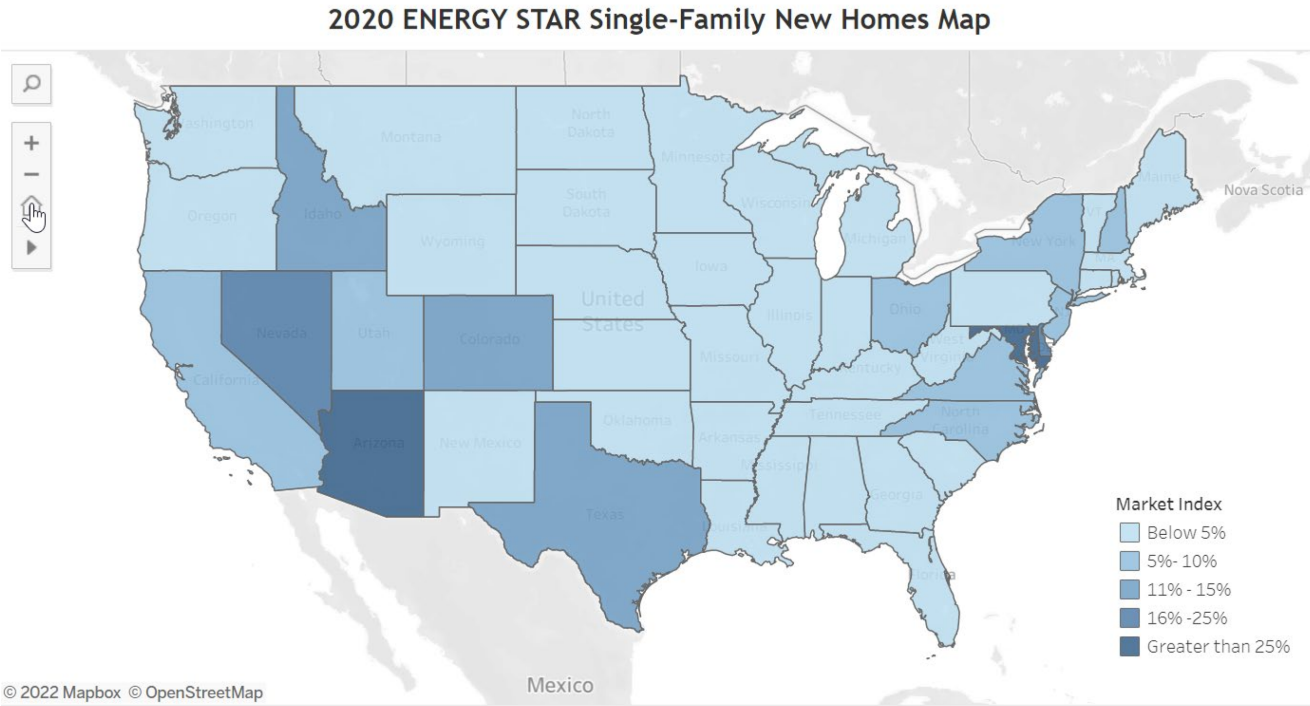
Table 3-9. Virginia and North Carolina 2020 Market Share of ENERGY STAR Certified Homes

State	# of Single Unit Housing Construction Projects Receiving Permits in 2020[27]	# of ENERGY STAR Certified Homes built in 2020[28]	Market Share of ENERGY STAR Certified Homes in 2020
Virginia	24,238	1,306	5.4%
North Carolina	60,505	4,401	7.3%
Total U.S.	**968,709**	**76,064**	**7.9%**

[27] Source: U.S. Census Building Permits Survey > Permits by State Annual (census.gov)

[28] ENERGY STAR Single-Family New Homes Map | Energy Efficient New Homes | ENERGY STAR

Figure 3-6. 2020 ENERGY STAR Single-Family New Home Map



To achieve the other research objectives, the study team will need to conduct primary data collection with program managers/implementers, builders participating in the RNCR Program, and builders active in the Virginia residential market that are not participating in the RNCR Program. The following sections describe these primary data collection tasks.

Task 1: In-depth interviews with program managers/implementers

In this task, the study team will complete in-depth interviews with those involved in managing and implementing Dominion's residential new construction program. The purpose of these interviews will be for the study team to gain a deeper understanding of how the program is designed, marketed, and delivered. This information will be useful for designing the interview guide for both the participating and non-participating builders.

At minimum, this task will include interviews with the Dominion manager of the program and with the lead representative of the program implementer. If these initial interviews indicate that additional interviews with program implementation staff would help the study team's program understanding, the team will complete these additional interviews. The interviews will cover the following topics:

- What marketing and outreach the program has done to builders and designers include delivery methods and messaging
- What outreach the program has made to Home Energy Rating System (HERS) raters
- What information the program is providing through its website and marketing collateral
- How the COVID-19 pandemic has impacted the Virginia new construction market
- What other factors/barriers are impacting program participation levels

In addition to these interviews, the study team will review program documents such as application forms and program eligibility information. Upon the completion of these program manager interviews and this document review, the study team may make changes to this work plan due to new information about program design or delivery.

Task 2: In-depth interviews with participating builders

As of July 2022, the Dominion RNCR Program had 18 participating builders. The study team will attempt to complete in-depth interviews with all these builders as well as any new participating builders who may have joined the program by the time we are in the field. To encourage a higher response rate, we plan to pay a $50 gift card to each builder who completes the interview. Because we intend to interview the full population of participating builders, we do not plan to develop a sample design for this group. However, after the interviews are completed, we will post-stratify the interview responses based on builder size.

This company size information will be based on information collected during the builder interviews such as the number of Virginia homes built per year or the number of their employees working in the Virginia residential new construction market. However, if the interviewed builders are unable to provide this company size information, we could use their level of RNCR program incentives as a proxy for company size. The ZoomInfo commercial database, which is discussed later in this work plan, also has information on number of employees and annual revenue. However, for larger builders that operate in multiple states, it would be difficult to estimate what percentage of these company size indicators were Virginia-specific.

The objectives of these interviews will be to understand the nature of the builders' participation in the RNCR Program and how their building practices within the program compare to their standard practices outside the program, whether these were their building practices before they joined the program or practices, they continue with non-participating homes. Specific interview topics will include:

- Firmographics
  - Company size (e.g., number of employees, average number of homes built per year)
  - Market focus (e.g., residential, multifamily, commercial)
  - Geographic footprint
- Participation characteristics
  - What motivated them to join the program?
  - Whether their company has participated in similar ENERGY STAR Certified Home programs outside of Virginia?
- Energy efficient building practices
  - What their recent building practices have been (interviewees will be shown Table 3-10 below and asked to provide the interviewers with percentages estimates for each year in the middle three columns)?[29]
  - If they built ENERGY STAR certified homes in Virginia outside the program, why they did not implement these projects through the program?
  - If they built homes that were more energy efficient than code but not qualifying for ENERGY STAR certification, why they went beyond code in these scenarios?
  - If they built homes that met ENERGY STAR standards or better, but did not get the actual certification, why they did not apply for the certification?

[29] We are asking about 2019 to get at pre-pandemic building practices. However, we realize that many builders may not be able to confidently provide market share estimates for 2019 estimates due to the uncertainty of their recall.

– What they project the energy efficiency "market shares" of their single-family residential homes will be in 2022 (the last column of Table 3-10)?

Table 3-10. 2019-2022 Residential Single-Family Home Construction by Energy Efficiency or Market Share

Energy Efficiency of Single-Family Homes Newly Constructed	Actual 2021	Actual 2020	Actual 2019	Projected 2022
Code minimum (meets but does not exceed the mandatory and prescriptive requirements of the International Energy Conservation Code (IECC))	__%	__%	__%	__%
More energy efficient (EE) than code requires but not qualifying for ENERGY STAR certification [Interviewers will show Table 3-11 to interviewees to clarify how these homes exceed EE code requirements]	__%	__%	__%	__%
ENERGY STAR certified homes not rebated through Dominion RNCR Program	__%	__%	__%	__%
ENERGY STAR certified homes rebated through Dominion RNCR Program	__%			__%
Homes that meet Energy STAR standards or better, but do not get the actual certification				
[Other EE category—if identified by the interview]	__%	__%	__%	__%
Total Single-Family Homes Constructed	**100%**	**100%**	**100%**	**100%**

The interviews will also use an expanded version of Table 3-11 to categorize construction practices. The evaluation team will identify any additional key parameters in the reference or baseline models used to determine gross energy savings and demand impacts. The key parameters generally pertain to mechanical systems, appliances, building envelope and lighting. The inputs and assumptions for this equipment and building construction are the primary driver for energy savings. The review will include a comparison of building codes in Virginia, the current program reference models, and the findings of the PNNL Virginia Residential Energy Code Field Study.

Table 3-11. Energy Efficiency specifications in Standard versus ENERGY STAR homes

Specification	Baseline Standard Plan	High Efficiency Energy Star v. 3.0
Infiltration (ACH50)	7	5
Duct leakage (%LTO)	6%	Duct leakage to outdoors modeled at the greater of ≤ 4 CFM25 per 100 sq.

		ft. of conditioned floor area or ≤ 40 CFM25.
Duct balancing?	No	Yes
Duct insulation	R-8 in unconditioned space	R-8 everywhere
Furnace	80% AFUE	90% AFUE
Water heater	Tanked	Tankless
Window u-value	0.35	0.3
Window SHGC	0.30	0.2
Fresh air systems?	No	Yes
Lighting (% LEDs)	50%	80%

Sources: Standard plan specifications are from the large builder NVR as presented in Virginia Electric and Power Company's 2019 DSM Update, Case No. PUR-2019-00201, Company Potential Documents for Use During Evidentiary Hearing (Company PE-7, page 2 of 3). ENERGY STAR specifications are from the same document as well as the official ENERGY STAR 3.0 standards.

- [IF THEY BUILT ENERGY STAR CERTIFIED HOMES IN 2019-2021 OUTSIDE THE DOMINON RNCR PROGRAM] What factors encouraged them to build these ENERGY STAR certified homes?
- [IF THEY BUILT ENERGY STAR CERTIFIED HOMES IN 2021 THROUGH THE DOMINION RNCR PROGRAM] What factors encouraged them to build these ENERGY STAR certified homes?
- [IF THEY BUILT ANY ENERGY STAR CERTIFIED HOMES IN 2019-2021] Whether these ENERGY STAR certified homes sell at a different price point than homes with similar sizes and features (and if they do, what is the typical price point difference)?
- [IF THEY BUILT ANY ENERGY STAR CERTIFIED HOMES IN 2019-2021] Whether they can make any generalizations about the types of customers who are buying ENERGY STAR certified homes?
- [IF NOT ALREADY MENTIONED] Whether ENERGY STAR certified homes are more likely to be built in certain geographic areas of Virginia (and, if yes, which areas)?

- Marketing and outreach practices
  - What sort of marketing and outreach their company do?
  - Whether there are certain types of homeowners that their marketing and outreach efforts focus on (and if so, which types)?
  - Whether they mention energy efficiency in their home promotions (and if so, how)?
- Program attribution
  - What influence, if any, the program had on their decision to build ENERGY STAR certified homes?
  - How would they rate the importance of that influence on a 0-10 scale?
  - What their 2021 energy efficiency market share would have been absent the program (Table 3-12)?

Table 3-12. 2021 Residential Single-Family Home Construction with and without the RNCR Program

Energy Efficiency of Single-Family Homes Constructed	Actual 2021 Sales (from Table 3-10)	2021 Sales if They Had Not Participated in the RNCR Program
Code minimum (meets but does not exceed code requirements)	__%	__%
More EE than code requires but not qualifying for ENERGY STAR certification	__%	__%
ENERGY STAR certified homes not rebated through Dominion RNCR Program	__%	__%
ENERGY STAR certified homes rebated through Dominion RNCR Program	__%	__%
Homes that meet Energy STAR standards or better, but do not get the actual certification	__%	__%
[Other EE category – if identified by the interview]	__%	__%
Total Single-Family Homes Constructed	**100%**	**100%**

Task 3: In-depth interviews with non-participating builders

In-depth interviews with non-participating builders will be key for understanding standard residential construction practices outside the RNCR Program. However, developing a sample frame of non-participating builders can be challenging. While the U.S. Census, as noted above, does collect information on building permits, these are not reported with the builders identified.

The EPA provides a list of builders who have built ENERGY STAR certified homes in Virginia either recently or over the longer term. It also shows how many of these certified homes these builders have constructed. However, this list does not include builders who have never built an ENERGY STAR Certified Home.

The study team contacted the building permit offices for three Virginia cities to see whether they provided information on permit applications in a publicly accessible database. All three cities said they did not publish these permit applications but could provide them in response to a Freedom of Information Act (FOIA) request. If many other cities in Virginia follow similar practices, we believe that submitting FOIA requests to multiple cities would be too labor intensive and waiting for the FOIA requests to be fulfilled would unduly delay this study.

Instead, we plan to leverage Dominion Energy's database of work requests submitted by builders to arrange for electric connection from the utility in order to develop the non-participating builder sample frame.[30] This work request database will allow us to not only identify non-participating builders for the interviews, but also to stratify this sample frame by the level of recent builder activity.

If this Dominion work request database has its limitations, we can supplement it with the commercial company database provided by ZoomInfo to develop the non-participating builder sample frame. We would filter this database by the builder's location (including Virginia and neighboring states), NAICS code (e.g., 236115, 236117), and RNCR Program participation status. While the ZoomInfo data will not be able to tell us is how active the builders are in the Virginia residential new construction market, the data will provide indicators of company size, such as number of employees or annual revenue, which could serve as reasonable proxies for company activity. For non-Virginia-based builders we will use early screening questions to ensure that they are active in the Virginia residential new construction market.

We will attempt to complete interviews with 20 non-participating builders. We will stratify the non-participating builder sample frame by company size or activity. To capture a larger share of the Virginia non-participating residential new construction market, we will target more of the larger non-participating builders. However, we will target a certain number of interviews with small or medium-sized non-participating builders because their standard practices may be different than those of the large builders and they may also face unique barriers to building more ENERGY STAR Qualified Homes. As with the participating builders, we will encourage higher response rates by paying a $50 gift card for each completed interview.

To ensure a more consistent comparison of the standard practices between participating and non-participating builders, the interview topics and the actual question wording for the non-participating builder interview guide will be very similar to those described above for the participating builder interview guide with the following exceptions:

- We will ask the non-participating builders whether they have heard of the Dominion RNCR Program (for the participating builder interviews we assume that they are already aware of the program). We will ask the non-participating builders who were aware of the Dominion RNCR Program why they chose not to participate in the program
- When asking non-participating builders about the energy efficiency market shares of the single-family homes they build (e.g., Table 3-10), we will not give them the scenario for "ENERGY STAR certified homes rebated through Dominion RNCR Program"
- We will not ask the non-participating builders any of the program attribution questions

Besides these interviews, the study team will examine EPA and U.S. Census data to estimate historical ENERGY STAR Certified Home market shares for Virginia. This analysis will look for any patterns in the historical data that might indicate a trend in the implementation of these certified homes.

Task 4: Analysis

To achieve the research objectives, we will need to analyze many different responses from the interviews with participating and non-participating builders as well as review historical data from the EPA and the U.S. Census. Table 3-13 maps the study's research objectives with the information sources.

Table 3-13. Mapping study research objectives with information sources

Research objective	Information source
Determining what the baseline penetration of ENERGY STAR certified homes was in Virginia before the introduction of the RNCR Program	Data from the EPA and the U.S. Census
Assessing whether there is a "natural" market for ENERGY STAR certified homes in Virginia that is growing independently of any program interventions	Participating builder interviews, non-participating builder interviews, ENERGY STAR Certified Home trend data from the EPA and the U.S. Census

[30] https://www.dominionenergy.com/virginia/start-stop-service/new-construction

Understanding the drivers of the construction of ENERGY STAR certified homes in Virginia, whether these are occurring inside or outside the RNCR Program	Participating builder interviews, non-participating builder interviews
Understanding what factors may discourage the construction of ENERGY STAR certified homes in Virginia	Participating builder interviews, non-participating builder interviews
Measuring the frequency of homes that are built in Virginia with energy efficiency features that are better than energy code requirements, but which do not meet the standards for ENERGY STAR certified homes	Participating builder interviews, non-participating builder interviews

Table 3-14 examines the pros and cons of specific pieces of evidence that the team will gather from these interviews with participating and non-participating builders. It explains why the study team will draw upon so many different pieces of evidence, since no one piece of evidence is without its shortcomings.

Table 3-14. Evidence Analyzed for Determining Baseline Characteristics of Virginia Single-Family Home New Construction Market

Evidence	Source	Pros	Cons
2021 Counterfactual EE market shares (3rd column of Table 3-12)	Participating builders	Allows for direct calculation of net effects of the RNCR program (e.g., the difference in market shares between the 2nd and 3rd columns of Table 3-12) from the perspective of those builders who are most familiar with the program impacts	Estimating counterfactual scenarios (e.g., what would have happened absent the program) is inherently difficult
2019-2021 reported EE market shares 2nd through 4th columns of non-participant's version of participant's Table 3-10)	Non-participating builders	• One representation as to what the EE market shares would be absent the RNCR program intervention • The frequency with which non-participants report building ENERGY STAR certified homes could be an indicator of the "natural market" for these types of homes	There may be self-selection effects, where builders who were already inclined to build more EE houses are attracted into the RNCR program. Over time, this could lead to a situation where the remaining non-participating builders are not as representative of what the full population of builders would have been absent the program. However, these kind of self-selection effects are more common with long-standing EE programs. The RNCR program has only been active since 2021, and there were no prior similar residential new construction

			programs before the start of the RNCR program offered by Dominion.
2019-2021 reported EE market shares (2nd through 4th columns of Table 3-10)	Participating builders	If participating builders report constructing a significant quantity of ENERGY STAR certified homes outside the program, this could be an indicator of a strong or growing “natural” market for ENERGY STAR certified homes that is not reliant on RNCR program support	Because these are participating builders, it is difficult to distinguish which building practices are due to the impacts of the program versus non-program effects
2022 forecasted EE market shares (last column of Table 3-10)	Participating and non-participating builders	If non-participants predict an increasing frequency in ENERGY STAR certified homes, or if participants predict an increasing frequency of ENERGY STAR certified homes outside the program, this could be an indicator of a strong or growing “natural” market for these homes	Forecasting future market shares can be inherently difficult
Ratings of program influence on 0-10 scale	Participating builders	Low program influence scores in conjunction with rising trends in non-program ENERGY STAR certified homes outside the program could be an indicator of a strong or growing “natural” market for these homes	Companies who pride themselves on being “green builders” may underestimate the influence of the RNCR program
2019 EE market share estimates	Participating and non-participating builders	This information, when compared with EE market share estimates for 2020-2021, can shed light on possible impacts of the COVID-19 pandemic on building practices	Builder recall of their EE market shares from 2019 may be unreliable due to the passage of time

After considering all this information, the study team will estimate the proportion of 2021 Virginia new single-family homes that were built, without RNCR Program intervention, to the following EE standards:

1) Code minimum (meets but does not exceed code requirements)
2) More EE than code requires but not qualifying for ENERGY STAR certification
3) Meeting ENERGY STAR Certified Home standards (both certified and noncertified homes)

Task 5: Reporting

The study team will draft a report that will include:

- Findings for each of the key research objectives listed above, except for the information being collected exclusively for the RNCR impact and NTG evaluation, which will be summarized in a separate report in 2023.
- A description of the evidence the team considered in reaching each of these findings
- An estimate of the proportion of 2021 Virginia new single-family homes that were built, without RNCR Program intervention, to the various EE standards
- A description of the data collection methodology including the development of the sample frame for the non-participating builders and the sample design
- An appendix that will include the final versions of the interview guides

Upon reviewing and addressing the comments from Dominion and other stakeholders on the draft report, the study team will issue a final report. This final baseline study report will be included with the EM&V report to be filed with the SCC in 2023.

Beside these reports, the study team will also present a summary of the report findings to stakeholders when schedules allow for the SCC stakeholder group.

Project schedule

Figure 3-7 shows the proposed schedule for this baseline study.

Figure 3-7. Project schedule

	2022											
Study Activities/Deliverables	**July**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
Dominion, stakeholder review/approval of work plan		**W**										
Interviews w/ RNCR Program managers/implementers												
Developing non-participating builder sample frame												
Developing builder interview guides												
Interviewing participating/non-participating builders												
Analysis												
Draft report										**D**		
Final report												**F**

DNV

APPENDIX B. IN-DEPTH INTERVIEW GUIDE FOR PARTICIPATING BUILDERS

Interview Information

Interviewer		Survey Length (min)	
Completion Date			

Contact Information

Phone	
Email	

Call Tracking

Date/Time	Notes
NEEA	

Introduction

[NOTE: THE QUESTIONS IN THIS INTERVIEW GUIDE WILL NOT NECESSARILY BE READ VERBATIM BUT MAY BE MODIFIED TO SUIT THE INTERVIEW]

1. Hi, my name is X OF DNV. We are conducting a study of the residential new construction market in Virginia on behalf of Dominion Energy. All the information we collect in this interview will be kept confidential; your name will not be included the study results. If you complete the full interview, you will receive a gift card with a value of $50.

   [IF THEY ASK HOW LONG THE INTERVIEW WILL TAKE, TELL THEM ABOUT 45 MINUTES]

   [ASK IF IT'S OK TO RECORD THE CALL].

   [IF THEY REFUSE THE INTERVIEW (NOT THE RECORDING), THANK THEM FOR THEIR TIME AND HANG UP]

Company, Interviewee Background

First, I had a few background questions about you and your company.

1. What is your job title?
2. Approximately how many full-time employees are in the division where you work?
3. Besides Virginia, in what other states does your company operate?
4. About how many single-family homes did your company build in the past year in Virginia? By single-family homes I mean either detached homes or attached homes such as townhouses.

a. About what % of these were built in Dominion Energy's service territory?

5. Does your company have different tiers of single-family homes they offer based on different price or quality tiers?

    a. [IF YES] Please explain what these different tiers are and how the characteristics of the houses might differ between tiers.

6. Are there certain areas of Virginia where you build more of your homes?

    a. [IF YES] Which areas of Virginia?

7. Does your company construct any multifamily buildings?

8. Does your company construct any commercial buildings?

Participation characteristics

9. We understand that your company is currently participating in Dominion's Residential New Construction Program, which encourages the building of Energy Star certified homes. From where did you first hear about this program?

10. What motivated your company to join this program?

11. Does your company participate in any similar programs promoting Energy Star certified homes in Virginia outside the Dominion service territory?

    a. [IF YES] In what other Virginia service territories?

    b. [IF YES] Do those other Virginia utilities offer incentives for ENERGY STAR certification?

12. Does your company participate in any similar programs promoting Energy Star certified homes in any other states besides Virginia?

    a. [IF YES] In what other states?

    b. Do those states offer incentives for ENERGY STAR certification?

General construction practices

[NOTE TO INTERVIEWERS: IF BUILDER INDICATED IN Q5. THAT THEY SELL DIFFERENT TIERS OF HOME QUALITY, TRY TO ASK THIS BATTERY OF QUESTIONS SEPARATELY FOR EACH TIER, STARTING WITH THE HIGHEST COST/QUALITY TIER]

13. We're interested in the different levels of energy efficiency in the single-family homes you build in Dominion Energy's Virginia service territory. I'm going to ask you about four different categories of energy efficient homes including:

    a. *Code Minimum:* These are single family homes you built in Dominion Energy's Virginia service territory that meet but do not exceed the mandatory and prescriptive requirements of the International Energy Conservation Code (IECC))

    b. *Better than Code:* These are single family homes you built in Dominion Energy's Virginia service territory that are more energy efficient than the Virginia code requires, but are not Energy Star certified

        i. [IF THEY MENTIONED THEY SELL MORE THAN ONE TIER OF HOUSING PRICE/QUALITY IN RESPONSE TO Q5] You earlier said that you sold more than one tier of housing with different tiers of price or quality. Is it the case that your base tier homes just meet code and your higher tier homes are built better than code? Or is it more complicated than this?

1. [IF THEY SAY'S IT'S MORE COMPLICATED THAN THIS. ASK THEM TO EXPLAIN THESE NUANCES]

c. *Energy Star Certified Program Homes:* These are Energy Star certified single family homes you built in Dominion Energy's Virginia service territory and sold through Dominion's Residential New Construction program

d. *Energy Star Certified Non-Program Homes:* These are Energy Star certified single family homes you built in Dominion Energy's Virginia service territory but did not sell through Dominion's Residential New Construction program

Now I'm going to ask you to estimate how your sales of single-family homes in Dominion Energy's Virginia service territory in recent years were distributed across these four categories. First, I'll start with 2021. How were your sales of single-family homes in Dominion Energy's Virginia service territory in that year distributed across these four categories? You should treat these categories as mutually exclusive and the percentages should add up to 100% [REPEAT THE ABOVE DEFINITONS OF THE FOUR CATEGORIES, IF NEEDED. RECORD THEIR RESPONSES IN THE TABLE BELOW].

14. Now please estimate how your 2020 sales of single-family houses in Dominion Energy's Virginia service territory we're distributed across these categories. Since Dominion didn't have a Residential New Construction program in 2020, for the third category we're just interested in the percentage of Energy Star certified homes you sold in 2020. [REPEAT THE ABOVE DEFINITONS OF THE FOUR CATEGORIES, IF NEEDED. RECORD THEIR RESPONSES IN THE TABLE BELOW]

15. Now I realize that 2019 is a while ago, but we are hoping to get one estimate of the mix of your single-family housing sales in Dominion Energy's Virginia service territory before the pandemic hit. Please estimate how your 2019 sales of single-family houses in Dominion Energy's Virginia service territory we're distributed across these categories. Since Dominion didn't have a Residential New Construction program in 2019, for the third category we're just interested in the percentage of Energy Star certified homes you sold in 2019. [REPEAT THE ABOVE DEFINITONS OF THE FOUR CATEGORIES, IF NEEDED. RECORD THEIR RESPONSES IN THE TABLE BELOW]

16. While we are only partially through 2022, we are hoping you could estimate how your 2022 sales of single-family homes in Dominion Energy's Virginia service territory are distributed across these categories. [SINCE THE DOMINION PROGRAM WAS OPERATIONAL IN 2022, MAKE SURE THEY PROVIDE ESTIMATES FOR BOTH PROGRAM AND NON-PROGRAM ES CERTIFIED HOMES. REPEAT THE ABOVE DEFINITONS OF THE FOUR CATEGORIES, IF NEEDED. RECORD THEIR RESPONSES IN THE TABLE BELOW]

Energy Efficiency of Single-Family Homes Newly Constructed	Actual 2021	Actual 2020	Actual 2019	Projected 2022
Code minimum	__%	__%	__%	__%
Better than code	__%	__%	__%	__%
Energy Star Certified Program Homes	__%			__%
Energy Star Certified Non-Program Homes	__%	__%	__%	__%
[Other EE category—if identified by the interview]	__%	__%	__%	__%
Total Single-Family Homes Constructed in 2021 in Dominion Energy's Virginia Service Territory	**100%**	**100%**	**100%**	**100%**

17. [IF THEY SOLD CODE MINIMUM IN 2021 OR 2022] You said you sold homes in Dominion Energy's Virginia service territory that were generally designed to just meet code [in 2020 or 2021]. On average, what percent of the hardwired lighting fixtures installed in these homes are LED?
    a. Do you still install CFLs at the homes you build?
        i. [IF YES] Roughly about what % of the lighting fixtures, including decorative lighting, do these CFLs account for?
18. [IF THEY SOLD ENERGY STAR CERTIFIED NON-PROGRAM IN 2021 OR 2022] You said you sold Energy Star certified homes in Dominion Energy's Virginia service territory [in 2020 or 2021] that were not sold through the Dominion Residential New Construction program. What were your reasons for not selling these Energy Star certified homes through the program?
19. [IF THEY SOLD BETTER THAN CODE HOMES IN 2021 OR 2022] You said you sold some single-family homes in Dominion Energy's Virginia service territory [in 2021/2022] that had energy efficiency features that were greater than building codes required? What were your reasons for building these above code houses?
20. [IF THEY SOLD HIGHER AND LOWER PRICE/QUALITY] TIER HOMES IN 2021 OR 2022] The following table shows what current Virginia code requires for certain home parameters that have implications for energy efficiency. It also shows the range of values that a 2018 government study found based on onsite data collection in the Virginia residential market.
    a. First, about what percent of the houses you built in Dominion Energy's Virginia service territory in 2021 were in the base tier of price or quality and what percent were in the higher tier(s)
    b. Please give me your best estimate of what the parameters in the table below are for the *base price/quality hou*ses you built in Dominion Energy's Virginia service territory in 2021

c. Please give me your best estimate of what the parameters in the table are below for *the average higher price/quality hou*ses in Dominion Energy's Virginia service territory you built in 2021

21. [IF THEY SOLD A SINGLE TIER AND SOME OF THE HOMES BETTER THAN CODE IN 2021 OR 2022]

The following table shows what current Virginia code requires for certain home parameters that have implications for energy efficiency. It also shows the range of values that a 2018 government study found based on onsite data collection in the Virginia residential market. Please give me your best estimate of what the parameters in the table below are for the single-family homes you built in Dominion Energy's Virginia service territory in 2021

Specification	2018 Typical Practice	**Current VA Code** IECC 2018 with amendments (effective 7/1/2021)	Baseline quality/price tier homes	Average higher quality/price tier homes]	Notes and comments
Tier Percentage of new homes: [STANDARD TIER + HIGH TIER ADD UP TO 100%]			**____%**	**____%**	
Lighting (% LEDs) Higher value is more efficient	45% to 100%	90% (previously 75%)	___ Average Value	___ Average Value	
			____ Meets code ____ Exceeds code Don't know _____	____ Meets code ____ Exceeds code Don't know _____	
Infiltration (ACH50) Higher value is less efficient	7.5 to 2.0	5	___ Average Value	___ Average Value	
			____ Meets code ____ Exceeds code Don't know _____	____ Meets code ____ Exceeds code Don't know _____	
		4 cfm25 per 100 sq. ft.	___ Average Value	___ Average Value	

Specification	2018 Typical Practice	Current VA Code IECC 2018 with amendments (effective 7/1/2021)	Baseline quality/price tier homes	Average higher quality/price tier homes]	Notes and comments
Duct leakage (%LTO) Higher value is less efficient	3.0 to 10.0 cfm25 per 100 sq. ft.		____ Meets code ____ Exceeds code Don't know _____	____ Meets code ____ Exceeds code Don't know _____	
Duct insulation Higher value is more efficient	N/A	unconditioned: R-8 (diameter is >3")	___ Average Value ____ Meets code ____ Exceeds code Don't know _____	___ Average Value ____ Meets code ____ Exceeds code Don't know _____	
Window u-value Lower value is more efficient	0.23 to 0.35	0.32 (previously 0.35)	___ Average Value ____ Meets code ____ Exceeds code Don't know _____	___ Average Value ____ Meets code ____ Exceeds code Don't know _____	
			___ Average Value	___ Average Value	

DNV

Specification	2018 Typical Practice	Current VA Code IECC 2018 with amendments (effective 7/1/2021)	Baseline quality/price tier homes	Average higher quality/price tier homes]	Notes and comments
Window SHGC Lower value is more efficient	0.16 to 0.32	0.36 (previously 0.4)	____ Meets code ____ Exceeds code Don't know _____	____ Meets code ____ Exceeds code Don't know _____	
Furnace (%AFUE)	N/A	80% (2010 proposed federal standard)	_ __ _ Average Value ____ Meets code ____ Exceeds code Don't know _____	_ __ _ Average Value ____ Meets code ____ Exceeds code Don't know _____	

22. [IF THEY SOLD a single tier and some of the homes BETTER THAN CODE HOMES IN 2021 OR 2022] For those homes that are better than code, are there other high efficiency features that you typically install?
    a. [IF YES] What other energy efficiency features do you typically install?

Characterizing the market for energy star certified homes

ASK THIS BATTERY ONLY IF THEY SAID THEY SOLD ENERGY STAR CERTIFIED HOMES, WHETHER WITHIN THE PROGRAM OR OUTSIDE THE PROGRAM

23. You said you sold Energy Star certified homes in Virginia. What factors encouraged you to build these Energy Star certified homes?
24. Do the Energy Star Certified homes you sell at a different price point than homes with similar sizes and features?
    a. [IF YES] What is the typical price point differences between the Energy Star Certified homes you sell and the homes with similar sizes and features?
25. Can you make any generalizations about the types of customers who purchase these Energy Star Certified homes in Virginia?
    a. [IF YES] What types of customers purchase these Energy Star Certified homes in Virginia?
26. Are there certain parts of Virginia where you are more likely to sell Energy Star Certified homes?
    a. [IF YES] What parts of Virginia?

Marketing and outreach practices

Now we would like to hear about your marketing and outreach practices.

27. What sort of marketing and outreach does your company do in Virginia?
    a. [IF NOT ALREADY MENTIONED] Are there certain types of homeowners that your marketing and outreach efforts focus on?
        i. [IF YES] What types of homeowners?
    b. [IF NOT ALREADY MENTIONED] Do you mention energy efficiency in your home promotions?
        i. [IF YES] How was energy efficiency featured in your promotions?

Program attribution

Lastly, I would like to ask you about possible influences of Dominion's Residential New Construction program.

28. What influence, if any, has the program had on their decision to build ENERGY STAR certified homes?
29. Using a ten-point scale where 10 means very influential and 1 means not influential at all, how influential has Dominion's Residential New Construction program been on your decision to build ENERGY STAR certified homes?
30. The middle column of the table below shows the distribution of your 2021 sales of single-family homes in Dominion Energy's Virginia service territory that you told me earlier. Please tell how this distribution would have been different, if at all, if you had not participated in the Dominion Residential New Construction program? [MARK % ESTIMATES IN THE LAST COLUMN OF THE TABLE]

Energy Efficiency of Single-Family Homes Constructed	Actual 2021 Sales (from table above)	2021 Sales if They Had Not Participated in the RNCR Program
Code minimum	__%	__%
Better than code	__%	__%
Energy Star Certified Program Homes	__%	__%
Energy Star Certified Non-Program Homes	__%	__%
[Other EE category—if identified by the interview]	__%	__%
Total Single-Family Homes Constructed in 2021 in Dominion Energy's Virginia Service Territory	**100%**	**100%**

That's all the questions I had. Thank you so much for your time.

APPENDIX C. IN-DEPTH INTERVIEW GUIDE FOR NON-PARTICIPATING BUILDERS

Interview Information

Interviewer		Survey Length (min)	
Completion Date			

Contact Information

Phone	
Email	

Call Tracking

Date/Time	Notes
NEEA	

Introduction

[NOTE: THE QUESTIONS IN THIS INTERVIEW GUIDE WILL NOT NECESSARILY BE READ VERBATIM BUT MAY BE MODIFIED TO SUIT THE INTERVIEW]

2. Hi, my name is X OF DNV. We are conducting a study of the residential new construction market in Virginia on behalf of Dominion Energy. All the information we collect in this interview will be kept confidential; your name will not be included the study results. If you complete the full interview, you will receive a gift card with a value of $50.

[IF THEY ASK HOW LONG THE INTERVIEW WILL TAKE, TELL THEM ABOUT 45 MINUTES]

[ASK IF IT'S OK TO RECORD THE CALL].

[IF THEY REFUSE THE INTERVIEW (NOT THE RECORDING), THANK THEM FOR THEIR TIME AND HANG UP]

Company, Interviewee Background

First, I had a few background questions about you and your company.

31. What is your job title?

32. Approximately how many full-time employees are in the division where you work?
33. Besides Virginia, in what other states does your company operate?
34. About how many single-family homes did your company build in the past year in Virginia? By single-family homes I mean either detached homes or attached homes such as townhouses.
    a. About what % of these were built in Dominion Energy's service territory?
35. Does your company have different tiers of single-family homes they offer based on different price or quality tiers?
    a. [IF YES] Please explain what these different tiers are and how the characteristics of the houses might differ between tiers.
36. Are there certain areas of Virginia where you build more of your homes?
    a. [IF YES] Which areas of Virginia?
37. Does your company construct any multifamily buildings?
38. Does your company construct any commercial buildings?

General Construction Practices

[NOTE TO INTERVIEWERS: IF BUILDER INDICATED IN Q5. THAT THEY SELL DIFFERENT TIERS OF HOME QUALITY, TRY TO ASK THIS BATTERY OF QUESTIONS SEPARATELY FOR EACH TIER, STARTING WITH THE HIGHEST COST/QUALITY TIER]

39. We're interested in the different levels of energy efficiency in the single-family homes you build in Dominion Energy's Virginia service territory. I'm going to ask you about four different categories of energy efficient homes including:
    a. *Code Minimum:* These are single family homes you built in Dominion Energy's Virginia service territory that meet but do not exceed the mandatory and prescriptive requirements of the International Energy Conservation Code (IECC))
    b. *Better than Code:* These are single family homes you built in Dominion Energy's Virginia service territory that are more energy efficient than the Virginia code requires, but are not Energy Star certified
        i. [IF THEY MENTIONED THAT THEY BUILD BETTER THAN CODE] "You mentioned that you build above code. Do you verify that performance with HERS ratings or any other 3rd-party verifier?"
            1. [IF YES, COLLECT INFO ON HOW THEY VERIFY THIS]
        ii. [IF THEY MENTIONED THEY SELL MORE THAN ONE TIER OF HOUSING PRICE/QUALITY IN RESPONSE TO Q5] You earlier said that you sold more than one tier of housing with different tiers of price or quality. Is it the case that your base tier homes just meet code and your higher tier homes are built better than code? Or is it more complicated than this?
            1. [IF THEY SAY'S IT'S MORE COMPLICATED THAN THIS. ASK THEM TO EXPLAIN THESE NUANCES]
    c. *Energy Star certified homes:* These are Energy Star certified single family homes you built in Dominion Energy's Virginia service territory

Now I'm going to ask you to estimate how your sales of single-family homes in Dominion Energy's Virginia service territory in recent years were distributed across these three categories. First, I'll start with 2021. How were your sales of single-family homes in Dominion Energy's Virginia service territory in that year distributed across these three categories? You should treat these categories as mutually exclusive and the percentages should add up to 100% [REPEAT THE ABOVE DEFINITONS OF THE THREE CATEGORIES, IF NEEDED. RECORD THEIR RESPONSES IN THE TABLE BELOW].

40. Now please estimate how your 2020 sales of single-family houses in Dominion Energy's Virginia service territory we're distributed across these categories.

41. Now I realize that 2019 is a while ago, but we are hoping to get one estimate of the mix of your single-family housing sales in Dominion Energy's Virginia service territory before the pandemic hit. Please estimate how your 2019 sales of single-family houses in Dominion Energy's Virginia service territory we're distributed across these categories. [REPEAT THE ABOVE DEFINITONS OF THE THREE CATEGORIES, IF NEEDED. RECORD THEIR RESPONSES IN THE TABLE BELOW]

42. While we are only partially through 2022, we are hoping you could estimate how your 2022 sales of single-family homes in Dominion Energy's Virginia service territory are distributed across these categories. [REPEAT THE ABOVE DEFINITONS OF THE THREE CATEGORIES, IF NEEDED. RECORD THEIR RESPONSES IN THE TABLE BELOW]

Energy Efficiency of Single-Family Homes Newly Constructed	Actual 2021	Actual 2020	Actual 2019	Projected 2022
Code minimum	__%	__%	__%	__%
Better than code	__%	__%	__%	__%
Energy Star certified homes	__%			__%
[Other EE category—if identified by the interview]	__%	__%	__%	__%
Total Single-Family Homes Constructed in 2021 in Dominion Energy's Virginia Service Territory	**100%**	**100%**	**100%**	**100%**

43. [IF THEY SOLD CODE MINIMUM IN 2021 OR 2022] You said you sold homes in Dominion Energy's Virginia service territory that were generally designed to just meet code [in 2020 or 2021]. On average, what percent of the hardwired lighting fixtures installed in these homes are LED?

    a. Do you still install CFLs at the homes you build?

        i. [IF YES] Roughly about what % of the lighting fixtures, including decorative lighting, do these CFLs account for?

    b. Do you still install halogen or incandescent lighting at the homes you build?

i. [IF YES] Roughly about what % of the lighting fixtures, including decorative lighting, do these incandescents and halogens account for?

44. Were you aware that since 2021 Dominion Energy has offered a program which offers financial incentives for building Energy Star certified homes?

    a. [IF YES AND THEY SOLD ENERGY STAR CERTIFIED HOMES IN 2021 OR 2022] You said you sold Energy Star certified homes in Dominion Energy's Virginia service territory [in 2021 or 2022]. What were your reasons for not selling these Energy Star certified homes through the program?

    b. [IF YES AND THEY DID NOT SELL ENERGY START CERTIFIED HOMES IN 2021 OR 2022] What were your reasons for not participating in this the Dominion Residential New Construction program?

45. [IF THEY SOLD BETTER THAN CODE HOMES IN 2021 OR 2022] You said you sold some single-family homes in Dominion Energy's Virginia service territory [in 2021/2022] that had energy efficiency features that were greater than building codes required? What were your reasons for building these above code houses?

46. [IF THEY SOLD HIGHER AND LOWER PRICE/QUALITY] TIER HOMES IN 2021 OR 2022] The following table shows what current Virginia code requires for certain home parameters that have implications for energy efficiency. It also shows the range of values that a 2018 government study found based on onsite data collection in the Virginia residential market.

    a. First, about what percent of the houses you built in Dominion Energy's Virginia service territory in 2021 were in the base tier of price or quality and what percent were in the higher tier(s)

    b. Please give me your best estimate of what the parameters in the table below are for the *base price/quality hou*ses you built in Dominion Energy's Virginia service territory in 2021

    c. Please give me your best estimate of what the parameters in the table are below for *the average higher price/quality hou*ses in Dominion Energy's Virginia service territory you built in 2021

47. [IF THEY SOLD A SINGLE TIER AND SOME OF THE HOMES BETTER THAN CODE IN 2021 OR 2022]

The following table shows what current Virginia code requires for certain home parameters that have implications for energy efficiency. It also shows the range of values that a 2018 government study found based on onsite data collection in the Virginia residential market. Please give me your best estimate of what the parameters in the table below are for the single-family homes you built in Dominion Energy's Virginia service territory in 2021.

Specification	2018 Typical Practice	**Current VA Code** IECC 2018 with amendments (effective 7/1/2021)	Baseline quality/price tier homes	Average higher quality/price tier homes]	Notes and comments
Tier Percentage of new homes: [STANDARD TIER + HIGH TIER ADD UP TO 100%]			**____%**	**____%**	
Lighting (% LEDs) Higher value is more efficient	45% to 100%	90% (previously 75%)	___ Average Value	___ Average Value	
			____ Meets code ____ Exceeds code Don't know _____	____ Meets code ____ Exceeds code Don't know _____	
Infiltration (ACH50) Higher value is less efficient	7.5 to 2.0	5	___ Average Value	___ Average Value	
			____ Meets code ____ Exceeds code	____ Meets code ____ Exceeds code	

Specification	2018 Typical Practice	**Current VA Code** IECC 2018 with amendments (effective 7/1/2021)	Baseline quality/price tier homes	Average higher quality/price tier homes]	Notes and comments
			Don't know _____	Don't know _____	
Duct leakage (%LTO) Higher value is less efficient	3.0 to 10.0 cfm25 per 100 sq. ft.	4 cfm25 per 100 sq. ft.	___ Average Value	___ Average Value	
			____ Meets code ____ Exceeds code Don't know _____	____ Meets code ____ Exceeds code Don't know _____	
Duct insulation Higher value is more efficient	N/A	unconditioned: R-8 (diameter is >3")	___ Average Value	___ Average Value	
			____ Meets code ____ Exceeds code	____ Meets code ____ Exceeds code	

Specification	2018 Typical Practice	**Current VA Code** IECC 2018 with amendments (effective 7/1/2021)	Baseline quality/price tier homes	Average higher quality/price tier homes]	Notes and comments
			Don't know _____	Don't know _____	
Window u-value Lower value is more efficient	0.23 to 0.35	0.32 (previously 0.35)	___ Average Value ____ Meets code ____ Exceeds code Don't know _____	___ Average Value ____ Meets code ____ Exceeds code Don't know _____	
Window SHGC Lower value is more efficient	0.16 to 0.32	0.36 (previously 0.4)	___ Average Value ____ Meets code ____ Exceeds code	___ Average Value ____ Meets code ____ Exceeds code	

Specification	2018 Typical Practice	**Current VA Code** IECC 2018 with amendments (effective 7/1/2021)	Baseline quality/price tier homes	Average higher quality/price tier homes]	Notes and comments
			Don't know _____	Don't know _____	
Furnace (%AFUE)	N/A	80% (2010 proposed federal standard)	___ Average Value	___ Average Value	
			____ Meets code ____ Exceeds code Don't know _____	____ Meets code ____ Exceeds code Don't know _____	

48. [IF THEY GAVE A RESPONSE TO THE AIR FILTRATION QUESTION] How do you test for air infiltration?
    a. [IF NOT ALREADY MENTIONED] Who performs your blower door or duct blasting tests?
49. [IF THEY SOLD a single tier and some of the homes BETTER THAN CODE HOMES IN 2021 OR 2022] For those homes that are better than code, are there other high efficiency features that you typically install?
    a. [IF YES] What other energy efficiency features do you typically install?

Characterizing the market for ENERGY STAR certified homes

ASK THIS BATTERY ONLY IF THEY SAID THEY SOLD ENERGY STAR CERTIFIED HOMES

50. You said you sold Energy Star certified homes in Virginia. What factors encouraged you to build these Energy Star certified homes?
51. Do the Energy Star Certified homes you sell at a different price point than homes with similar sizes and features?
    a. [IF YES] What is the typical price point differences between the Energy Star Certified homes you sell and the homes with similar sizes and features?
52. Can you make any generalizations about the types of customers who purchase these Energy Star Certified homes in Virginia?
    a. [IF YES] What types of customers purchase these Energy Star Certified homes in Virginia?
53. Are there certain parts of Virginia where you are more likely to sell Energy Star Certified homes?
    a. [IF YES] What parts of Virginia?

Marketing and outreach practices

Now we would like to hear about your marketing and outreach practices.

54. What sort of marketing and outreach does your company do in Virginia?
    a. [IF NOT ALREADY MENTIONED] Are there certain types of homeowners that your marketing and outreach efforts focus on?

i. [IF YES] What types of homeowners?

b. [IF NOT ALREADY MENTIONED] Do you mention energy efficiency in your home promotions?

i. [IF YES] How was energy efficiency featured in your promotions?

That's all the questions I had. Thank you so much for your time.

About DNV

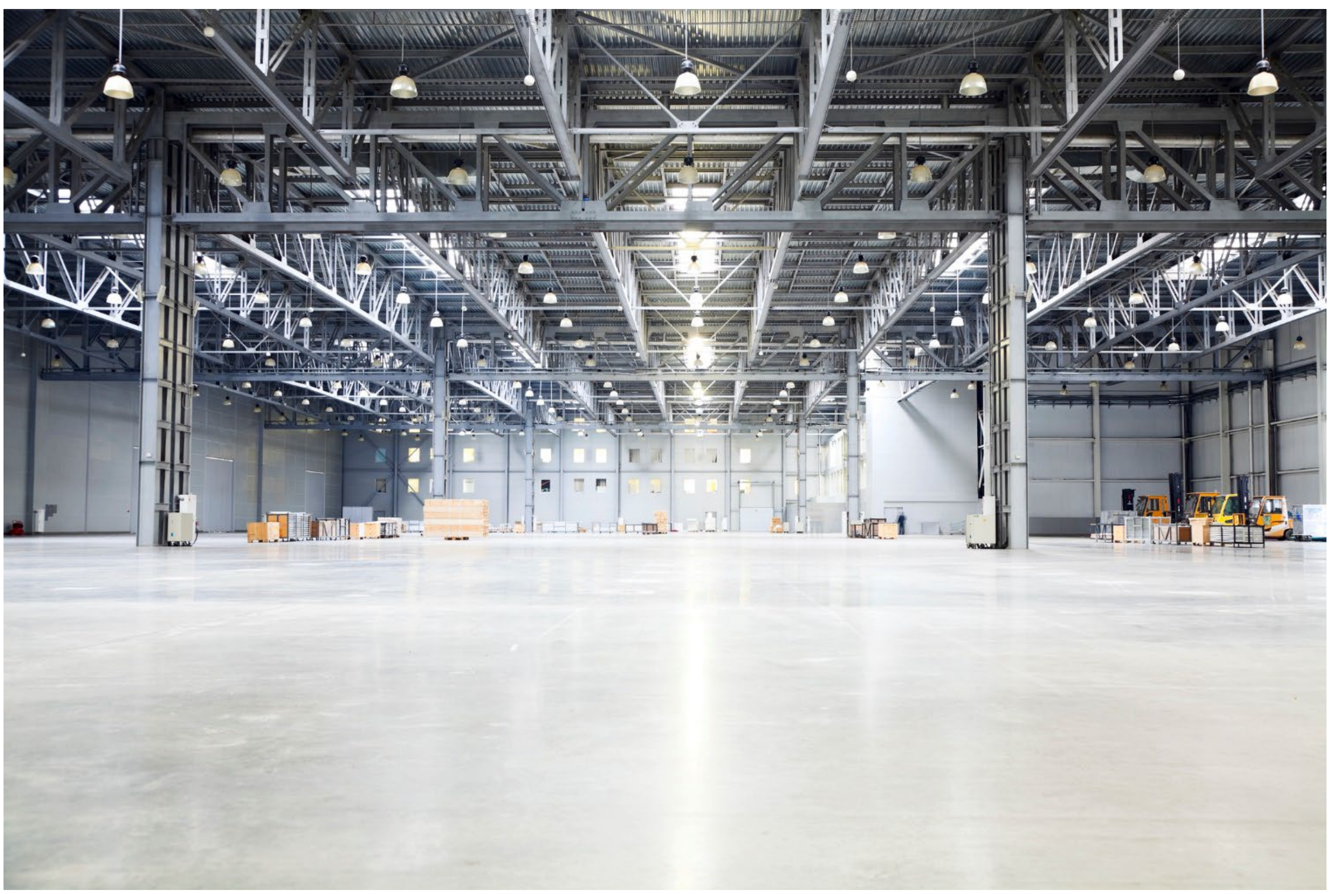
DNV is a global quality assurance and risk management company. Driven by our purpose of safeguarding life, property and the environment, we enable our customers to advance the safety and sustainability of their business. We provide classification, technical assurance, software and independent expert advisory services to the maritime, oil & gas, power and renewables industries. We also provide certification, supply chain and data management services to customers across a wide range of industries. Operating in more than 100 countries, our experts are dedicated to helping customers make the world safer, smarter and greener.

Appendix K

Non-Residential Lighting End Use Baseline, Gross and Net Impact, and Persistence Study

Dominion Energy

Date: May 23, 2023



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1 EXECUTIVE SUMMARY

This report presents the results of a coordinated bundle of three studies of Dominion Energy's (Dominion Energy or the Company) non-residential lighting measures. DNV conducted these studies across two active programs and two programs that had closed to customer enrollment. The three studies in this bundle are:

- A Baseline Study to understand baseline values for future savings calculations
- A Gross and Net Impact Evaluation to re-estimate net energy and peak demand[1] savings and to provide peak coincidence factors for the calculation of future program peak[2] reductions.
- A Persistence Study to determine the proportion of prior program year savings still in place and operable

The above studies were conducted in response to the Virginia State Corporation Commission (SCC) final order in Case No. PUR-2020-00156, filed on October 27, 2021. Specifically, the order requires Dominion Energy to:

1. Conduct two baseline studies (page 16)
2. Conduct impact evaluations (Attachment A)
3. Verify persisting measure installation and operability (page 14)

Bundling these three studies together cost-effectively meets the SCC requirements while offering the Company comprehensive insight into the highest-saving energy efficiency measure in the portfolio. This is especially important as the market moves rapidly toward the natural adoption of LED technologies because there will be fewer opportunities to generate bountiful energy savings from lighting. This bundle of studies is key to understanding the changing role that lighting can play as the Company identifies other sources of savings as it works toward the goals of the Virginia Clean Economy Act (VCEA).

Table 1-1 lists each energy efficiency program that DNV evaluated, which studies they were part of, and the years each program was active.

[1] Based on current Dominion Energy Technical Reference Manual definitions of summer (non-holiday weekdays, June-August, 2pm-6pm) and winter (non-holiday weekdays, January and February, 7am-9am and 6pm-8pm) peaks.

[2] Using Dominion Energy's definitions of summer (non-holiday weekdays, July, 3pm-4pm) and winter (non-holiday weekdays, January, 7am-8am) coincident peaks.

Table 1-1. Dominion Energy's programs studied in this report

Program name	DSM phase	Acronym	Program years[3]	Baseline	Net-to-gross	Gross impact	Persistence
Non-Residential Lighting Systems & Controls	3	CLT2	May 2014 – December 2018				✓
Non-Residential Lighting Systems & Controls	7	CLT3	October 2019 – December 2022	✓	✓	✓	✓
Small Business Improvement	5	SBIP	July 2016 – December 2020				✓
Small Business Improvement Enhanced	8	SBI2	January 2021 – Ongoing	✓	✓	✓	✓

[3] Program end dates represent when the programs were closed to customer enrollment. For EM&V tracking purposes, participation and the resulting energy savings were counted based on the rebate approval date, which can occur after programs are closed to customer enrollment.

1.1 Key findings and recommendations

The key findings from the Baseline Study, Impact Evaluation, and Persistence Study are as follows.

1.1.1 Baseline study

The Baseline Study had the following key findings:

Finding 1. Retrofit baselines are defined as the fixture replaced at the time of the retrofit project.

For interior lighting, T8 and incandescent fixtures together accounted for 91% of all replaced fixtures with the remainder being High-Intensity Discharge ("HID") and T5. For exterior lighting, 72% of the replaced fixtures were HID, 26% T8, and the remaining 2% incandescent.

Finding 2. The majority of sites classified as retrofits in the program tracking data were confirmed during the evaluation.

49 of the 52 sites evaluated were confirmed as retrofits. The remaining three projects were found to be major renovations. Since major renovations are code-triggering events, they should follow the same savings estimation approach as new buildings. Therefore, savings for these three projects were evaluated using lighting power density (LPD) instead of per-fixture savings estimation methods. Further, the evaluation used code LPD to represent the baseline condition rather than pre-existing fixture types.

Finding 3. DNV estimates the baseline for non-residential new construction lighting to be 24% better than the Virginia Energy Conservation Code (VECC).

This is based on plan reviews of new construction lighting in 36 recent Virginia new construction projects and interviews with 19 design and/or installation firms and is supported by a literature review of industry standard practice (ISP) studies in other jurisdictions. This finding applies to both the 2015 and 2018 VECC versions; additional analysis is recommended to assess new construction baselines for future code versions.

Finding 4. There is high market penetration of LEDs for both new construction and retrofit applications.

100% of the rebated fixtures evaluated through the impact study were LEDs, and 100% of the fixtures identified via plan reviews were LEDs. Additionally, interviewees consistently reported high penetration of LEDs and a market that has mostly transitioned to efficient lighting for new construction and retrofits.

Based on these findings, DNV makes the following recommendations:

Recommendation 1. Update program applications to include "major renovation" as an option for the reason the work was performed.

The classification of the project determines the algorithm used to calculate energy savings. To increase the accuracy of the classification and resulting energy savings estimates, DNV recommends adding "major renovation" as an option on the program applications for "Reason for Work Done." Projects falling into this category should follow the same savings estimation approach and baseline assumptions as new construction projects do. These are described in the following two recommendations.

Recommendation 2. Consider calculating incentives for new construction/major renovation lighting based on design, using a performance basis.

The VECC specifies new construction lighting based on LPD, which is measured in watts per square foot. Prescriptive programs typically offer per-fixture incentives and do not assess lighting design. We recommend consideration that new construction or major renovation projects should go through the Dominion Energy Virginia Non-Residential New Construction Program or other similar programs that assess lighting design via LPD, rather than the Non-Residential Lighting Systems & Controls Program which does not.

Recommendation 3. Consider updating new construction/major renovation lighting baselines with respect to the results of the ISP estimated in this study.

Regarding performance incentives for the Non-residential New Construction Program, DNV recommends reviewing the baseline used for calculating the incentives. The recent study suggests that a 24% reduction in code baseline LPDs should be considered to reflect the ISP results from this study. This applies to both VECC 2015 and VECC 2018 code LPDs. DNV recommends this result be revisited for projects permitted under future code versions.

1.1.2 Impact evaluation

1.1.2.1 Gross findings

Updated hourly load shapes and annual hours of use

Finding 1. Updated annual hours of use

DNV combined lighting logger data from a previous 2010 study and this study to calculate updated annual hours of use (HOU) estimates by building type specific to the Company's customers. Table 1-2 provides the site counts from the 2010 study, current study, and the total site count by building type. This table also compares the HOU of these metered sites to the current Dominion Energy Technical Reference Manual (TRM) assumptions, as shown in the Non-Residential volume of the TRM in Appendix F of the program year 2022 evaluation, measurement, and verification report. The metering average annual HOU is all within 20% of the current TRM assumptions.

Table 1-2. Updated HOU by building type

Building type	2010 metering study sites	Current study sites	Total metered sites	Metering site avg. annual HOU	Dominion Energy TRM HOU
Assembly	4	0	4	4,692	4,058
Education	2	3	5	2,558	2,233
Food	9	0	9	7,203	7,272
Health	1	3	4	4,077	3,817
Lodging	1	3	4	4,802	4,058
Mercantile	22	0	22	5,444	4,696
Office	6	0	6	3,296	3,044
Warehouse	6	0	6	4,222	4,361

Finding 2. Updated gross realization rate

This study developed updated gross realization rates (RRs) for the CLT3 and SBI2 programs using the updated HOU and a blend of onsite (n=9) and virtual site verifications (n=42). The existing RRs for energy and peak demand savings, for each program, are 100% and were based on the program design assumptions. As Table 1-3 shows, the updated gross kWh RRs were found to be over 120%, while the summer and winter on-peak gross kW RR were consistently close to 100%.

Table 1-3. Updated gross RR

Program	Population	Sample	Gross realization rate (kWh)	Relative precision (kWh)	Gross realization rate (Summer kW)	Relative precision (Summer kW)	Gross realization rate (Winter kW)	Relative precision (Winter kW)
CLT3	397	36	123.7%	7.7%	101.5%	15.4%	99.3%	7.9%
SBI2	97	15	121.4%	8.5%	99.4%	11.5%	99.5%	5.9%
All	494	51	123.5%	7.0%	101.3%	14.0%	99.3%	7.2%

Finding 3. Updated net-to-gross ratio

This study developed updated net-to-gross (NTG) ratios for the CLT3 and SBI2 programs through surveys of 158 customers. As Table 1-4 shows, the overall NTG ratio for both programs was 46.4%. This was largely driven by the results of the CLT3 program, which had an NTG ratio of 45.3%. These are lower than existing NTG ratios, which are based on program design assumptions.

Table 1-4. Updated NTG ratio

Program	Population	Sample	Existing NTG ratio	Updated NTG ratio	Relative precision
CLT3	815	131	70.0%	45.3%	18.9%
SBI2	97	27	93.0%	71.7%	14.3%
All	912	158	N/A	46.4%	17.7%

Based on these findings, DNV makes the following recommendations:

Recommendation 1. Apply the program-specific gross RRs to their respective tracking data.

The CLT3 gross RR was developed at the program level and should be applied to all measures offered through the program. The SBI2 gross RR only includes lighting measures offered through the program and should only be applied to such.

Recommendation 2. Apply the program-specific NTG ratios to their respective tracking data.

The CLT3 NTG ratio was developed at the program level and should be applied to all measures offered through the program. The SBI2 NTG ratio only includes lighting measures offered through the program and should only be applied to such.

Recommendation 3. Update the TRM HOU to the Dominion-specific HOU developed in this study.

Following this update, the operational adjustment component of the gross RR should be reset to 100% and the overall gross RRs should be recalculated for future savings estimates to avoid duplication of impacts related to operating hours.

1.1.3 Persistence study

Finding 1. Updated effective useful life

This study developed an updated effective useful life (EUL) estimate for non-residential lighting measures through site verifications of 181 customers and a review of over 45,000 LEDs, T8s, T5s, and occupancy sensors. Table 1-5 presents the results of the analysis, which produced an estimated EUL of 10.1 years.

Table 1-5. EUL results

Sampled sites	Tracking data products	Evaluated products	EUL (years)	Percent installed	Hours of use
181	45,274	40,225	10.1	88.8%	5,548

Based on these findings, DNV makes the following recommendations:

Recommendation 1. Update the EUL used to calculate lifetime savings.

The EUL of 10.1 years should be applied to all the measures in the CLT2 and CLT3 program, and the lighting measures of the SBI2 program. The SBIP EUL is assigned at the program level and not the measure level; therefore, no adjustments should be made to the program-level EUL (14 years) as it contains a blend of lighting and non-lighting measures.

2 INTRODUCTION

This report presents the results of a coordinated bundle of three studies of Dominion Energy's non-residential lighting measures. DNV conducted these studies across two active programs and two programs that had closed to customer enrollment. The three studies in this bundle are:

- A Baseline Study to understand baseline values for future savings calculations
- A Gross and Net Impact Evaluation to re-estimate net energy and peak demand savings
- A Persistence Study to determine the proportion of prior program year savings still in place and operable

The above studies were conducted in response to the Virginia State Corporation Commission (SCC) final order in Case No. PUR-2020-00156, filed on October 27, 2021. Specifically, the order requires Dominion Energy to:

1. Conduct two baseline studies (page 16)
2. Conduct impact evaluations (Attachment A)
3. Verify persisting measure installation and operability (page 14)

Dominion Energy and Commission Staff agreed to conduct baseline studies for the DSM Phase VII Non-Residential Lighting Systems & Controls Program and the Residential New Construction Program.[4] Additionally, based on the criteria outlined in Attachment A of the Order, the high program budget and savings contribution from non-residential lighting measures, primarily in the Non-Residential Lighting Systems & Controls Program, elevates that program for impact evaluation. Additionally, the two other high-impact programs are the Small Business Improvement Program (DSM Phase V) and the current iteration of the program, Small Business Improvement Enhanced (DSM Phase VIII), where lighting measures account for roughly 90% of their savings. Given that the non-residential lighting measures offered in the Small Business Improvement programs are very similar to the measures offered in the Non-Residential Lighting Systems & Controls Program, DNV had an efficient and cost-effective opportunity to study two programs under this bundle of studies. Finally, the programs were a natural candidate for a persistence study because non-residential lighting measures from the four programs studied contributed the largest share of portfolio savings during the years targeted in the Virginia Clean Economy Act (VCEA), 2022 to 2025, among all programs, active and closed.

DNV bundled these three studies together to cost-effectively meet SCC requirements while offering the Company comprehensive insight into the highest-saving energy efficiency measure in the portfolio. This is especially important as the market moves rapidly toward the natural adoption of LED technologies, because there will be fewer opportunities to generate bountiful energy savings from lighting. This bundle of studies will be key to understanding the evolving role that lighting can play as the Company continues to work toward the VCEA goals and identify other sources of savings.

Table 2-1 lists each program that was evaluated, which studies they were part of, and the years each program was active.

[4] The Residential New Construction Program Baseline Study is presented in APPENDIX J of the 2022 EM&V Report.

Table 2-1. Program studied

Program name	DSM phase	Acronym	Program years[5]	Baseline	Net-to-gross	Gross impact	Persistence
Non-Residential Lighting Systems & Controls	3	CLT2	May 2014 – December 2018				✓
Non-Residential Lighting Systems & Controls	7	CLT3	October 2019 – December 2022	✓	✓	✓	✓
Small Business Improvement	5	SBIP	July 2016 – December 2020				✓
Small Business Improvement Enhanced	8	SBI2	January 2021 – Ongoing	✓	✓	✓	✓

2.1 Baseline Study goals

The objective of the Non-Residential Lighting Baseline Study was to estimate non-residential lighting baseline practices in Dominion Energy service territory for both the new construction and the retrofit/replacement markets. Retrofit baselines are defined as the existing conditions (fixtures) present at a building before any lighting upgrades were completed. For new construction, baselines are set by market lighting design practices, referred to as industry standard practices (ISP). These lighting designs, measured in lighting power density (LPD), which is expressed in watts per square foot, are compared to the requirements of the energy code. The new construction baselines are characterized by how much better or worse the ISP code is, typically expressed as a percentage better or worse than energy code requirements. The specific objectives for new construction and retrofit/replacements are:

- **Retrofit baselines:** The objective for retrofit projects was to summarize the types and distribution of existing lighting fixtures present before lighting program activities.
- **New construction baselines:** The objective of the new construction analysis was to develop an estimate of the new construction lighting baseline for Dominion Energy territory. This is a comparison of lighting design practices to the energy code requirements, commonly referred to as the ISP. This includes calculating the LPD, measured in watts per square foot, and comparing it to energy code requirements, which vary by space type.

[5] Program end dates represent when the programs were closed to customer enrollment. For EM&V tracking purposes, participation and the resulting energy savings were counted based on the rebate approval date, which can occur after programs are closed to customer enrollment.

2.2 Impact Evaluation goals

The objective of the Non-Residential Lighting Gross and Net Impact Evaluation was to re-estimate net energy and peak demand savings for the active Non-Residential Lighting & System Controls Program and lighting component of the active Small Business Improvement Enhanced Program from program inception through year-end 2021 (the study period).

2.3 Persistence Study goals

The objective of the Non-Residential Lighting Persistence Study was to determine the proportion of previously rebated equipment in place and operating, especially during the VCEA reporting years.

3 BASELINE STUDY

For the Baseline Study, DNV leveraged the data collection efforts and analysis completed as part of the Impact Evaluation to inform retrofit baselines and conducted additional primary and secondary research to inform new construction baseline findings.

3.1 Data collection

3.1.1 Retrofit baselines

For non-residential lighting, retrofit baselines are defined as the existing conditions present before any lighting upgrades were completed. DNV gathered existing equipment data from facilities during both the onsite and virtual site visits conducted as part of the impact assessment, leveraging the sampling and recruitment done for this activity. This included confirming project details from the tracking data, including the overall project type (retrofit, early replacement, major renovation, new construction), the fixture types, and fixture quantities. The analysis summarizes insights from this review, identifying the distribution of lighting technologies and fixture quantities across the sampled sites, segmenting by interior and exterior lighting, and summarizing the interior data by building type.

3.1.2 New construction baselines

For non-residential new construction lighting, there are no existing fixtures, so the baseline is defined by examining lighting designs to assess ISP and comparing that to code requirements. The typical metric is LPD, measured in watts per square foot. The energy code is often used by programs as the baseline, but primary and secondary research can provide additional details regarding whether ISP lighting design is at code, better than code, or worse than code. DNV conducted the following research activities to inform new construction baselines for Dominion Energy:

1. **Project lighting reviews**. DNV reviewed lighting designs for 36 non-residential new construction buildings that were issued for the general contractor and/or specialized trade bids in 2021 and 2022. The scope of this task did not include full population estimation, statistical sampling of buildings, and extrapolation of results to the population. Rather, the intent was to gather data about new construction lighting design from available construction drawings. DNV leveraged the Builders and Construction Exchange for Virginia (BCEVA) to identify projects for inclusion in this analysis. This approach did not identify program participants; rather, DNV gathered data directly from BCEVA and was no more likely to include participants than non-participants. DNV downloaded construction drawings directly from BCEVA for all sites with available documentation and conducted lighting reviews using the US Department of Energy's COMcheck software. COMcheck analyzes compliance for major building systems in new construction and for lighting design, it calculates the percentage better or worse than code based on site square footage and installed fixtures. The outputs from COMcheck are sometimes included as screenshots in construction drawings demonstrating code compliance. DNV reviewed the construction drawings for each site. Where there was an existing COMcheck for lighting design, DNV verified the entries, and where there was no COMcheck supplied on drawings, DNV measured all available spaces where possible within each building and inventoried the lighting design for each measured space using the software.
2. **Lighting designer and contractor interviews**. DNV conducted interviews with 19 lighting designers and installers working in Virginia. These interviews sought to understand how design and installation firms approach lighting design, their awareness of energy codes with respect to lighting, and perspectives on the current and future lighting market in Virginia. DNV identified design and installation firms from the lists of Dominion Energy program qualified vendors and by scraping lighting and design firm information from the BCEVA project reviews. DNV offered an incentive of $100 for completing an interview. Table 3-1 shows the disposition summary from the interview effort. Over five weeks starting in February 2023, DNV contacted 120 firms via email and telephone, a total of 383 contact attempts, to complete the 19 interviews, for a completion percentage of 16% of companies contacted.

Table 3-1. Disposition summary of lighting designer and contractor interviews

Disposition	BCEVA contacts	Dominion Energy qualified vendors	Totals
Complete	3	16	19
Refused	5	8	13
Not reached	23	60	83
Business or contact no longer available	1	4	5
Totals	**32**	**88**	**120**

3. **Benchmarking literature review**. DNV reviewed lighting baseline research conducted in other jurisdictions to benchmark insights from the Virginia research. DNV reviewed lighting baseline, and ISP studies in Massachusetts, Connecticut, and New Jersey.

3.2 Results

3.2.1 Retrofit baseline results

To assess retrofit baselines, DNV analyzed 49 sites, 8 through the onsite metering and 41 through virtual site visits. Note that three sites were originally classified as retrofit but were determined to be major renovations during the DNV review; these sites are excluded from retrofit baselines and are addressed in Section 3.2.1.1. For all sites classified as retrofit in the analysis, DNV aggregated the types and quantities of fixtures replaced through the program. Table 3-2 summarizes the fixtures overall, and Figure 3-1 and Figure 3-2 break out the fixtures by interior and exterior (including parking garage) applications.

Table 3-2. Distribution of existing fixtures for retrofit projects

Fixture type	Interior	Exterior	Total
HID	265	812	1,077
Incandescent	1,551	19	1,570
T8	2,769	237	3,006
T5	80	0	80
Total	**4,665**	**1,068**	**5,733**

For interior lighting, incandescent and T8 fixtures were the most common baseline fixture type, collectively accounting for 92% of all evaluated fixtures. For exterior lighting, HID fixtures were the primary baseline condition at 76% of the evaluated fixtures, followed by T8 at 22%. The remainder were incandescent fixtures. LEDs were installed for 100% of the fixtures across all reviewed retrofit projects.

Figure 3-1. Interior lighting fixture distribution for retrofit projects

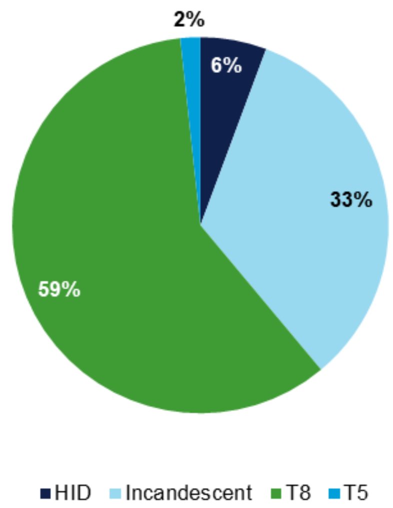


Figure 3-2. Exterior lighting fixture distribution for retrofit projects

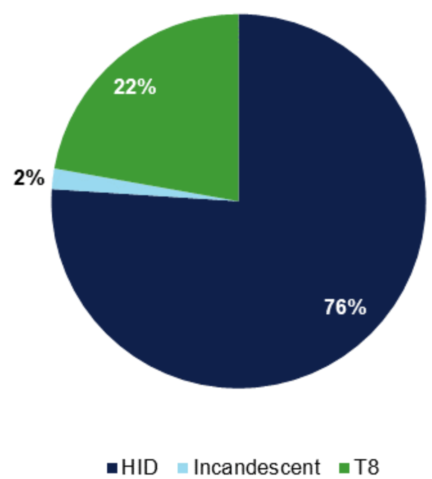
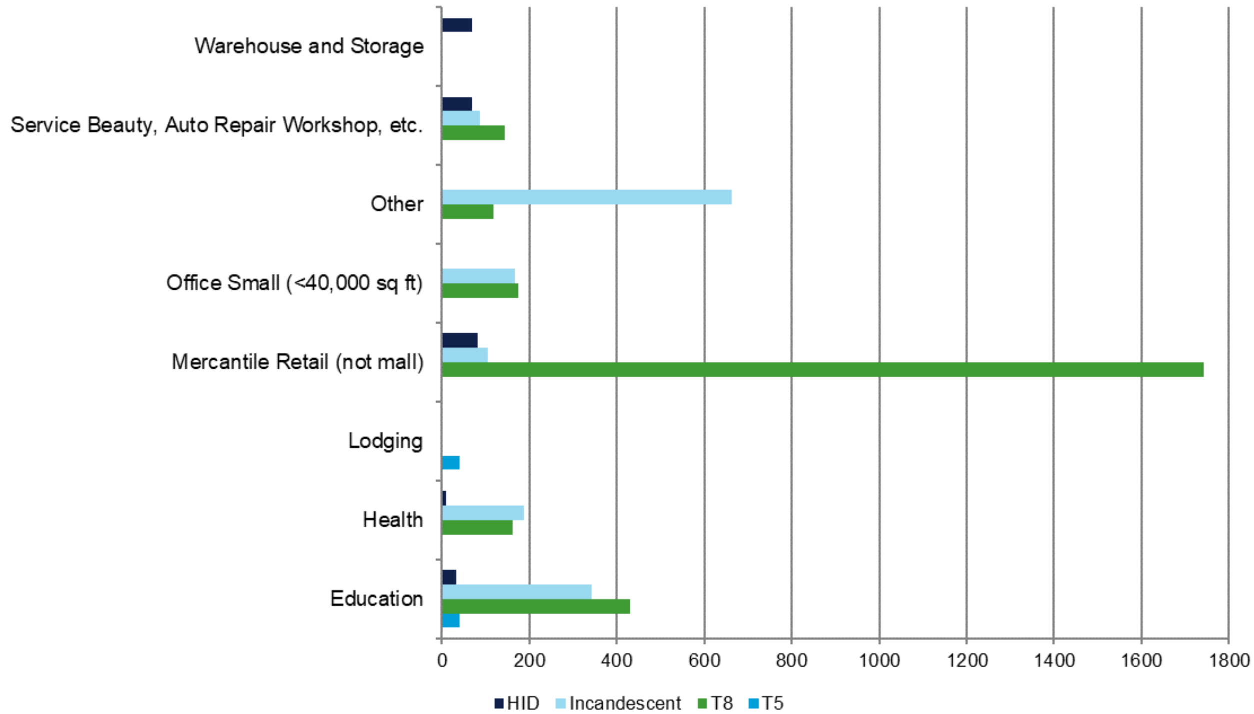


Figure 3-3 shows the distribution of interior fixtures by building type. Most retail retrofitted fixtures were T8, while education facilities had a mix of mostly T8 and incandescent retrofits.

Figure 3-3. Distribution of interior retrofit fixtures by building type



3.2.1.1 Update to major renovation baselines for retrofit records

As mentioned above, the impact site visits included inquiries about the event type (retrofit, new construction, major renovation, etc.) that led to the installation of the program lighting. While all the impact sites were classified as retrofit events in the tracking system, three site contacts (one onsite and two virtual) reported that the program installations occurred as the result of a major renovation at their facility. The impact analysis accounted for this by incorporating a baseline adjustment into the updated gross realization rate. The evaluation baselines for these three sites were calculated by applying the 2015 International Energy Conservation Code (IECC) lighting power density (LPD) values by building area type,[6] based on the square footage of the areas where program fixtures were installed as shown in Table 3-3. These LPD baseline wattages were applied in the impact analysis and are reflected as technology adjustments to the tracking savings in the updated gross realization rate.

[6] https://codes.iccsafe.org/content/IECC2015/chapter-4-ce-commercial-energy-efficiency, Table C405.4.2(1).

Table 3-3. Impact visit renovation baseline wattages based on 2015 IECC LPDs

Site ID	Building type	Space type	A Tracking baseline wattage	B Evaluation installed quantity	C Evaluation installed wattage	D Sq. ft. of space	E 2015 IECC LPD building area type	F 2015 IECC LPD	H=D*F/B LPD baseline wattage
S60817641 _CLT3	Education	Classrooms	96	332	41	40,309	School/University	0.87	105.6
		Hallways/Stairs	64	313	33	30,587	School/University	0.87	85.0
		Classrooms	64	9	33	879	School/University	0.87	85.0
		Hallways/Stairs	42	86	19	4,839	School/University	0.87	48.9
		Workshop	175	18	60	3,198	Workshop	1.19	211.4
		Classrooms	32	58	12	2,061	School/University	0.87	30.9
S729774200 _CLT3	Office Large	Office	120	53	32	20,109	Office	0.82	311.1
		Office	480	8	32	3,035	Office	0.82	311.1
		Office	1360	13	22	3,391	Office	0.82	213.9
S78782345 _CLT3	Office Small	Office	96	186	40	18,321	Office	0.82	80.8
		Office	89	49	30	3,620	Office	0.82	60.6
		Office: Exit Signs	40	17	1	42	Office	0.82	2.0
		Office: Exit Signs	90	7	1	17	Office	0.82	2.0

3.2.2 New construction baseline results

This section presents the results of the three new construction data collection activities, as well as DNV's integration of these results to assess new construction baselines.

3.2.2.1 Lighting plan reviews

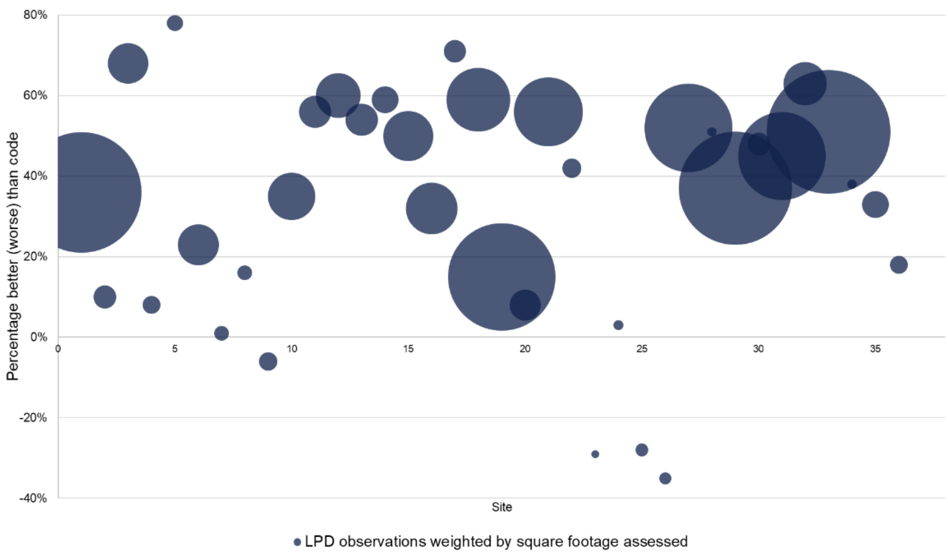
DNV conducted LPD reviews for 36 sites sourced from the BCEVA website. These were all projects that were issued for bid in 2021 or 2022, with lighting designs governed by the energy code in place at the time of permitting (either VECC 2015 or VECC 2018 depending on timing). The data collection approach did not incorporate an assessment of program participation for these sites, but due to the low number of new construction program participants, DNV does not expect that these sites participated in Dominion Energy programs to receive lighting incentives. Table 3-4 shows the site count and square footage by building type. Overall, for the 36 buildings included, DNV assessed LPD design for over 920,000 square feet. This dataset is based on the data available in BCEVA; it likely overrepresents public buildings (education and municipal) and likely underrepresents other segments such as multifamily, retail, and office.

Table 3-4. Baseline plan review site summary

Building type	Site count	% of sites	Square footage assessed	% of square footage
Education	7	19%	514,173	56%
Municipal (park facilities, maintenance buildings, post offices, fire station, & library)	13	36%	194,755	21%
Multifamily	2	6%	86,580	9%
Retail	8	22%	58,170	6%
Office	4	11%	10,411	1%
Other (hotel & healthcare)	2	6%	57,144	6%
Total	**36**	**100%**	**921,234**	**100%**

Figure 3-4 is a bubble chart that shows the distribution of site observations weighted by the square footage assessed at each building. This figure shows that nearly all buildings assessed had LPD designs better than code, with only several small buildings assessed as worse than code and the highest assessed at 78% better than code. Six buildings were greater than 50,000 square feet, and all were better than code, ranging from 15% better to 52% better. All fixtures observed in this review, even for sites that were slightly worse than code, were LED fixtures.

Figure 3-4. Plan review observations weighted by assessed square footage



DNV calculated the average percentage better or worse than code to be 41% better than code, weighted by square footage assessed. Segmenting by code version did not have a material impact on the results, as shown in Table 3-5. The ubiquitous use of LEDs for all fixtures in these new construction sites drives this result, as LED adoption continues to outpace code LPD requirements.

Table 3-5. Weighted average percentage better or worse than code for lighting plan reviews

Code version basis of design	Site count	SF	Percentage better or worse than code
VECC 2015	11	218,189	40%
VECC 2018	25	703,045	41%
Totals	**36**	**921,234**	**41%**

Key takeaway: Plan reviews of 36 recent buildings in Virginia show lighting designs at 41% better than code when weighted by square footage. All buildings reviewed specified 100% LED fixtures on their construction drawings.

3.2.2.2 Lighting designer and contractor interviews

DNV conducted interviews with 19 firms doing non-residential lighting design and/or installation work in Virginia. This included 16 firms identified by recruiting from Dominion Energy's lists of approved program vendors, and three firms identified by scraping BCEVA data to find lighting design teams.

Interviewee summary

Table 3-6 shows the distribution of interviewees by project type. DNV asked the respondents to estimate the total number of projects completed during the program period, and the percentage of new construction and retrofit. DNV used these responses to develop the estimated counts in the table. Overall, 11 of the 19 respondents did some new construction projects during the program period. This distribution of projects was a smaller percentage of new construction (24%) than anticipated, likely reflecting the program focus on retrofit projects for prescriptive per-fixture incentives.

Table 3-6. Interviewee estimated project types and counts for 2020/2021 calendar years

Project type	Count of respondents	Count of NC projects	Count of retrofit projects	Total projects
Both new construction and retrofit	9	217	681	898
New construction only	2	108	0	108
Retrofit only	8	0	366	366
Total	19	325	1047	1,372

DNV also asked respondents about their role in Virginia projects; 11 did some lighting design, while 8 only did lighting installations. Table 3-7 shows these results and corresponding project counts.

Table 3-7. Interviewee reported project roles for Virginia 2020/2021 calendar year

Project role	Count of respondents	Count of NC projects	Count of retrofit projects
Both lighting design and installations	8	85	706
Lighting design only	3	118	252
Lighting installations only	8	122	89
Total	19	325	1,047

Estimating ISP from interviews

DNV asked the respondents who indicated involvement in new construction projects to estimate the percentage of projects that have lighting designs at code, better than code, or worse than code. Overall, nine respondents answered this question, representing 217 (67%) of the 325 new construction buildings estimated overall. Where respondents identified project designs as better than code, DNV asked how much better than code their typical designs are. Three respondents provided estimates; when weighted by their share of buildings above code, this estimate is 24% better than code.

DNV did not ask interviewees about typical worse-than-code performance, but used -19% as a proxy from the plan reviews. This value represents the square footage weighted average of the four plan review sites identified as worse than code. Multiplying the estimated percentages of projects by the percentages better or worse than code gives us ISP for each performance level, which can be summed to get an overall estimate of ISP from the interviews of 8% better than code, as shown in Table 3-8.

Table 3-8. Estimates of new construction lighting design compared to code LPD

Performance level	Interviewee estimated percentage of projects	Estimated percentage better or worse than code	ISP estimate
Better than code	39%	24%	9%
At code	54%	0%	0%
Worse than code	7%	-19%	-1%
ISP Estimate			8% better than code

Additional interview insights for new construction

The lighting designer and contractor interviews identified several additional insights to consider when assessing overall new construction baselines:

- **Market transformation to LEDs for new construction**. DNV asked interviewees several questions to assess the market penetration of LEDs. The qualitative responses support the high penetration of LEDs for both retrofit and new construction lighting. Interviewees were asked to estimate the distribution of fixtures by technology for the projects their companies completed during the program period and to estimate the anticipated penetration of high-efficiency (LED) lighting in the Virginia market over the next three years (2023 through 2025).

- Of the 11 respondents that indicated that they do new construction projects, 7 indicated that the percentage of LEDs was greater than 95% of all fixtures they install, 1 indicated 75% LED and 25% T5 lighting but primarily for retrofits, and 3 could not answer.
- When asked about the percentage of lighting installed in Virginia that will be high-efficiency lighting, 8 of the 11 new construction respondents estimated that efficient lighting would be greater than 90% of the market (5 said the market was fully transitioned or 100%, 3 more said it was greater than 90%, 1 said 80%, and 2 did not answer).

- **Interviewees reported lower energy code awareness and knowledge than anticipated**. DNV asked the interviewees several questions to better understand their knowledge of energy codes and found that awareness of the code and code processes was lower than anticipated. For example, DNV asked all 19 interviewees what the prevailing energy code was in Virginia and received many incorrect or partially correct responses. Six of the interviewees identified that they were unsure or relied on other firms to do the design and focus on the installation only. This focus on installation and lack of knowledge suggests that their estimates are likely worse than the actual ISP, as they may not fully account for the impact of high LED adoption on building designs exceeding code LPD.

Key takeaway: Based on interviewee responses, DNV estimates a new construction baseline of 8% better than code. However, DNV expects that this number is likely worse than the actual baseline, as the interviewees validated the high penetration of LEDs, which typically results in significantly better-than-code performance in LPD design and revealed lower than anticipated knowledge and awareness of code requirements.

3.2.2.3 Literature review

To complement the plan reviews and interviews conducted for this study, DNV also completed a literature review of non-residential lighting ISP studies in other jurisdictions. These studies include prior research completed by DNV and partner firms. Table 3-9 shows the results of this benchmarking research. All these studies found ISP to be better than code, largely due to the increasing prevalence of LED fixtures in new construction, and the energy code lagging LED adoption despite incremental increases in stringency with each successive code version. In Massachusetts, analysis of LPD ISP has been conducted for the past three codes, with ISP increasing even as code stringency has increased. The 2022 CT study assessed code compliance and lighting ISP, comparing results against the energy code in place at the time of the study (IECC 2015), as well as the next code iteration (IECC 2021). Three of these benchmarking studies reflect an equivalent or similar code to IECC 2015, which is the code in place in Virginia during the most recent program period. All three of these studies had similar findings, recommending that ISP be set to 40% better than code LPD values.

Table 3-9. Benchmarking literature review results

Jurisdiction	Code of code equivalent	Date completed	LPD ISP result
MA	IECC 2009	2017	22% better than code
MA	IECC 2012	2018	33% better than code
MA	IECC 2015	2021	40% better than code
NJ	ASHRAE 90.1-2013 (roughly equivalent to IECC 2015)	2022	40% better than code
CT	IECC 2015	2022	40% better than code
CT	IECC 2021	2022	20% better than code

Key takeaway: All lighting ISP studies have shown LPD to be better than code, with several studies looking at IECC 2015 finding ISP to be 40% better than code LPDs. This result aligns with the Virginia plan review findings, highlighting the role that high adoption of LEDs has in pushing lighting designs better than code LPDs.

3.2.2.4 Estimation of new construction baseline

Overall, the results of the Baseline Study provide strong evidence that new construction lighting design LPD is better than code requirements. The high penetration of LEDs, found in plan reviews and confirmed by interviewees, is a strong data point, as LED adoption outpaces the increasing stringency in each version of the energy code.

Without conducting a more comprehensive study of new construction lighting in Virginia, there is no single method to estimate the new construction baseline. However, the data collected for this study can be combined, along with market insights identified through the literature review, to develop a baseline estimate. Table 3-10 summarizes the key takeaways from each of the data collection activities, along with some limitations and considerations for each, highlighted by the following insights:

- The plan reviews found an ISP of 41% better than code from the 36 buildings reviewed. While it's possible that some of these buildings participated in Dominion Energy programs, the data collection approach from BCEVA was no more likely to recruit participants than non-participants. This result may be better than the actual ISP if participants are contributing to the result.
- This plan review estimate is supported by the literature review findings of 40% better than code for similar code versions in three different states. This lends credibility to the plan review finding and aligns with widespread LED adoption.
- On the other hand, the interviews with lighting designers and contractors and analysis of their responses lead to an estimate of an ISP of 8% better than code. DNV considers this estimate to be worse than the actual ISP due to the interviewee's confirmation of high LED adoption, and the lack of knowledge and awareness of the code requirements (and how LEDs may affect LPD design).
- The plan review and interview estimates are likely the upper and lower bounds of the true ISP, with the actual ISP in between.
- DNV thus recommends that the plan review and interview results are weighted evenly to produce a baseline estimate of 24% better than code for new construction lighting design (41%*0.5 + 8%*0.5 = 24%). The literature review finding was not included in this calculation, but it provides additional support to the plan review finding.

Table 3-10. Summary of data collection key takeaways, limitations, and considerations

Data collection activity	Key takeaway	Limitations and considerations
Lighting plan reviews	41% better than code	• Reflects over 900,000 square feet of new construction in Virginia • Plan review likely overrepresents public buildings and likely underrepresents other building types such as office, retail, and multifamily
Interviews with lighting designers and installers	8% better than code	• Reflects 325 new construction projects • Self-reported responses from interviewees with limited code knowledge, likely low estimate due to high adoption of LEDs
ISP literature review	40% better than code for IECC 2015	• Consistent with plan review findings in Virginia
DNV ISP recommendation	**24% better than code**	

Recommendations for program enhancements

Based on the baseline assessment, DNV makes the following recommendations for Dominion Energy's new construction lighting programs:

Recommendation 1. Update program applications to include "major renovation" as an option for the reason the work was performed.

The classification of the project determines the algorithm used to calculate energy savings. To increase the accuracy of the classification and resulting energy savings estimates, DNV recommends adding "major renovation" as an option on the program applications for "Reason for Work Done." Projects falling into this category should follow the same savings estimation approach and baseline assumptions as new construction projects do. These are described in the following two recommendations.

Recommendation 2. Consider calculating incentives for new construction/major renovation lighting based on design, using a performance basis.

The VECC specifies new construction lighting based on LPD, which is measured in watts per square foot. Prescriptive programs typically offer per-fixture incentives and do not assess lighting design. We recommend consideration that new construction or major renovation projects should go through the Dominion Energy Virginia Non-Residential New Construction Program or other similar programs that assess lighting design via LPD, rather than the Non-Residential Lighting Systems & Controls Program which does not.

Recommendation 3. Consider updating new construction/major renovation lighting baselines with respect to the ISP results estimated in this study.

Regarding performance incentives for the Non-residential New Construction Program, DNV recommends reviewing the baseline used for calculating the incentives. The recent study suggests that a 24% reduction in code baseline LPDs should be considered to reflect the ISP results from this study. This applies to both VECC 2015 and VECC 2018 code LPDs. DNV recommends this result be revisited for projects permitted under future code versions.

4 IMPACT EVALUATION

The objectives of the Impact Evaluation were to re-estimate net energy and peak demand savings for the DSM Phase VII Non-Residential Lighting & System Controls Program (CLT3) and the lighting component of the DSM Phase VIII Small Business Improvement Enhanced Program (SBI2) from program inception through year-end 2021. To achieve the objectives of the Impact Evaluation, DNV collected and analyzed lighting logger data, net-to-gross (NTG) survey data, and site verification data.

4.1 Updating hours of use with metering data

To update the hours of use, DNV used metering data from a prior study, with additional metering for building types not sufficiently represented in that study. The prior study data were lighting logger data from a 2010 Impact Evaluation that we performed for Dominion Energy's DSM I Commercial Lighting Program. Because non-residential lighting usage (without lighting controls in place) is unlikely to change over time for the same building types, it is both reasonable and economical to leverage the Dominion Energy-specific lighting logger data for this follow-on comprehensive study. The use of this data assumes that any effects of COVID-19 are temporary and that buildings will return to prior occupancy levels if they have not yet.

The 2010 study conducted metering for 10 building types using 252 lighting loggers. The number of each building type studied is featured in Table 4-1.

Table 4-1. Dominion Energy 2010 study lighting logger installations by building type

Building type	Site count
Education	2
Food	9
Health Care	1
Lodging	1
Mercantile	22
Office	6
Other	1
Public Assembly	4
Warehouse and Storage	6

Based on this review and a review of the tracking data for the CLT3 and SBI2 programs, DNV determined that the number of education, health care, and lodging building types studied in the 2010 Impact Evaluation was insufficient to represent the population of buildings in the CLT3 and SBI2 programs. DNV judges that these building types have returned to pre-pandemic operating hours. Therefore, DNV targeted a small sample of each of these building types for new metering in this study to help bolster the 2010 logger dataset.

4.2 Sample design

DNV sampled the CLT3 program and SBI2 program to achieve the following data collection goals:

- **Metered data** to generate updated building level HOU for education, health care, and lodging building types
- **Verification data** to confirm technologies and quantities
- **NTG survey data** to determine the influence that the program had on customer's decisions to install energy-efficient equipment

We used a stratified ratio methodology for the CLT3 program sample design based on tracking electric savings. As mentioned above, we stratified buildings in the educational, health, and lodging categories to recruit sites from these domains to participate in lighting logger installations. We collected this lighting logger information to supplement the lighting logger data from the 2010 Impact Evaluation conducted by DNV. All other building types were combined into a single “Other” category for the sample design. We stratified by size (savings level) in addition to building type.

For the SBI2 program, we used a stratified ratio methodology based on tracking electric savings across all building types. For the SBI2 program, the priority was to recruit virtual visits first and net surveys second. Table 4-2 presents the sample design summary, which contains the number of sites in the population and sample, savings, and cut points for each stratum by program and building type.

Table 4-2. Impact Evaluation sample design

Program	Building type	Stratum	Maximum savings (kWh)	Population	Savings (kWh)	Sample	Inclusion probability
CLT3	Education	1	22,187	6	72,233	2	0.33
		2	50,482	2	73,022	2	1.00
		3	75,760	2	140,549	2	1.00
		4	239,722	4	573,461	4	1.00
	Health	1	15,137	8	62,885	3	0.38
		2	24,125	4	83,380	3	0.75
		3	30,643	3	84,899	2	0.67
		4	198,237	2	254,968	2	1.00
	Lodging	1	22,280	32	230,939	4	0.13
		2	58,005	8	321,047	3	0.38
		3	102,268	5	407,361	3	0.60
	Other	1	35,699	433	5,962,949	26	0.06
		2	90,413	134	7,615,893	26	0.19
		3	163,109	71	8,864,884	26	0.37
		4	222,098	50	9,546,942	25	0.50
		5	441,692	36	10,823,734	25	0.69
		6	727,511	12	6,973,479	12	1.00
SBI2	Other	1	18,741	58	460,334	9	0.16
		2	39,161	21	585,221	8	0.38
		3	68,476	13	688,688	8	0.62
		4	186,615	5	638,333	5	1.00

For further details on the impact sample design, see APPENDIX A.

4.3 Data collection

DNV collected lighting logger data, verification data, and survey data to complete the objectives of the Impact Evaluation.

4.3.1 Lighting logger installations

DNV recruited nine sites across three different building types (education, health, and lodging) via email and phone for lighting logger installations. At each recruited site, engineers verified the presence of the lighting equipment received through the program, discussed baseline characteristics of the lighting that was replaced, gathered information on the HVAC systems that serve the spaces where program lighting was installed, and installed Dent lighting loggers[7] to monitor hours of use (see the data collection form in APPENDIX E). To gather winter peak period operation, 48 lighting loggers were installed from December 2022 through mid-January 2023 across the nine sites and were left installed for an average of 6.5 weeks. Upon removal of the lighting loggers, participants were given a $100 gift card for their participation in the study.

4.3.2 NTG surveys

DNV used Qualtrics, an online survey platform, to administer the NTG surveys. DNV sent an email generated through Qualtrics to the selected sample with a personalized link to complete the NTG survey. We designed the online survey to take 15-20 minutes to complete and respondents were offered a $25 electronic Amazon gift card for completing it. At the end of the survey, respondents were asked to participate in a virtual site visit and were offered an additional $50 electronic Amazon gift card. The virtual site visits are discussed in Section 4.3.3.

After the initial email was sent through Qualtrics, DNV followed up with respondents to schedule virtual visits, and with non-respondents to request they complete the NTG survey, either independently online or over the phone. Once the selected sample was exhausted, DNV repeated the recruitment process with targeted backup samples to achieve the survey completion goal of 200.

4.3.3 Site verifications

DNV performed site verification visits to verify the installation and operation of the lighting measures installed through the program. We confirmed that the program products were present in the quantities provided in the tracking system, and verified that the model numbers found during the site visit were consistent with those provided in the site documentation whenever possible. We also inquired about the event type (retrofit, new construction, major renovation, etc.) that led to the installation of the program lighting measures and gathered baseline information on the lighting products that were replaced by the program products. The baseline data collected was also utilized in the Baseline Study, as discussed in Section 3.2.1. Information was also gathered on the heating and cooling systems that serve the spaces where program lighting was installed to calculate interactive savings.

Aside from the nine lighting logger sites that were verified through onsite inspection, all other sites were verified virtually using the virtual audit/inspection tool, Blitzz.[8] Blitzz is a browser-based application that can be used on any smart phone, tablet, or computer without the need to register or install a separate application. It works as follows:

1. When initiating the virtual visit, the evaluation engineer sends a web browser link via SMS or email to the site contact's mobile phone number or email address.
2. The site contact clicks on the link and the virtual visit tool opens in a web browser on the site contact's device.
3. The tool requests access to the device's microphone and camera, and when the site contact grants it, the evaluator will use audio and video to guide the site contact to areas or equipment of interest.
4. The evaluator can trigger the device's camera to take pictures of equipment and systems, which can be used to document quantities and other measure-specific parameters.

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[7] Dent lighting loggers have internal batteries and operate via photocell to collect the date and time that the lighting equipment of interest is turned on and off.
[8] https://blitzz.co/

4.4 Results

4.4.1 Gross findings

This section presents findings related to gross savings by program, which were informed by the lighting logger data and site verifications.

4.4.1.1 Lighting logger analysis

The lighting logger data collected from the current study was combined with the lighting logger data collected in the 2010 Impact Study. The combined data set, consisting of 300 lighting loggers installed at 66 sites, was post-stratified to the current population to develop case weights for the sample. The weight for a size-building type stratum was the ratio of the population count to the sample count for that expansion cell. The meter data for each site were combined into a single hourly profile using a fixture wattage weighted average. The site data, which metered sites for an average of 6.5 weeks, was then annualized for each site. The annualized hourly data was expanded to the population to develop 8,760 hourly lighting profiles and annual hours of use (HOUs) by building type. Table 4-3 presents the results of the post-stratification of the recruited sample, including the numbers of accounts in the population and sample, total savings, cut point, and weight by strata. The number of strata was optimally established based on the number of sites, the variability of site savings, and the amount of savings by site within each building type domain.

Table 4-3. Lighting logger post-stratification table

Building type	Stratum	Maximum savings (kWh)	Population accounts	Total savings (kWh)	Sample accounts	Weight
Education	1	78,313	84	2,047,643	3	28.0
Education	2	1,608,783	14	3,553,967	2	7.0
Food	3	995,761	1,005	58,199,371	9	111.7
Health	4	109,341	74	2,419,459	3	24.7
Health	5	745,852	12	4,006,693	1	12.0
Lodging	6	73,193	570	7,015,801	3	190.0
Lodging	7	2,145,078	54	12,706,084	1	54.0
Office	8	94,373	596	12,305,596	7	85.1
Office	9	1,384,935	77	19,992,177	3	25.7
Mercantile	10	65,288	778	22,623,324	17	45.8
Mercantile	11	211,179	269	28,391,959	4	67.3
Mercantile	12	4,452,235	85	39,694,271	1	85.0
Warehouse	13	224,837	390	16,823,984	6	65.0
Warehouse	14	3,419,861	44	28,205,977	1	44.0
Assembly	15	44,944	27	362,986	2	13.5
Assembly	16	126,801	8	577,555	2	4.0
Other	17	1,788,334	1,539	90,816,683	1	1,539.0
Total	N/A	17,569,108	5,626	349,743,530	66	N/A

Results from the lighting logger expansion are presented in Table 4-4. Hours of use were within 20% of the TRM values for all building types except “Other,” which were not a part of this analysis due to the diverse mixture of buildings that make up “Other” and the large sample size required to create an updated estimate.

Table 4-4. Annual hours of use results

Building type	Analysis annual HOU	TRM annual HOU
Assembly	4,692	4,058
Education	2,558	2,233
Food	7,203	7,272
Health	4,077	3,817
Lodging	4,802	4,058
Mercantile	5,444	4,696
Office	3,296	3,044
Warehouse	4,222	4,361

4.4.1.2 Site verification analysis

For each sampled site, DNV calculated the evaluated gross savings value. This value adjusts the tracked savings value to correct for various discrepancies as described in Figure 4-1. Site-level HOU was adjusted using the building type values determined by the analysis described in the prior section and were considered Operational Adjustments.

Figure 4-1. Savings discrepancy factors

Adjustment factor	Description
Documentation	Tracking savings were recalculated using all quantities, fixture types/wattages, and hours documented in the project file. Discrepancies and documentation errors are reflected in this adjustment.
Technology	Changes due to the identification of different technology (fixture type and wattage) at the site than in the program data
Quantity	Changes due to the monitoring of a different quantity of lighting measures installed at the site than in the program data
Operational	Changes due to the monitoring of different lighting operation hours at the site than assumed in the program data
Interactive	Changes due to differences in savings caused by the interaction between lighting fixtures and the electric HVAC systems in the building versus the interactive savings assumptions in the program data

Table 4-5 details the weighted results of the site-level energy savings analysis by adjustment factor, for each program and overall. The full site-level analysis results can be found in APPENDIX G.

Table 4-5. Weighted site-level analysis results by program and overall

Program	Tracking kWh	Doc Adj	Tech Adj	Qty Adj	Op Adj	Interactive Adj	Evaluation Savings
CLT3	58,188	(1,768)	614	(87)	11,970	1,770	70,686
SBI2	23,975	-	(681)	(52)	5,159	706	29,107
Overall	82,163	(1,768)	(67)	(139)	17,129	2,476	99,793

4.4.1.3 Expansion – RR

The results of the site-level analyses were weighted and projected to the population to develop a gross realization rate which is the ratio of evaluated savings to tracking savings for each program. Table 4-6 summarizes the gross impact analysis findings for energy (kWh) by the adjustment factor for each program and overall. The impact analysis produced a gross RR of 123.7% for CLT3, 121.4% for SBI2, and an overall gross RR of 123.5%. The largest driver for the high RR was the operational adjustments based on the HOU analysis discussed in Section 4.4.1.1.

Table 4-6. Gross RR results for energy savings (kWh)

Program	Result	Accounts	Documentation	Technology	Quantity	Operational	Interactive	Overall gross RR
All	Population	494						
	Sample	52						
	Gross RR		98.9%	102.4%	101.5%	122.7%	104.8%	123.5%
	Relative Precision		4.0%	3.4%	2.6%	5.6%	3.3%	7.0%
CLT3	Population	397						
	Sample	37						
	Gross RR		98.8%	102.9%	101.7%	122.8%	104.9%	123.7%
	Relative Precision		4.5%	3.7%	2.9%	6.1%	3.6%	7.7%
SBI2	Population	97						
	Sample	15						
	Gross RR		100.0%	97.2%	99.8%	121.5%	102.9%	121.4%
	Relative Precision		0.0%	3.8%	0.3%	8.1%	3.0%	8.5%

Table 4-7 summarizes the gross impact findings for summer and winter on-peak demand (kW) by the program. Overall, demand estimates were consistently close to 100%, with a slightly higher gross RR in the summer at 101.3%, than in the winter, which had a gross RR of 99.3%. These realization rates are based on the current TRM definitions, which are as follows:

- Summer: Non-holiday weekdays, June-August, 2pm-6pm
- Winter: Non-holiday, weekdays, January and February, 7am-9am and 6pm-8pm

To more closely align the coincident summer and winter peak demand reductions in future iterations of the TRM, this study also produced the following peak coincidence factors for each season based on the following peak definitions:

- Summer: 70.5% for non-holiday weekdays, July, hour-ending 16 (3pm-4pm)
- Winter: 79.8% for non-holiday weekdays, January, hour-ending 8 (7am-8pm)

These values are in alignment with the Company's forecasting coincident peak hours, which are documented in the TRM.

Table 4-7. Gross RR results summer and winter demand (kW)

Program	Result	Accounts	Summer kW	Winter kW
All	Population	494		
	Sample	51		
	Gross RR		101.3%	99.3%
	Relative Precision		14.0%	7.2%
CLT3	Population	397		
	Sample	36		
	Gross RR		101.5%	99.3%
	Relative Precision		15.4%	7.9%
SBI2	Population	97		
	Sample	15		
	Gross RR		99.4%	99.5%
	Relative Precision		11.5%	5.9%

4.4.2 Net findings

This section presents the findings of the NTG survey for attribution, spillover, and the final NTG ratio. The main output of the NTG survey analysis is the NTG ratio, defined as (1 – free-ridership + spillover), where (1 – free-ridership) is equal to attribution.

4.4.2.1 Attribution analysis

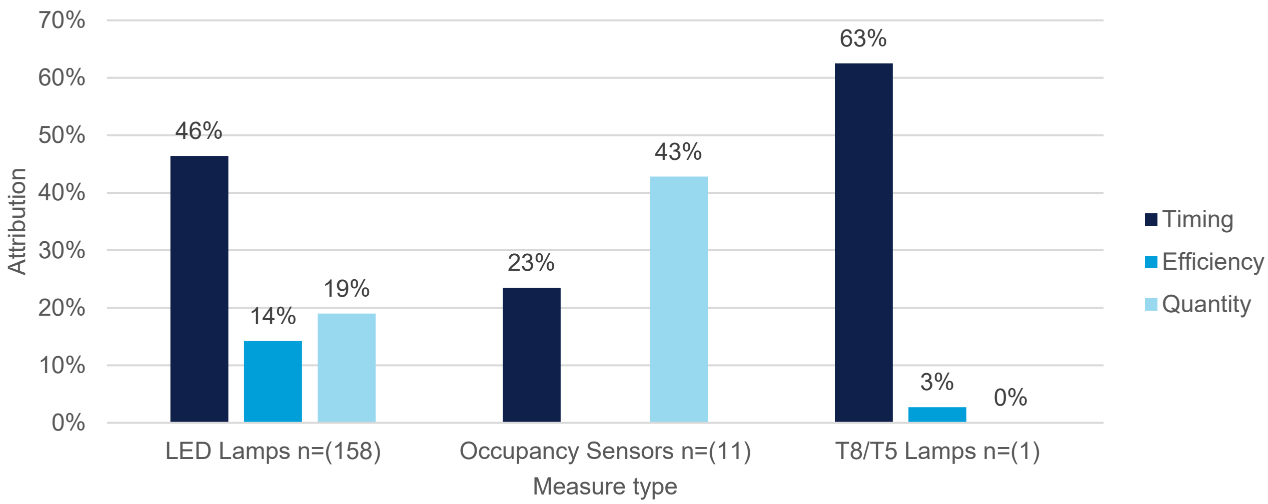
Three components are used to calculate attribution.

- **Timing-** Did the participant implement the efficiency equipment more quickly than they otherwise would have without the existence of the program?
- **Efficiency-**Did the participant implement higher-efficiency equipment than they otherwise would have without the existence of the program?
- **Quantity-**Did the participant implement more efficient equipment than they otherwise would have without the existence of the program?

All survey respondents who purchased LED Lamps or T8/T5 were asked questions about the timing, efficiency, and quantity of their measure installations. Those who purchased occupancy sensors were asked only about timing and quantity, as efficiency does not apply to this measure. The survey is in APPENDIX D.

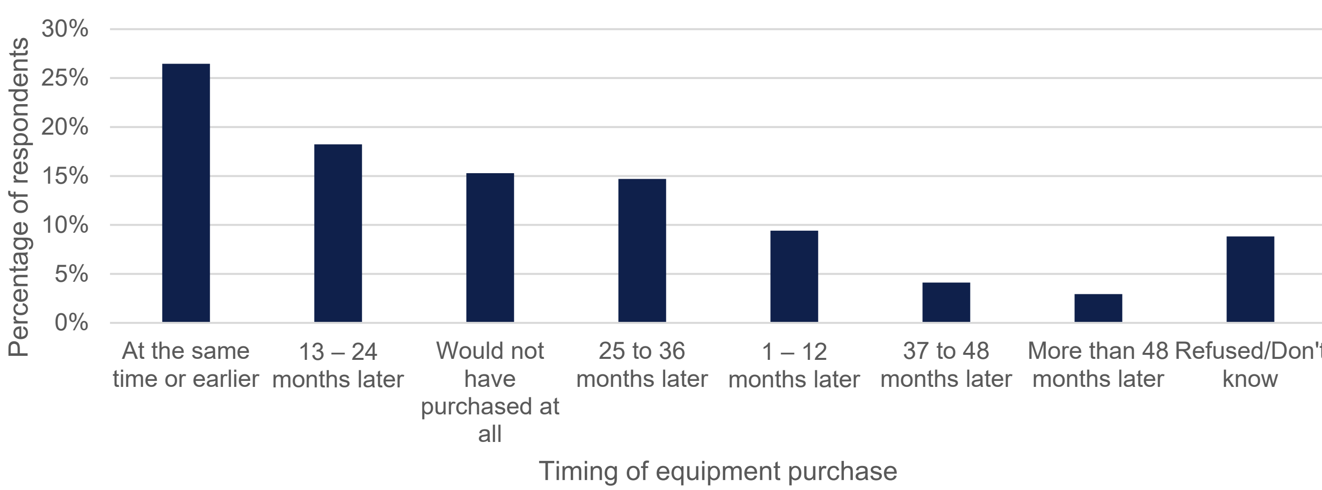
Figure 4-2 shows the average timing, efficiency, and quantity attributions for respondents by measure type. For LED and T8/T5 lamps, timing was the biggest contributor to overall attribution, which means that the program accelerated the timeline for purchasing the equipment. For occupancy sensors, the quantity was the biggest contributor to overall attribution, which means that the program influenced the number of sensors purchased.

Figure 4-2. Timing, efficiency, and quantity attribution scores for respondents by measure type



Timing attribution is determined by respondents' answers to the timing question, which are shown in Figure 4-3. For those that selected "More than 48 months later" or "Would not have purchased [..]" it is assumed that the measure would never have been installed without the influence of the program, and these respondents receive full timing attribution or a timing attribution of 100%, expressed as 1. Those who selected "At the same time or earlier" receive a timing attribution of 0%, expressed as 0, as the program did not influence the timing of their purchase. For all other cases, the timing attribution is a value between 0 and 1 equal to the mid-point of the selected range divided by 48 months.

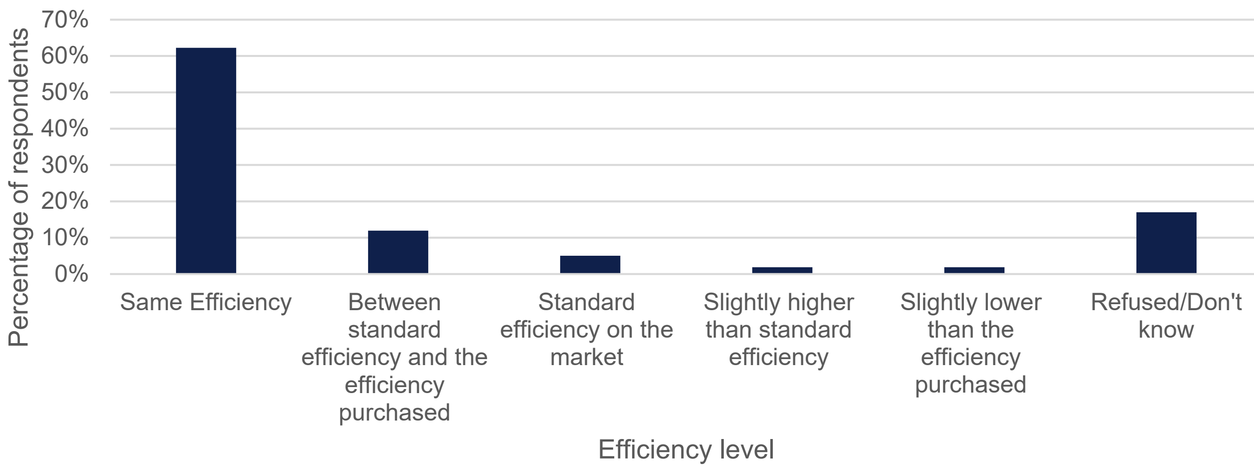
Figure 4-3. When respondents would have purchased efficient equipment in the absence of the program



The efficiency attribution is determined by respondents' answers to two questions. The first asks whether, in the absence of the program, they would have purchased equipment of the same efficiency. The second question asks respondents who say they would not have purchased the same efficiency and what level they would have purchased without the support of the program. Respondents who said they would have purchased the same level of efficiency receive an efficiency attribution of 0, as the program did not influence the level of efficiency purchased. Those who say they would have purchased "Standard efficiency on the market" receive a full efficiency attribution of 1, because without the program they would not have purchased efficient equipment. For all other cases, the efficiency attribution is a value between 0 and 1 measuring the level of efficiency that would have been installed.

Figure 4-4 shows the survey respondents' answers to both efficiency questions. Seventy-five percent of respondents said they would have purchased equipment with the same efficiency without the program. Of the 25% of respondents that said they would have purchased equipment with a different efficiency, the most frequent response was "between standard efficiency and the efficiency purchased."

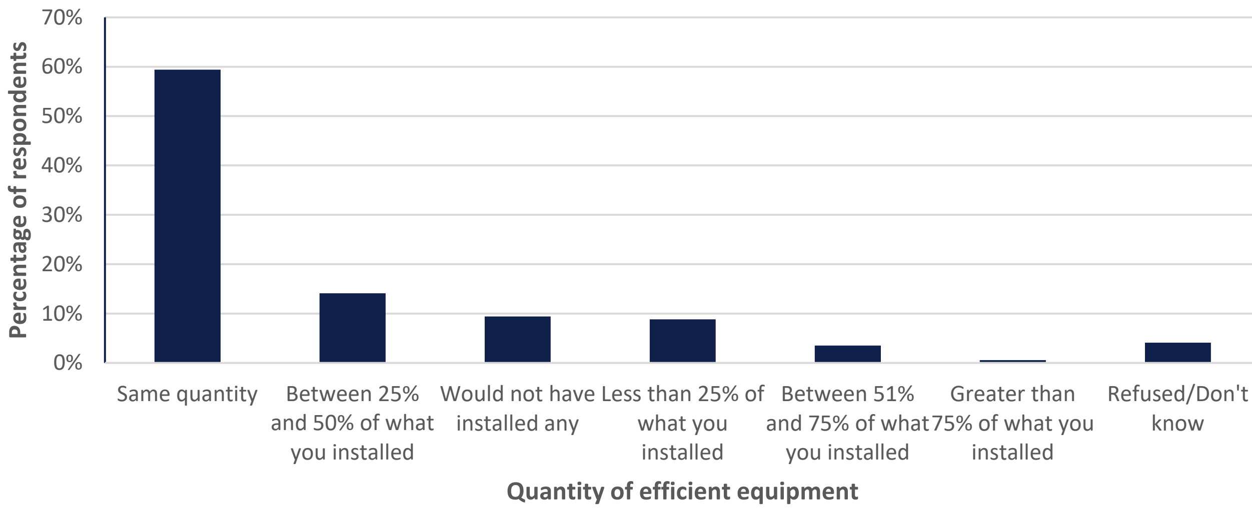
Figure 4-4. Efficiency of equipment respondents would have purchased in the absence of the program



Quantity attribution is determined by the response to the two quantity questions. The first asks whether, in the absence of the program, respondents would have purchased the same amount of equipment. The second question asks respondents who say they would not have purchased the same amount what percentage of equipment they would have bought without the support of the program. Respondents who said they would have purchased the same amount received a quantity attribution of 0, as the program did not influence the amount purchased. Those who say they would have purchased none receive full quantity attribution of 1, because without the program they would not have purchased any equipment. For all other cases, the quantity attribution is a value between 0 and 1 measuring the percentage that would have been installed.

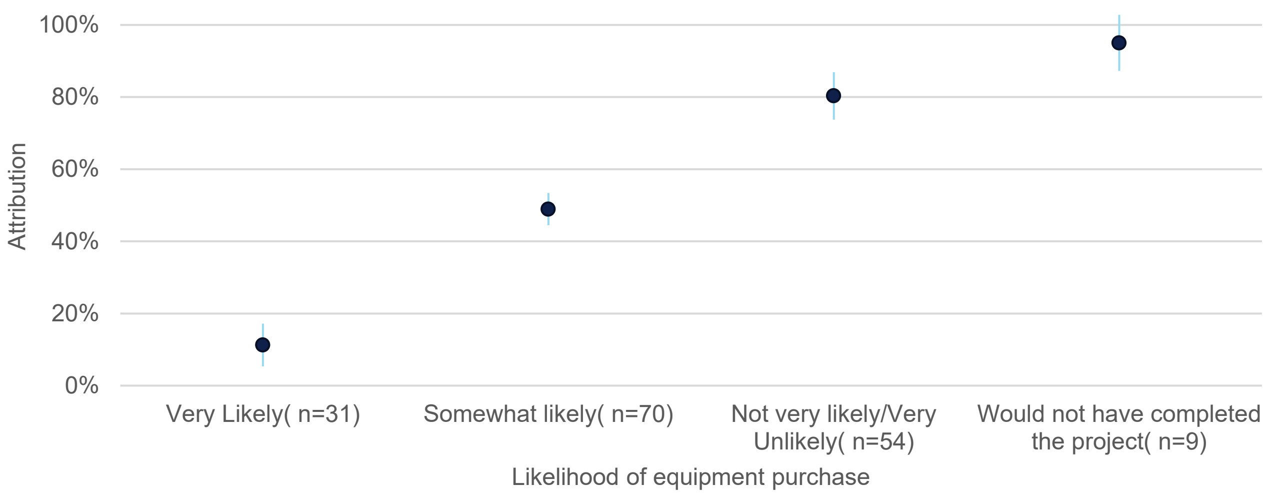
Figure 4-5 shows the survey respondents' answers to the quantity question. Of respondents who said they would not have purchased the same amount of equipment, the most frequent response was "Between 25% and 50% of what you installed."

Figure 4-5. Quantity of efficient equipment respondents would have purchased in the absence of the program



The first question in the attribution section determines whether Dominion Energy's program had any influence on a participant's new commercial lighting purchase. This indicator serves as a secondary check on the final estimated attribution value. The trend line in Figure 4-6 shows that the influence results are in line with overall attribution results.

Figure 4-6. Likelihood the respondents would have installed the equipment in the absence of the program



The scores of the timing, efficiency, and quantity questions were combined to calculate an attribution score for each participant. Next, the scores were weighted based on savings and expanded to the populations to produce program-level and overall attribution scores, as shown in Table 4-8.

Table 4-8. Program and overall attribution scores

Program	Sample	Attribution	Relative precision	Lower confidence interval	Upper confidence interval
Non-Residential Lighting	131	42.2%	18.4%	34.4%	49.9%
Small Business	27	69.1%	13.4%	59.8%	78.4%
All	158	43.3%	17.2%	35.9%	50.8%

4.4.2.2 Spillover analysis

Participant spillover represents the savings attributable to the program from lighting equipment that was installed without receiving any rebate as a result of participating in the Dominion Energy program. It is calculated by a series of questions used to determine the quantity and efficiency of lighting equipment installed and the influence the Dominion Energy program had on the decision to install the additional equipment.

First, respondents are asked if they have purchased any additional, not subsidized, lighting equipment of the same efficiency since their participation in the program; 11% of the respondents surveyed indicated they had. Those respondents are asked additional questions about the quantity of additional equipment purchased and the influence that their participation in the Dominion Energy program had on their decision to purchase the equipment. Their responses to the quantity and influence questions are used to determine the amount of spillover at the site.

Table 4-9 shows the results of the influence spillover questions. About 3 out of 4 respondents said that their experience with the Dominion program they participated in, the contractor, and the equipment influenced their decision to purchase new efficient equipment.

Table 4-9. Factors that influenced spillover purchases

Spillover influence questions	Yes	No
Did a recommendation by the contractor or designer whom you worked with under the Dominion Energy program influence your decision to install some or all of this efficient lighting equipment?	74%	26%
Did your experience with the energy-efficiency lighting equipment installed through the Dominion Energy program influence your decision to install some or all of this efficient lighting equipment?	79%	21%
Did your participation in any past program(s) offered by Dominion Energy influence your decision to install some or all of the efficient lighting equipment?	70%	30%

The scores of the spillover questions were weighted based on savings and expanded to the populations to produce program-level and overall spillover scores, as shown in Table 4-10.

Table 4-10. Decision maker attribution, spillover, and NTG results

Program	Sample	Spillover	Relative precision	Lower confidence interval	Upper confidence interval
Non-Residential Lighting	131	3.1%	98.2%	0.1%	6.1%
Small Business	27	2.6%	101.6%	0.0%	5.2%
All	158	3.1%	94.6%	0.2%	6.0%

4.4.2.3 Expansion – NTG ratio

Results from the NTG survey were projected to the population to develop an NTG ratio for each program. Table 4-11 presents the results of the post-stratification, including the numbers of accounts in the population and sample, total savings, cut point, and weight by stratum.

Table 4-11. Decision-maker NTG survey post-stratification results

Program	Building type	Stratum	Maximum savings (kWh)	Accounts	Total savings (kWh)	Sample	Weight
CLT3	Education	1	239,723	14	859,265	2	7.0
CLT3	Health	2	198,237	17	486,131	10	1.7
CLT3	Lodging	3	102,269	45	952,947	4	11.3
CLT3	Other	4	40,718	457	6,724,794	73	6.3
CLT3	Other	5	103,285	133	8,731,973	22	6.0
CLT3	Other	6	184,100	70	10,262,521	9	7.8
CLT3	Other	7	281,863	50	11,035,573	6	8.3
CLT3	Other	8	727,512	29	12,984,755	5	5.8
SBI2	Other	9	24,916	65	623,271	17	3.8
SBI2	Other	10	50,001	21	738,542	5	4.2
SBI2	Other	11	186,616	11	1,010,764	5	2.2

Table 4-12 presents the results of the net-to-gross analysis. A total of 158 decision-maker surveys were conducted across the two programs. Overall, the lighting program had a 46.4% NTG ratio with a relative precision of 17.7% at the 90% confidence level. The SBI2 NTG ratio was 26.4% greater than the CLT3 NTG ratio. The NTG ratios for both programs were lower than their respective existing NTG ratios, which were based on program design assumptions.

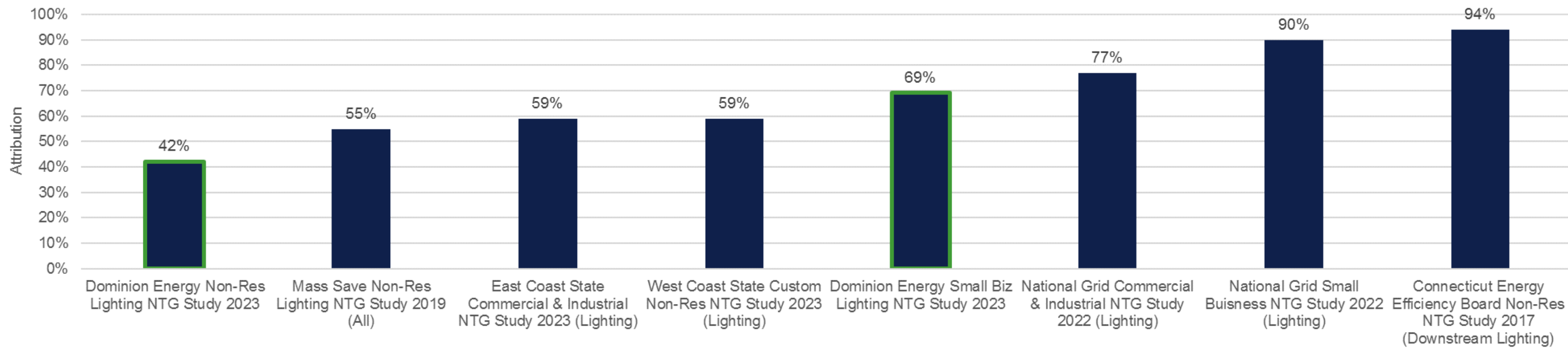
Table 4-12. Decision-maker NTG survey results

Program	Population	Sample	Existing NTG ratio	Updated NTG Ratio	Relative Precision
CLT3	815	131	70.0%	45.3%	18.9%
SBI2	97	27	93.0%	71.7%	14.3%
All	912	158	N/A	46.4%	17.7%

Comparison of results to other jurisdictions

Figure 4-7 shows Dominion Energy's NTG ratio compared to jurisdictions offering similar energy efficiency programs for non-residential lighting.

Figure 4-7. Dominion Energy NTG results compared to similar studies in other jurisdictions



5 PERSISTENCE STUDY

The objective of the Non-Residential Lighting Persistence Study was to determine the proportion of previously rebated equipment in place and operating, especially during the VCEA reporting years. This was accomplished by conducting virtual verification visits of sites that installed lighting measures through the CLT2 or SBIP programs from 2014 to 2019. That data was combined with the site verification visits that were conducted as part of the Impact Evaluation, which comprised participants of the CLT3 or SBI2 programs from 2020 to 2021. This allowed DNV to collect data across a span of 8 years to properly inform a survival analysis.

5.1 Sample design

A stratified ratio methodology was used for the additional Persistence Study sample design, drawn from the CLT2 and SBIP programs, and based on tracking electric savings. Sites were grouped explicitly into two domains: measure type and age of installed measure. Measure type was defined as sites with occupancy sensors installed and those without. Age bins were defined by a range of install years: 3 to 5 years, 6 to 7 years, and 8 years. Each combination of measure group and year was optimally stratified by total electric savings based on the number of accounts in the population and the variability of electric energy savings. For further details, see APPENDIX A.

Table 5-1. Persistence study sample design

Program	Installed age	Measure type	Stratum	Maximum	Accounts	Energy savings (kWh/year)	Sample	Incl_Prob
CLT2	3 to 5 yrs	OCC SENSOR	1	143,299	290	12,455,466	3	0.01
		OCC SENSOR	2	3,419,860	40	21,611,600	3	0.08
		OTHER	1	40,540	1126	16,352,348	5	0.00
		OTHER	2	96,849	328	21,040,604	5	0.02
		OTHER	3	209,356	175	24,743,901	5	0.03
		OTHER	4	353,882	100	28,080,815	5	0.05
		OTHER	5	4,452,235	49	35,415,928	4	0.08
	6 to 7 yrs	OCC SENSOR	1	268,525	378	10,815,663	4	0.01
		OCC SENSOR	2	2,509,460	28	19,052,779	3	0.11
		OTHER	1	32,204	1302	13,105,121	5	0.00
		OTHER	2	59,702	364	16,902,436	5	0.01
		OTHER	3	102,794	242	18,780,460	5	0.02
		OTHER	4	229,358	146	21,294,656	4	0.03
		OTHER	5	1,637,797	60	27,490,301	4	0.07
	8 yrs	OCC SENSOR	1	557,348	2	670,796	2	1.00
		OCC SENSOR	2	1,833,900	1	1,833,900	1	1.00
		OTHER	1	22,784	72	504,025	4	0.06
		OTHER	2	57,370	17	705,001	4	0.24
		OTHER	3	100,947	10	790,264	3	0.30
		OTHER	4	199,360	7	932,295	3	0.43
		OTHER	5	342,892	3	1,010,310	3	1.00
SBIP	3 to 5 yrs	OTHER	1	27,030	807	10,246,783	4	0.00
		OTHER	2	66,976	308	12,664,268	3	0.01
		OTHER	3	4,684,075	117	18,298,595	3	0.03
	6 to 7 yrs	OTHER	1	15,289	13	127,661	3	0.23
		OTHER	2	19,059	8	140,028	3	0.38
		OTHER	3	75,426	5	187,857	3	0.60
		OTHER	4	239,558	1	239,558	1	1.00

5.2 Data collection

Working in coordination with the Impact Evaluation, the Persistence Study consisted of 128 site verifications that installed lighting measures incentivized through the CLT2 or SBI2 program from 2014 to 2019. Like the Impact Evaluation site verifications discussed in Section 4.3.3, DNV reviewed the program tracking data and site documentation for each of the sampled persistence sites to gain an understanding of the program lighting installed at each site. We then performed the virtual site verifications using Blitzz. These visits were performed to quantify the number of program products that were still installed and operating and were supplemented with similar data collected from the 52 impact site visits, described in Section 4.3.3. During the site verification, measures were classified as:

- Installed and operating
- Installed but burned out
- Failed and replaced
- In storage
- Unaccounted for

Table 5-2 presents a summary of the final sample of survey participants. A total of 182 sites were recruited for the analysis representing over 45,000 bulbs and occupancy sensors, of which approximately 89% were still installed and in use.

Table 5-2. Persistence study sample summary

Sampled sites	Tracking products	Evaluated products	Percent installed
181	45,274	40,225	88.8%

5.3 Analysis

This section of the report discusses the methods employed to estimate measure persistence to date. A measure's EUL is defined as its median retention time; that is, the time at which half the units of the measure installed during a program year are not retained. To analyze retention, this study employed a method commonly referred to as "survival analysis." The set of techniques referred to as survival analysis is widely employed to analyze data representing the duration between observable events. The tracking and verified data were fed into two models: a Kaplan-Meier life test model and a parametric survival analysis, which are briefly explained below. DNV was not able to collect enough occupancy sensor data to analyze them independently in the survival analysis; therefore, we conducted the survival analysis at the program level with data for all technologies fed into a single model. The results are dominated by LED lighting, which accounts for the majority of the evaluated measures and savings in all of the programs studied in this report (CLT2, CLT3, SBIP, SBI2). A detailed explanation of the methodology can be found in APPENDIX A.

5.3.1 Kaplan-Meier (non-parametric) estimator

Combining the non-persistence data from multiple program years requires a way to take into consideration unknown future events. Put another way, we need a method that can handle observations of measures that are installed at the time of the site visit, but that will experience a removal event at some unknown point in the future (right censoring). Life-test or Kaplan-Meier (KM) survival curves are a simple yet powerful way to summarize unit operation vs. failure over a certain date range. The goal is to estimate a survival curve—i.e., what % of installed units survive to any given age, plotting % surviving vs age. With the non-parametric approach, that curve is calculated based on the percent of those that survive to a given year who also survive to the next. (e.g., of those that survive to year 3, what % survive to year 4).

If measures have been installed long enough that more than 50% of the measures are no longer in place, a non-parametric approach, such as a KM approach, can offer a characterization of measure persistence. The limitation of the non-parametric approaches is that they cannot be projected beyond the limits of the maximum observed elapsed years. In many cases where estimates of measure persistence are sought, over 50% of the measures are still surviving in the field, thereby limiting the ability to use KM for the EUL estimate. However, the KM approach is still useful for comparing with the parametric results.

5.3.2 Parametric survival analyses

The parametric analysis allows an estimate of the percent that will survive to longer ages than are yet observable in the data, by assuming the decay in the survival curve follows a particular form. The same data used for the non-parametric KM estimator is used to estimate the parameters of a general form or distribution. With these parameters, we can draw the projected survival rates for higher ages than have yet been observed. We can also calculate the EUL, as the age at which 50% of the units will no longer be in place, that is, the median survival time.

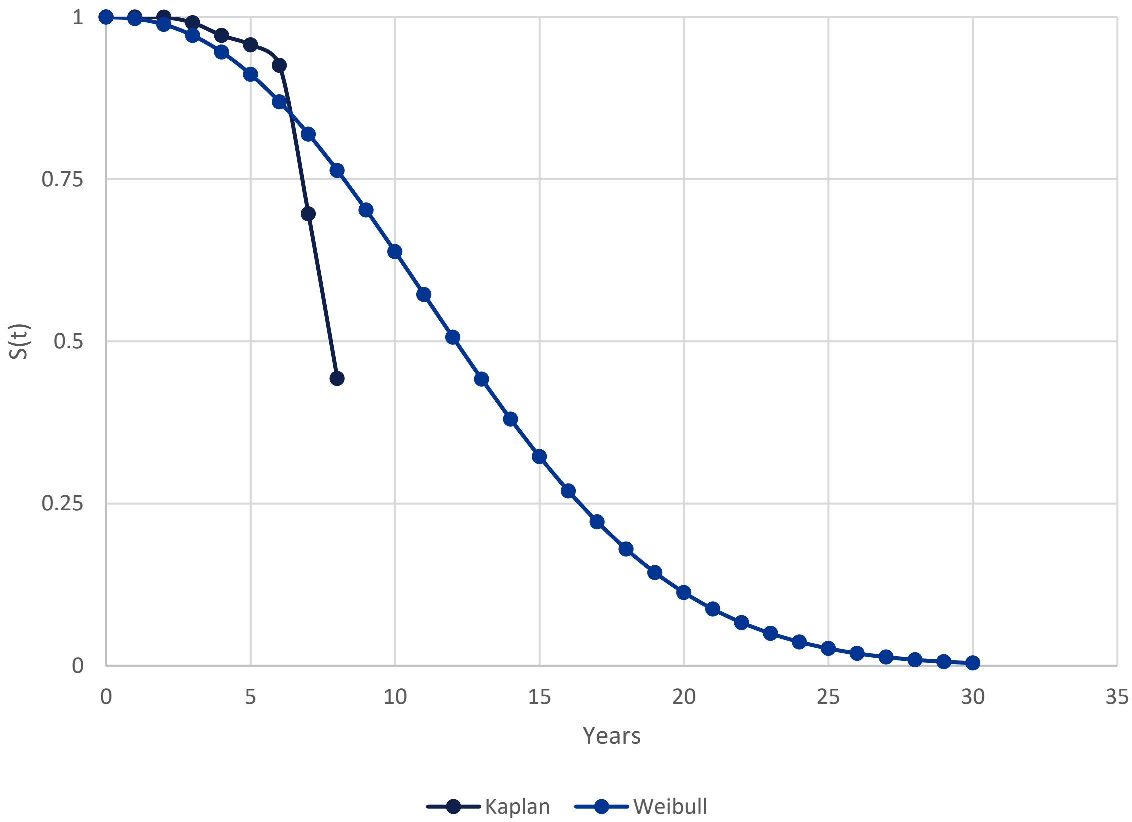
For this study, DNV applied a parametric model with a Weibull distribution. The Weibull is broadly used for survival analysis and has a general shape consistent with the way equipment failures tend to happen.

5.4 Results

Figure 5-1 presents the results of the Kaplan-Meier analysis in light blue and the Weibull analysis in dark blue. The Kaplan-Meier analysis estimates an EUL of eight years, which means that at year 8, the threshold of 50% of installed measures has stopped functioning. The results of the Kaplan-Meier analysis are driven by two factors. The first is the limited number of sites for years 6 to 8. The second is a very large site with over 4,000 bulbs that performed a remodel and removed thousands of bulbs. That is, we have a few observations to define the shape of the curve from year 6 to year 8, and the results we have are dominated by a single site.

The parametric survival analysis using Weibull distribution estimates an EUL of 12.1 years is shown in dark blue. This model is less affected by the large site and has a flatter curvature in the 6-8-year window.

Figure 5-1. Persistence model results



The actual EUL is likely to lie somewhere between the KM estimate and that from the Weibull analysis. The KM estimate of 8 years is dominated by one large site that removed a large number of bulbs for a remodel. However, a remodel rather than failure is the most likely reason for bulb removal in the early years and should not be excluded from the EUL analysis. Nonetheless, this low value is somewhat anomalous. On the other hand, the 12-year estimate from the Weibull is inconsistent with the average annual hours of use (5,548) and the technical life of an LED, generally rated at around 50,000 hours. Moreover, the Weibull estimate is an extrapolation to 4 years past the highest age in the available data set.

We take the midpoint between the two estimates, 10.1 years, as a reasonable estimate of EUL of the lighting program. This value is more consistent with the annual hours of use and LED lifetime and balances the more conservative and more generous results from the two analysis approaches.

Table 5-3 presents the results of the various analyses of the Persistence Study along with the uncertainty associated with the estimates. The Kaplan-Meier analysis estimates an EUL of 8 years ± 0.2 years and the Weibull analysis estimates an EUL of 12.1 ± 0.6 years.

Table 5-3. Persistence study EUL results

Sampled sites	NR Lighting EUL (years)	EUL Kaplan-Meier (years)	KM Error Bound	KM Relative Precision [9]	EUL Weibull (years)	Weibull Error Bound	Weibull Relative precision	Weighted Annual HOU
181	**10.1**	8.0	0.2	2.5%	12.1	0.6	4.9%	5,548

[9] Relative precision is calculated at the 66% level of confidence

APPENDIX A. IMPACT EVALUATION SAMPLING METHODOLOGY

Approach

Hours of use

DNV has reviewed the 2010 lighting study that DNV performed for Dominion Energy to verify sufficient sample sizes are available by building type for an indigenous lighting analysis. It should be noted that the original 2010 study sample was designed by rate and not by building type. During the review, DNV staff identified three building types for which inadequate sample sizes are available to represent the current program population: Education, Lodging, and Health. DNV staff proposes to include a relatively modest additional lighting logger metering component for each of these building types in the current study. The project team will identify the additional customers to the meter as part of the sample design and selection process.

Sample design

The proposed sample design aims to achieve ±10% relative precision at the 90% confidence level for both gross and net realization rates. The sample will be stratified by gross savings, as summarized in the monthly performance indicator tables, and will include domains explicitly for Education, Lodging, and Health building types. All other building categories will be collapsed into an "Other" building type category. DNV staff will recruit customers from these explicit strata – or groups to sample by – for additional lighting logger installation.

To achieve ±10% relative precision for the survey-based net impact analysis, a sample of 200 sites is necessary given an assumed error ratio of 1.0 shown in Table A-1. Most savings (86%) are contained in the "Other" building type category with a sample of n=140 allocated to this stratum. The expected precision for this group is ±11.3%. The remaining 60 sites are allocated to the three isolated building type domains: Education, Health, and Lodging; and one domain for the Phase VIII Small Business Improvement Enhanced (SBI2) program category.

Table A-1. Net impact sample design

Program	Building type	Accounts	Gross savings (kWh/year)	Error ratio	Sample	Expected relative precision
CLT3	Education	15	973,265	1.0	10	22.6%
CLT3	Health	17	486,131	1.0	10	22.4%
CLT3	Lodging	59	1,742,628	1.0	10	46.2%
CLT3	Other	798	55,445,047	1.0	140	11.3%
CLT3	**CLT3 Total**	**889**	**58,647,072**	**1.0**	**170**	**10.8%**
SBI2	**SBI2 Total**	**185**	**5,558,464**	**1.0**	**30**	**26.8%**
Grand Total		**1,074**	**64,205,536**	**1.0**	**200**	**10.1%**

Table A-2. Gross impact sample design

Program	Building type	Accounts	Claimed savings	Error ratio	Sample	Expected relative precision
CLT3	Education	15	973,265	0.3	6	16.5%
CLT3	Health	17	486,131	0.3	6	14.0%
CLT3	Lodging	59	1,742,628	0.3	6	20.7%
CLT3	Other	798	55,445,047	0.3	35	8.3%
CLT3	**CLT3 Total**	**889**	**58,647,072**	**0.3**	**53**	**7.9%**
SBI2	**SBI2 Total**	**185**	**5,558,464**	**0.3**	**7**	**20.5%**
Grand Totals		**1,074**	**64,205,536**	**0.3**	**60**	**7.4%**

The gross impact verification analysis, which will use a form of on-site assessment, is expected to have a lower error ratio, e.g., 0.3 when compared to the NTG survey analysis. Using this error ratio yields a required sample of 60 customers, which is shown in Table A-2. The sample of 60 is heavily allocated to the Phase VII Non-Residential Lighting Systems & Controls program (CLT3) “Other” category with the remaining 25 sites allocated to the targeted building types and the SBI2 program. Under this design, we anticipate an expected relative precision of ±7.4%.

During the NTG survey recruitment, DNV staff will recruit all customers for the gross verification until the target number of customers in each stratum is reached. In addition, for the explicit strata customers to include in the lighting logger study, DNV staff will recruit a customer from each of the three strata designs presented in Table A-3. The additional lighting logger sites will be combined with the sample from the 2010 study for that phase of the analysis.

Table A-3. Lighting logger sample design

Program	Building type	Strata	Max savings	Accounts	Claimed savings	Sample
CLT3	Education	1	50,482	8	176,356	1
CLT3	Education	2	84,513	4	307,962	1
CLT3	Education	3	239,722	3	488,947	1
CLT3	Health	1	18,646	10	99,076	1
CLT3	Health	2	30,643	5	132,088	1
CLT3	Health	3	198,237	2	254,968	1
CLT3	Lodging	1	51,505	48	611,795	1
CLT3	Lodging	2	128,733	10	843,505	1
CLT3	Lodging	3	287,329	1	287,329	1

APPENDIX B. NET-TO-GROSS ANALYSIS METHODOLOGY

The following scoring rubric outlines how site-level net-to-gross was calculated based on respondents' survey responses.

Attribution is a factor of three components, timing (t), quantity (q), and efficiency (e). There were 5 TEQ questions in the survey and each determined the score of t, e, or q. If a respondent left a blank or indicated they didn't know the response for a TEQ question, a savings weighted average for t, e, or q was imputed and filled in. Any respondent who left all the TEQ questions blank was dropped from the data.

Timing, efficiency, and quantity score			
Timing	FR2. What was the effect, if any, that Dominion Energy incentives and other Dominion Energy services ad on your decision to install [Measure Type] when you did. Without Dominion Energy, would you have installed [Measure Type] at the same time, earlier, later, or never?	Same time or earlier	t = 0
		1 - 12 months later	t = 6
		13 - 24 months later	t = 18
		25 - 36 months later	t = 30
		37 - 48 months later	t = 42
		More than 48 months later	t= 48
		Would not have purchased at all	t = 48
		Don't know	t = average of FR2 responses
		Refused	t = average of FR2 responses
Efficiency	FR3. Without Dominion Energy would you have installed equipment of the same efficiency as what you installed, lower efficiency, or higher efficiency?	Same	e = 0
		Lower	(go to FR3_1)
		Higher	e = 0
		Not applicable	e = not applicable
		Don't know	e = average of FR3 responses
		Refused	e = average of FR3 responses
	FR3_1. Without the program, would you have purchased equipment that was	Standard efficiency or according to code	e = 1
		Slightly higher than standard efficiency	e = .7
		Between standard efficiency and the efficiency that was installed	e = .5
		Slightly lower than the high efficiency that was installed	e = .3
		Don't know	e = average of FR3_1 responses
		Refused	e = average of FR3_1 responses
Quantity	FR4. Without Dominion Energy, would you have purchased the same quantity of fixtures, fewer, or more?	Same amount or more	q = 0
		Less	(go to FR4_1)
		Would not have installed any	q = 1
		Not applicable	q = not applicable
		Don't know	q = average of FR4 responses

Timing, efficiency, and quantity score			
		Refused	q = average of FR4 responses
	FR4_1. What percent of the quantity you installed would you estimate that you would have still installed without the program?	Less than 25% of what you installed	q= .5
		Between 25% and 50% of what you installed	q= .4
		Between 51% and 75% of what you installed	q = .3
		Greater than 75% of what you installed	1= .1
		Don't know	q = average of FR4_1 responses
		Refused	q = average of FR4_1 responses

Simple program attribution is calculated based on the respondent's efficiency and quantity scores using the following method. Acceleration incorporates the timing component. And finally, attribution combines simple program attribution and acceleration. Attribution is a value between 0 and 1.

Simple program attribution	
if e = 1	SPA = 1
if q = 1	SPA = 1
if t = 48	SPA = 1
Otherwise	SPA = 1 - (1-e) * (1-q)
For all cases	ACC = (t/48) * (1 - SPA)
For all cases	ATTRIBUTION = SPA + ACC

Spillover is calculated based on the respondent's responses to the following questions. Spillover is a value between 0 and 1. The sum of spillover and attribution is the site-level net-to-gross ratio.

Spillover			
Spillover	S1. Has your company purchased and installed any [measure # description] on its own for this or other facilities served by Dominion Energy?	Yes	s1 = 1
		No	s1 = 0
		Don't know	s1 = 0
	S1b. Was this equipment of the same efficiency level or a higher level of efficiency as the equipment you installed through the program(s)?	Yes	s1b = 1
		No	s1b = 0
		Don't know	s1b = 0
Quantity	S2. How many energy-efficient [measure # description] did your company purchase on its own since participating in these programs?	Enter %	s2 = %/100
Influence	Did a recommendation by the contractor or designer whom you worked with under the Dominion Energy Programs influence your decision to install some or all this efficient [measure # description] on your own?	Yes	If b or c = "Yes" then s3a = 1 otherwise s3a = 0
		No	s3a = 0
		Don't know	s3a = 0

Spillover			
	Did your experience with the energy-efficient equipment installed through the Dominion Energy Programs influence your decision to install some or all this efficient [measure # description] on your own?	Yes	s3b = 1
		No	s3b = 0
		Don't know	s3b = 0
	Did your participation in any past program offered by Dominion Energy influence your decision to install some or all this efficient [measure # description] on your own?	Yes	s3c = 1
		No	s3c = 0
		Don't know	s3c = 0

APPENDIX C. BASELINE LIGHTING DESIGNER AND CONTRACTOR INTERVIEW GUIDE

Overview

The objective of the Baseline Study is to gain a comprehensive understanding of industry-standard practices in Dominion Energy's service territory, focusing on lighting design (lighting power density or LPD) for new construction and on the equipment that is being replaced in Dominion Energy's non-residential lighting DSM programs.

This document contains the interview guide that DNV will use to interview lighting designers and contractors to gather market information regarding building design approaches and baseline conditions. These results will be combined with project-level lighting assessments to estimate the lighting baselines for new construction, as well as the typical equipment replaced through the programs.

Data collection

Upon the acceptance of this final interview guide, DNV will recruit a sample of lighting designers and/or contractors via email and/or phone to schedule and conduct the interview.

Instrument information

Overview of data collection

Upon the acceptance of this final interview guide, DNV will recruit a sample of lighting designers and/or contractors via email and/or phone to schedule and conduct the interview. DNV anticipates that this interview will take approximately 30-45 minutes to complete.

Topics and associated questions

Question	Objective
Introduction Intro1 – Intro5	Introduce interview effort, ensure contact is knowledgeable about their firm's approach to lighting, and gather information about the types of lighting projects the firm completes.
Program Awareness P1 – P7	Determine **r**espondents' familiarity with and participation in Dominion Energy lighting programs
Baseline Code BC1 – BC5	Understand how building codes influences purchasing decisions for both new construction and retrofit/replacement projects. Sub-objective to better understand code enforcement practices and opportunities to improve lighting designs.
New Construction Project Review NC1 – NC3	Review up to three new construction projects completed in 2020 and 2021, if there is sufficient data for project-level inquiry
Barriers B1 – B3	Identify the barriers to installing high-efficiency lighting
Market Share MS1 – MS5	Gather lighting expert perspectives on future lighting market share and program influences

Sample intro email

Subject: Dominion Energy's 2020-2021 Lighting Evaluation

Dear [Contact Name],

Dominion Energy is committed to providing our customers with safe, reliable, and affordable energy. As part of this effort, we are conducting an evaluation of lighting projects completed in 2020 and 2021.

Dominion Energy has engaged an independent research firm, DNV (www.dnv.com), to evaluate the effectiveness of this program. Independent evaluation of program activities is an important element in supporting the continuous improvement of our programs.

In the next few weeks, DNV will contact you to request your cooperation in completing a phone interview.

Your participation will provide important feedback to Dominion Energy on the program. Your data will remain completely anonymous. If you have any questions about this evaluation, please contact Dominion Energy at the number below.

Interview guide

Introduction (Intro)

Hi, my name is [INTERVIEWER NAME]**.** I am calling from DNV, an energy consulting firm on behalf of Dominion Energy. We are conducting a study of the commercial lighting market in Virginia.

Dominion Energy would like your input and perspectives in this survey to understand how to best structure future energy efficiency programs designed to serve customers like you.

Your answers will be held in the strictest confidence. The information you provide will be combined with information from other lighting experts that complete the interview. Individual responses will not be published. The results are reported in summaries such as group averages, percentages, and other general statistics.

[IF THEY ASK HOW LONG THE INTERVIEW WILL TAKE, TELL THEM ABOUT 30- MINUTES]

[ASK IF IT'S OK TO RECORD THE CALL].

[IF THEY REFUSE THE INTERVIEW (NOT THE RECORDING), THANK THEM FOR THEIR TIME AND HANG UP]

Intro1. What lighting services does your company provide in Virginia? [LISTEN FOR DESIGN, INSTALL, DESIGN/BUILD, TEST, REPAIR]

Intro2. [IF LIGHTING DESIGNER OR INSTALLER] We are interested in understanding the types of lighting technologies you typically design or install as a part of commercial and industrial (also known as C&I) lighting projects. Are you familiar with different types of lighting equipment? This can include Linear LEDs (TLEDs), LED Integrated Fixtures, High/Low Bay Lamps, and Fluorescent T5s, T8s, and T12s.

[IF NO, ASK FOR CONTACT AT COMPANY WHO DOES KNOW ABOUT LIGHTING]

a. Please provide the name and phone number for someone at your company who we can ask about lighting.

[THANK THEM FOR THEIR TIME AND HANG UP]

Intro3. About how many C&I lighting projects did your company complete in Virginia in 2020 and 2021? Please include new construction buildings, as well as major or "gut" renovations, defined here as projects that impact more than half of the square footage in a building, as well as smaller lighting retrofit and/or fixture replacement projects.

Intro4. Of the C&I lighting projects your company completed in Virginia in 2020 and 2021, approximately what percent of those projects were new construction or major renovation projects versus lighting retrofit or fixture/lamp replacement projects?

a. Percentage of new construction / major renovation projects: _____

b. Percentage of retrofit / replacement projects: ____

Intro5. How does your company differentiate between major renovation projects and retrofit or lighting replacement projects?

a. Is there a threshold or other criteria that you use to classify projects?

Program awareness (P)

[ASK P1 TO PARTICIPANTS AND P2 IF PARTICIPATION OF INTERVIEWEE IS UNKNOWN]

P1. [FOR PARTICIPANTS, THEN GO TO P3] We understand that your company is currently participating in Dominion Energy's Lighting Systems and Controls Rebate Program. Where did you first hear about this program?

P2. [WHEN PARTICIPATION IS UNKNOWN] Are you familiar with Dominion Energy's Lighting Systems and Controls Rebate Program?

a. **[IF YES]** Have you participated in this program for any Commercial & Industrial (or C&I) lighting projects in Virginia in 2021 or 2022?

b. **[IF YES, GO TO P3]**

c. **[IF NO]** Why not? [THEN GO TO P6].

P3. What motivated your company to participate in this program?

P4. Approximately what percent of the C&I lighting projects that your company completed in Virginia in 2021 and 2022 received discounts or rebates from Dominion Energy?

P5. [IF P4 PERCENT IS LESS THAN 100%]. Why do some projects not receive discounts or rebates from Dominion Energy?

P6. Does your company participate in any similar programs promoting energy-efficient lighting in Virginia outside the Dominion Energy service territory?

a. [IF YES] In what other Virginia service territories and programs?

P7. Does your company participate in any similar programs promoting energy-efficient lighting in any other state besides Virginia?

a. [IF YES] In what other states and programs?

Building and energy code (BC) impact on design

This section of the interview focuses on the building code and how you use this code in your lighting work.

BC1. First, let's discuss relevant building codes that affect your work

a. What are the relevant building codes and current versions for lighting in Virginia?

b. What is the minimum energy efficiency level for lighting laid out by this code?

c. How does the code impact your approach to design and/or installation of lighting projects?

BC2. [IF INTRO4 PERCENTAGE OF NEW CONSTRUCTION >0%] Great, now I would like to discuss how you and your company approach lighting for new construction and major renovation projects and code.

a. What are the factors that influence the lighting power density of the lighting design for new construction projects your firm completes?

b. In general, for new construction projects, how does your lighting design compare to the code lighting requirements? [probe for whether design is at code, better, or worse than code.]

c. [IF BETTER THAN CODE] Is there a typical threshold or target that you strive for in your lighting design?

d. What methods do you use to assess compliance with commercial energy code?

[PROBE FOR CHECKLIST, CALCULATIONS, SOFTWARE, COMCHECK, MODELING, ETC.]

e. Of the new construction Commercial & Industrial lighting projects your company completed in Virginia in 2020 and 2021, approximately what percentage of projects would you estimate had a lighting design just at the code minimum lighting requirement?

   i. And what percentage of projects would you estimate had better than code lighting designs?

   ii. And what percentage of projects would you estimate had worse than code lighting designs?

f. Based on your experience in this industry and in Virginia, what percentage of all new construction lighting across all projects in Virginia would you estimate was worse than code in 2020 and 2021?

g. Has your organization made any changes in your lighting design procedures to ensure compliance with the energy code in the past 5 years?

h. [IF PARTICIPANT] You mentioned previously that your firm participates in Dominion Energy's C&I lighting programs. Does your lighting design or approach differ for new construction projects that participate in the Dominion Energy programs from projects that do not participate?

   i. [IF YES] In what ways is it different? [probe for LPD differences or others]

BC3. Next, let's review your experience with enforcement of building energy codes related to lighting in the Commonwealth of Virginia.

a. Please describe the lighting energy code enforcement practices you've encountered in Virginia for lighting.

b. Do you observe variance in the quality or the level of code enforcement across jurisdictions you work with?

i. [IF YES] What do you think is the reason for this?

c. How is the lighting design typically reviewed by code enforcement officials?

BC4. Next, let's review factors that influence compliance with building energy codes related to lighting.

a. Are there factors that encourage energy efficient lighting designs such as business, economic, political, or something else, regardless of code? [IF YES] what are the primary factors?

b. What are the primary factors that create challenges to achieving code compliance?

c. On a scale of 1 to 5, where 1 means "Never" and 5 means "Very likely", how likely is it that lighting design across the Commonwealth would satisfy code requirements naturally, without an enforcement body?

d. What efforts are you aware of across the State or in specific jurisdictions to improve compliance with the lighting provisions of the code?

e. From your perspective, what factors, other than trainings, have led to changes in energy code compliance?

f. In your experience, do you feel that practitioners and code officials know how to do lighting power density or LPD calculations correctly?

g. Based on your experience, approximately what percentage of lighting projects meet the code's lighting power density requirements?

BC5. **[**IF INTRO4 PERCENTAGE OF RETROFIT / REPLACEMENT >0%] Now, I'd like to discuss how you approach lighting for retrofit and replacement projects.

a. What are the factors that influence the energy efficiency of the lighting design for retrofit or replacement projects your firm completes?

b. In general, for retrofit/replacement projects, how does your lighting design compare to the code lighting requirements?" [PROBE FOR WHETHER DESIGN IS AT CODE, BETTER, OR WORSE THAN CODE, OR IF THEY DO NOT ASSESS CODE LPD FOR RETROFITS]

c. [IF BETTER THAN CODE] Is there a typical threshold or target that you strive for in your lighting design?

d. [IF DO NOT ASSESS LPD FOR LIGHTING]. You indicated that you don't assess energy code lighting for retrofit/replacement projects. Can you please describe how you determine what needs to be replaced? [PROBE FOR LIKE-FOR-LIKE REPLACEMENT, MATCHING FIXTURE LAYOUTS, CHANGING TO LEDS OR OTHER TECHNOLOGIES]

e. What methods do you use to assess compliance with the commercial code for retrofit projects?

[PROBE FOR CHECKLIST, CALCULATIONS, SOFTWARE, COMCHECK, MODELLING, ETC.]

f. Of the retrofit C&I lighting projects your company completed in Virginia in 2020 and 2021, approximately what percentage of projects would you estimate had a lighting design at the code minimum lighting requirement?

 i. And what percentage of projects would you estimate had better than code lighting designs?

 ii. And what percentage of projects would you estimate had worse than code lighting designs?

g. How do you integrate lighting controls into retrofit projects? [PROBE FOR DETAILS ON LIGHTING CONTROLS]

h. [IF PARTICIPANT] You mentioned previously that your firm participates in Dominion Energy's Commercial & Industrial lighting programs. Does your lighting design or approach differ for retrofit projects that participate in the Dominion Energy programs from projects that do not participate?

 i. [IF YES] In what ways is it different? [PROBE FOR LPD DIFFERENCES OR OTHERS]

New construction (NC) project review

[ONLY COMPLETE THIS SECTION IF WE HAVE NEW CONSTRUCTION PROJECT DETAILS FOR THE INTERVIEWEE]. We've identified several projects that your firm completed in 2020 or 2021. I'd like to ask you several questions about each. [ITERATE FOR UP TO 3 PROJECTS AS AVAILABLE].

NC1. The first project we have identified is [PROVIDE PROJECT NAME/ADDRESS/DESCRIPTION].

a. Do you recall this project? (provide details from project plans to assist recall if necessary)

 i. [IF NO, COLLECT CONTACT INFORMATION FOR PERSON WHO WOULD BE BETTER ABLE TO SPEAK TO PROJECT]

b. Do you recall how you approached the lighting design for this project?

c. Based on your recollection, was the design for this project at code, better than code, or worse than code?

d. [IF BETTER THAN CODE]. What are the factors that drove this project to exceed code? [Probe for: Standard design exceeds code, client request, others]

e. [IF PARTICIPATING PROJECT] Did the program influence the lighting design?

 i. [IF YES] How?

 ii. [IF NO] So the lighting design would have been the same without the program, correct?

[REPEAT FOR UP TO 3 TOTAL PROJECTS: NC1 – NC3]

Barriers (B)

We have a few more questions on lighting design.

B1. [FOR PARTICIPANTS] Does the Dominion Energy lighting program make it easier to install high efficiency lighting than it would be without the program?

B2. In your opinion, is there a need for lighting programs to increase efficiency of lighting products in Dominion Energy territory? Why or why not?

a. Has the market fully transitioned to high efficiency lighting?

B3. What are the remaining barriers preventing universal use of high-efficiency lighting?

Market share (MS)

Finally, we have a few questions to help us understand lighting expert perspectives on current and future market share.

MS1. In the past year, can you please estimate the total number of lamps, bulbs, and lighting fixtures that your firm has designed/installed.

[Probe: A ballpark estimate is fine, no need for exact figures.]

MS2. How many [or what percentage] of those lamps/bulbs/fixtures would you estimate were from each of the following fixture types:

a. LED: ___

b. T5: ____

c. High performance T8 (HPT8): ____

d. T8: ____

e. Other (please describe): _____

MS3. [FOR PARTICIPANTS] Without the Dominion Energy program, would you have installed more, the same amount, or less energy efficiency equipment?

MS4. What do you believe will be the approximate share of total lighting equipment that will be energy efficient in…

i. 2023

ii. 2024

iii. 2025

MS5. If the program were to immediately stop, what do you think would be the approximate share of total lighting equipment that will be energy efficient in…

i. 2023

ii. 2024

iii. 2025

Those are all the questions we have currently. Thank you for your time.

APPENDIX D. NET-TO-GROSS SURVEY

Overview

The objectives of the gross and net Impact Evaluation are to verify and re-estimate energy and peak demand savings for the DSM Phase VII Non-Residential Lighting & System Controls Program and lighting component of the DSM Phase VIII Small Business Improvement Enhanced Program from program inception through year-end 2021 (the study period). Given the similarities in the lighting measures offered in both programs, including the lighting measures from the Small Business program into the existing study of the Non-Residential Lighting program will have minimal additional incremental cost, but provide the additional benefit of producing gross and net adjusted savings for a large portion of the Company's 2022 to 2025 reported savings, savings to be compared against the Virginia Clean Economy Act (VCEA) targets.

Data collection

DNV will contact customers for surveys and schedule a virtual site visit at a day and time that will minimize disruption to the customer's operations and activities. DNV will stage and consolidate its communications with customers to achieve this goal. First, DNV plans to send an email to the selected sample of customers in both programs with a request to complete the NTG survey. NTG survey participants will receive a $25 Amazon electronic gift card for completing the survey.

If the response rate is low, DNV will then contact customers via follow-up e-mails and direct phone calls to increase response rates.

Instrument information

Overview of data collection

Descriptor	This instrument
Instrument type	Web/Phone Survey
Estimated time to complete	10 – 15 minutes
Population description	Participants in Dominion Energy's Non-Res Lighting Systems and Controls Program or Small Business Program between January 1, 2020 and December 31, 2021.
Sampling strata definitions	Stratification by program and building type
Population size	**Lighting systems and controls – 5,589** Education - 96 Health - 85 Lodging - 625 Other – 4,783 **Small business – 1,668** Other – 1,668

Descriptor	This instrument
Completion goal(s)	**Lighting systems and controls - 170** Education - 10 Health - 10 Lodging - 10 Other - 140 **Small business - 30** Other - 30
Contact list source	Dominion Energy tracking data
Contact sought	Site decision-maker (facilities manager or other program contact)

Topics and associated questions

Questions	Objective
I1	Explain purpose of survey
SCRN1 – SCRN4	Ensure we are speaking with the correct person
V1 – V5	Verify the measures were installed and remind respondent of rebate received from Dominion Energy
RB1 – RB5	Provide context around purchasing lighting equipment (I.e., motivations, need for equipment, role of Dominion Energy program, etc.)
FR1 – FR4	Ask about overall influence, timing, efficiency, quantity to calculate free-ridership
SO1 - SO	Ask about spillover
S1 – S4	Ask about satisfaction with the program
C1 - C3	Close survey

Survey variables

Variable	Explanation
Company_Name	Name of the participating organization
Customer_Name	Name of primary contact at participant organization
First_Name	First name of primary contact at participant organization
Last_Name	Last name of primary contact at participant organization
Customer_Email	Email for primary contact at participant organization

Variable	Explanation
Customer_Phone	Phone for primary contact at participant organization
Customer_Address	Address of participating organization
Address	Address where equipment was installed
M_ID_1	ID for measure installed
M_Date_1	Date measure was installed
M_Type_1	Type of measure installed
M_Reward_1	Amount of rebate received by participating organization
M_ID_2	[If more than one measure] ID for measure installed
M_Date_2	[If more than one measure] Date measure was installed
M_Type_2	[If more than one measure] Type of measure installed
M_Reward_2	[If more than one measure] Amount of rebate received by participating organization
M_ID_3	[If more than two measures] ID for measure purchased
M_Date_3	[If more than two measures] Date measure was installed
M_Type_3	[If more than two measures] Type of measure purchased
M_Reward_3	[If more than two measures] Amount of rebate received by participating organization

Survey instrument

Introduction (I)

EMAIL

Subject Line: Tell Us About Your Experience with Dominion Energy Lighting Programs

I1. According to our records, your company recently purchased and received a rebate for efficient lighting systems and/or lighting sensors/controls through a Dominion Energy Program.

Dominion Energy is seeking feedback on your experience through the following survey. This survey should only take about 10-15 minutes to complete, and in appreciation of your time, we will send a $25 Amazon electronic gift card to the e-mail address you provide at the end of the survey.

Your answers will be held in the strictest confidence. The information you provide will be combined with information from other businesses that complete the survey. Individual business data will not be published. The results are reported in summaries such as group averages, percentages, and other general statistics.

PHONE

I1. Hello, my name is **[SURVEYOR NAME]**. I am calling from DNV, an energy services firm on behalf of Dominion Energy. We are calling concerning your participation in **Dominion Energy's [IF SB_FLAG = 1]** Small Business Program **[IF LS&C_FLAG = 1**] Lighting Systems & Controls Program.

Dominion Energy is seeking feedback on your experience through a quick survey. This survey should only take about 10-15 minutes. In appreciation of your time, we will send a $25 Amazon electronic gift card to the e-mail address you provide at the end of the survey

Your answers will be held in the strictest confidence. The information you provide will be combined with information from other businesses that complete the survey. Individual business data will not be published. The results are reported in summaries such as group averages, percentages, and other general statistics.

WEB SURVEY

INTRO. Welcome to Dominion Energy's **[PROGRAM NAME]** Survey! Our records indicate you recently purchased and received a rebate for efficient lighting systems and/or lighting sensors/controls through Dominion Energy's **[PROGRAM NAME]** and are eligible to participate in this survey.

This survey should take approximately 10-15 minutes to complete. In appreciation of your time, we will send a $25 Amazon electronic gift card to the e-mail address you provide at the end of the survey.

If you have any problems, please email Kyle.Bonus@dnv.com for assistance. To begin the survey, click "next."

Screener (SCRN)

SCRN1. Our records show that **[COMPANY NAME]** completed the following energy-efficiency lighting projects at **[CUSTOMER_ADDRESS]** between January 1, 2020, and December 31, 2021.

[M_Type_1]

[M_Type_2]

[M_Type_3]

Were you involved in the decision to install any of this equipment or approve any of these energy-saving upgrades?

1	Yes **[CUSTOMER_NAME]**	Skip to SCRN 3
2	No	Continue to SCRN 2
-98	Don't know	

SCRN2. Can you please provide the contact information for another person at **[COMPANY NAME]** who was involved with the decision-making process to purchase these energy-saving upgrades between January 1, 2020 and December 31, 2021?

1	Yes – please provide the name and phone or email address **[OPEN ENDED RESPONSE]**	Skip to C4
2	No	Skip to C4_1
-98	Don't know	

SCRN3. Before today, were you aware that the cost of these energy-savings upgrades was discounted by Dominion Energy?

1	Yes	Continue to V1
2	No	Skip to C4
-98	Don't know	

Verify Measure Installation (V)

V1. We'd like to verify the installation of the following measures at the address we have on record: **[CUSTOMER_ADDRESS]**. Please confirm the information below is correct.

[M_Type_1] installed on **[M_Date_1]** and received a **[M_Reward_1]** rebate

1	Yes	Skip to V2
2	No	Continue to V1_1
-98	Don't recall	Skip to V2

V1_1. Please let us know the correct information regarding your purchase of **[M_Type_1]**.

50	**[RECORD UPDATED INFORMATION]**	Continue to V2

V2. [M_Type_2] installed on **[M_Date_2]** and received a **[M_Reward_2]** rebate

1	Yes	Skip to V3
2	No	Continue to V2_1
-98	Don't recall	Skip to V3

V2_1. Please let us know the correct information regarding your purchase of **[M_Type_2]**.

50	**[RECORD UPDATED INFORMATION]**	Continue to V3

V3. [M_Type_3] installed on **[M_Date_3]** and received a **[M_Reward_3]** rebate

1	Yes	Skip to R1
2	No	Continue to V3_1
-98	Don't recall	Skip to R1

V3_1. Please let us know the correct information regarding your purchase of **[M_Type_3]**.

50	**[RECORD UPDATED INFORMATION]**	Continue to R1

Replacement behavior (R)

This section is meant to understand the drivers behind the lighting projects that you undertook.

R1. Please think back to the time when you were deciding to purchase the lighting equipment, what factors motivated you to purchase the energy-saving equipment? Select all that apply **[MULTIPLE RESPONSE; RANDOMIZE BEFORE 'OTHER']**

		[M_Type_1]	**[M_Type_2]**	**[M_Type_3]**	
1	Old equipment was outdated				Continue to R2
2	Old equipment was not performing well				
3	Old equipment failed				
4	Past experience with the same type of equipment you installed				
5	Wanted to save money				
6	Wanted to save energy				
7	Wanted to reduce cost of operation				
8	The information provided by this program				
9	The rebate provided by this program				
10	Recommended by utility representative				
11	Recommended by contractor/engineer				

12	Recommended by deal/trader				
13	Liked the appearance of the new equipment more than the old one				
14	Improve productivity in working environment				
50	Other **[GO TO R1_1]**				
-98.	Don't know				
-99	Refused				

R1_1. **[IF R1=50]** You indicated there were other factors motivating you to purchase the energy saving equipment. Pleas specify the motivations:

[M_Type_1]	**[OPEN ENDED RESPONSE]**	Continue to R2
[M_Type_2]	**[OPEN ENDED RESPONSE]**	
[M_Type_3]	**[OPEN ENDED RESPONSE]**	

R2. Was this project the result of any of the following? Select all that apply **[MULTIPLE RESPONSE; RANDOMIZE BEFORE 'OTHER']**

		[M_Type_1]	**[M_Type_2]**	**[M_Type_3]**	
1	New construction or a major addition				Continue to R3
2	A renovation or planned upgrade				
3	To replace failing or broken equipment				
4	To improve equipment efficiency				
5	To improve operational efficiency				
6	Part of planned or preventative maintenance				
7	Due to new tenant upgrades				

50	Other **[GO TO R2_1]**				
-98	Don't know				
-99	Refused				

R2_1. [IF R2=50] You indicated this project was a result of another factor. Please specify:

[M_Type_1]	**[OPEN ENDED RESPONSE]**	Continue to R3
[M_Type_2]	**[OPEN ENDED RESPONSE]**	
[M_Type_3]	**[OPEN ENDED RESPONSE]**	

R3. How did you first hear about Dominion Energy's **[IF SB_FLAG = 1]** Small Business Program **[IF LS&C_FLAG = 1]** Lighting Systems & Controls Program?

1	From a previous project	Continue to R4
2	From contractor/vendor/supplier	
3	From Dominion Energy representative	
4	From colleague within my organization	
5	From colleague or someone else outside my organization	
6	From bill insert	
7	From web search	
50	Other **[OPEN ENDED RESPONSE]**	
-98	Don't know	
-99	Refused	

R4. What role, if any, did Dominion Energy's program play in your decision to install this equipment at this location?

50	**[M_Type_1]** at **[M_Address_1]**	**[OPEN ENDED RESPONSE]**	Continue to R5
51	**[M_Type_2]** at **[M_Address_2]**	**[OPEN ENDED RESPONSE]**	

52	**[M_Type_3]** at **[M_Address_3]**	**[OPEN ENDED RESPONSE]**	

R5. What challenges, if any, did you encounter when getting this project approved and/or completed? Select all that apply [**MULTIPLE RESPONSE; RANDOMIZE BEFORE 'OTHER'**]

		[M_Type_1]	**[M_Type_2]**	**[M_Type_3]**	
1	Payback or return on investment (ROI)				Continue to FR1
2	Confidence in realizing estimated savings				
3	Unknown technology or process				
4	Lack of time/unwilling to make time to understand what efficiency options make sense for facility and research a vendor to implement equipment				
5	Permit barriers				
6	Lack of access to financing				
7	Internal bureaucracy or inability to gain decision maker's attention				
8	Lack of credibility or legitimacy (i.e., needs third reference)				
50	Other **[GO TO F5_1]**				
51	None of the above				
-98	Don't know				
-99	Refused				

R5_1. **[IF FR5=50]** You indicated there were other challenges you encountered when getting this project approved and/or completed? Please specify these challenges:

[M_Type_1]	**[OPEN ENDED RESPONSE]**	Continue to FR1
[M_Type_2]	**[OPEN ENDED RESPONSE]**	
[M_Type_3]	**[OPEN ENDED RESPONSE]**	

Free-ridership – Direct attribution (FR)

The following questions will ask about how the Dominion Energy program effected your decision on the timing of installing lighting equipment, the efficiency level of lighting equipment installed, and the quantity of lighting equipment installed.

FR1. Without the Dominion Energy program, how likely is it that you would have installed the lighting that you did?

	Very likely	Somewhat likely	Not very likely	Very Unlikely	Would not have completed the project	Don’t know	Not applicable	Prefer not to answer
[M_Type_1]								
[M_Type_2]								
[M_Type_3]								

Timing

FR2. Without the Dominion Energy program, would you have installed the following measure(s) at the same time, later, or never?

		[M_Type_1]	**[M_Type_2]**	**[M_Type_3]**	
1	At the same time or earlier				Continue to FR3
2	1 – 12 months later				

3	13 – 24 months later				
4	25 to 36 months later				
5	37 to 48 months later				
6	More than 48 months later				
7	Would not have purchased at all				
-98	Don't know				
-99	Refused				

Efficiency

[IF M_TYPE_1 = OCCUPANCY SENSOR – DON'T DISPLAY]

[IF M_TYPE_2 = OCCUPANCY SENSOR – DON'T DISPLAY]

[IF M_TYPE_3 = OCCUPANCY SENSOR – DON'T DISPLAY]

FR3. Without the Dominion Energy program, would you have installed the same efficiency lighting equipment as what you installed?

		[M_Type_1]	
1	Yes		Skip to FR4
2	No		Continue to FR3_1

-98	Don't know		Skip to FR4
-99	Prefer not to answer		

FR3.1 [**IF <u>TYPE 2=NOT EMPTY]</u>** Without the Dominion Energy program would you have installed the same efficiency lighting equipment as what you installed?

		[M_Type_2]	
1	Yes		Skip to FR4
2	No		Continue to FR3_1
-98	Don't know		Skip to FR4
-99	Prefer not to answer		

FR3.2 [**IF <u>TYPE 3=NOT EMPTY]</u>** Without the Dominion Energy program would you have installed the same efficiency lighting equipment as what you installed?

		[M_Type_3]	
1	Yes		Skip to FR4
2	No		Continue to FR3_1
-98	Don't know		Skip to FR4
-99	Prefer not to answer		

FR3_1. [IF FR3=2] Without the program, would you have purchased lighting equipment that was…

		[M_Type_1]	
1	Standard efficiency on the market		

2	Slightly higher than standard efficiency		Continue to FR4
3	Between standard efficiency and the efficiency purchased		
4	Slightly lower than the efficiency purchased		
-98	Don't know		
-99	Prefer not to answer		

FR3_1.1. [IF FR3.1=2] Without the program, would you have purchased lighting equipment that was…

		[M_Type_2]	
1	Standard efficiency on the market		Continue to FR4
2	Slightly higher than standard efficiency		
3	Between standard efficiency and the efficiency purchased		
4	Slightly lower than the efficiency purchased		
-98	Don't know		
-99	Prefer not to answer		

FR3_1.2. **[IF FR3.2=2]** Without the program, would you have purchased lighting equipment that was…

		[M_Type_3]	
1	Standard efficiency on the market		Continue to FR4
2	Slightly higher than standard efficiency		
3	Between standard efficiency and the efficiency purchased		
4	Slightly lower than the efficiency purchased		
-98	Don't know		

-99	Prefer not to answer		

Quantity

FR4. Without the Dominion Energy program, would you have purchased the same quantity of fixtures, fewer, or more?

		[M_Type_1]	[M_Type_2]	[M_Type_3]	
1	Same amount or more				Skip toSO1
2	Less				Continue to FR4_1
3	Would not have installed any				Skip to SO1
4	Not applicable				
-98	Don’t know				
-99	Refused				

FR4_1. What percent of the quantity you installed would you estimate that you would have still installed without the program?

		[M_Type_1]	[M_Type_2]	[M_Type_3]

1	Less than 25% of what you installed				Continue to SO1
2	Between 25% and 50% of what you installed				
3	Between 51% and 75% of what you installed				
4	Greater than 75% of what you installed				
-98	Don't know				
-99	Refused				

Spillover (SO)

This next section will cover any additional efficient lighting installations you have completed since participating in the Dominion Energy program.

SO1. Has your company purchased and installed any lighting equipment that was not subsidized by Dominion Energy for this or other facilities served by Dominion Energy since participating in this program?

1	Yes	Continue to SO1_1
2	No	Skip to S1
-98	Don't know	
-99	Refused	

SO1_1. Was this equipment the same efficiency level or a higher efficiency level than the equipment you installed through the program?

1	Same efficiency or higher efficiency	Continue to SO2
2	Lower efficiency	Skip to S1

-98	Don't know	
-99	Refused	

SO2. What quantity of lighting equipment did your company purchase? (Please provide your response as a percentage compared to the amount installed through the program.)

50	**[RECORD QUANTITY PURCHASED]**	Continue to SO3_1

SO3_1. Did a recommendation by the contractor or designer who you worked with under the Dominion Energy program influence your decision to install some or all of this efficient lighting equipment?

1	Yes	Continue to SO3_2
2	No	
-98	Don't know	
-99	Refused	

SO3_2. Did your experience with the energy-efficiency lighting equipment installed through the Dominion Energy program influence your decision to install some or all of this efficient lighting equipment?

1	Yes	Continue to SO3_3
2	No	
-98	Don't know	
-99	Refused	

SO3_3. Did your participation in any past program(s) offered by Dominion Energy influence your decision to install some or all of the efficient lighting equipment?

1	Yes	

2	No	Continue to SO4
-98	Don't know	
-99	Refused	

SO4. Why did you not apply for a rebate for this lighting equipment through a Dominion Energy program? Select all that apply. **[MULTIPLE RESPONSE; RANDOMIZE BEFORE 'OTHER']**

1	Too much paperwork	Skip to S1
2	Cost savings not worth the effort of applying	
3	Takes too long to get approval	
4	The equipment would not qualify	Continue to SO4_1
5	The vendor used does not participate in Dominion Energy programs	Skip to S1
6	Outside Dominion Energy service territory	
7	Did not have time because the equipment was needed immediately	
8	Thought the program had ended	
9	Didn't know the equipment qualified under another program	
10	Just didn't think of it	
11	Unable to get rebate	
12	Other	Continue to SO4_1
-98	Don't know	Skip to S1
-99	Refused	

SO4_1. [IF SO4=4] You reported that you did not apply for a rebate for the lighting equipment through a Dominion Energy program because the equipment would not qualify. Can you please expand on why the equipment did not qualify.

50	**[OPEN ENDED RESPONSE]**	Continue to S1

Satisfaction (S)

Finally, please answer a few questions regarding your overall satisfaction with the program.

S1-S4. [IF SO1 = 2 – 99, SO4= 1 -3, 5 -11, 98, 99] On a scale of 5 to 1, where 5 represents very satisfied and 1 very dissatisfied, please respond to the following questions.

	5- Very satisfied	4- Somewhat satisfied	3- Neutral	2- Somewhat satisfied	1- Very dissatisfied	Don't know	Prefer not to answer	
How satisfied or dissatisfied are you with the rebate you received?								Continue to C1
How about the timeliness of the rebate payment?								
How about the rebate application forms and other paperwork?								
How about the administrative aspects of the program?								

Closing (C)

[IF BACKUP = 1]

C1. Do the answers provided here apply to the other sites where you installed efficient lighting equipment through the Dominion Energy program?

1	Yes, please specify: **[OPEN ENDED REPONSE]**	Continue to C2

2	No	
-98	Don’t know	
-99	Prefer not to answer	

C2. Are there other energy-saving technologies or appliances for which you feel Dominion Energy should offer a rebate?

1	Yes **[OPEN ENDED REPONSE]**	Continue to C2
2	No	
-98	Don’t know	
-99	Refused	

C3. Do you have a suggestion or recommendation to improve the delivery of this program for customers like yourself?

50	**[OPEN ENDED REPONSE]**	Continue to C4
-98	Don’t know	
-99	Refused	

T1. Those are all the questions we have at this time. We will reach out to the contact person you have recommended to complete the survey. Thank you for your time.

T1_1. Thank you for answering our questions. However, we are looking for someone more familiar with the decision to install the equipment previously mentioned.

C4. As a part of this study, we will also be conducting virtual site visits to assess the lighting systems and/or controls discussed in this survey. The virtual visit should take approximately 1 hour and we are offering an additional $50 Amazon electronic gift card for your participation. Please indicate your interest:

1	I am interested in having a DNV representative contact me to schedule a virtual site visit	Continue to C4_1
2	I am interested in having a DNV representative contact me to learn more about the virtual site visits	

3	I am not interested in participating in a virtual site visit	Continue to GC1

C4_1. [IF C4=1,2] Someone from DNV will contact you to schedule the virtual visit. Please indicate if any of the following contact information is incorrect:

1	Name: ${e://Field/Full%20name}	Continue to C4_2
2	Company name: ${e://Field/Company_Name}	
3	Company address: ${e://Field/Address}	
4	Email: ${e://Field/Email}	
5	Phone number: ${e://Field/Customer_Phone}	
6	All information is correct	Continue to GC.1
-98	I am not interested	

C4_2. [SHOW FOR ANY ITEMS SELECTED IN C4_1] Please provide the correct information:

Gift card (for those who completed the entire survey)

GC.1 In appreciation of your time, we are offering a $25 electronic gift card from Amazon to those who complete the survey. If you would like to receive this electronic gift card, please enter the e-mail address where you would like it to be sent.

1	Preferred e-mail: **[OPEN ENDED RESPONSE]** Recipient's name **[OPEN ENDED RESPONSE]**	End
3	Prefer not to receive the gift card	

DNV

APPENDIX E. METERING, IMPACT, AND PERSISTENCE DATA COLLECTION FORM

Site ID: ______________________ Logger Install Date: ______________________

Auditor: ______________________ Logger Removal: Date: ______________________

Area ID	Space description	Detailed space description	Controls (Occupancy sensors, dimmers, etc)	Baseline lighting fixtures			Program lighting fixtures			Logger installed		
				Qty	Watts	Description (Length, lamps, ballast, etc)	Qty	Watts	Description (Length, lamps, ballast, etc)	Code	Logger ID	Notes
A1	*Office*	*Bldg 1, Flr 2, Office #732*	*OS*	*4*		*2L 4' T8/EB HIGH LMN*				*Log1*	*38655*	

Area ID	Space description	Detailed space description	Controls (Occupancy sensors, dimmers, etc)	Baseline lighting fixtures			Program lighting fixtures			Logger installed		
				Qty	Watts	Description (Length, lamps, ballast, etc)	Qty	Watts	Description (Length, lamps, ballast, etc)	Code	Logger ID	Notes
A1	*Office*	*Bldg 1, Flr 2, Office #732*	*OS*	*4*		*2L 4' T8/EB HIGH LMN*				*Log1*	*38655*	

5.4.1.1 OPERATING SCHEDULES

SCH ID	Days[10]	Operating hours		Operating season[11]		%Lit[12]
		Start time	End time	Start date	End date	
L1	ALWAYS ON	0:00	24:00	Jan 1	Dec 31	100%
L2		:	:			%
L3		:	:			%
L4		:	:			%
L5		:	:			%
L6		:	:			%
L7		:	:			%
L8		:	:			%
L9		:	:			%
L10		:	:			%
L11		:	:			%
L12		:	:			%
L13		:	:			%
L14		:	:			%
L15		:	:			%
L16		:	:			%
LV	Vacation/Shutdown	N/A	N/A			%
LH	Holidays	N/A	N/A	Days/year:		%

- ☐ *New Year's Day*
- ☐ *MLK Day*
- ☐ *Washington's Birthday*
- ☐ *Good Friday*
- ☐ *Memorial Day*
- ☐ *Independence Day*
- ☐ *Labor Day*
- ☐ *Columbus Day*
- ☐ *Veterans Day*
- ☐ *Thanksgiving Day*
- ☐ *Thanksgiving Friday*
- ☐ *Christmas*
- ☐ *Other*___________________
- ☐ *Other*___________________
- ☐ *Other*___________________

Notes: ____

____

____

5.4.1.2 IMPORTANT QUESTIONS

Schedule changes since installation?____

____

Seasonal variation in schedules?____

____

Occupancy/production/business variations? ____

____

Monitored month(s) typical? ____

____

____

Were the lighting installations part of a major renovation? If so, obtain renovated square footage. ___________________________

____

[10] Categorize operation as appropriate for this business, e.g. Mon–Fri, Mon–Wed, Sat–Sun, holidays, etc.
[11] For use when schedules are different by season, month, or other time period
[12] Estimated diversity fraction of occupied space that is lit under this schedule

[If part of a major renovation, auditor to check off all that apply] What other equipment was replaced at the time of the renovation project?

- ☐ Ceiling grid removed
- ☐ Terminal AC units replaced
- ☐ Studs were exposed
- ☐ Anything else? [Auditor to list what, if anything else] ____

____

What were the reasons for choosing the installed lighting types? If more than one provided, what was the primary reason? (replacing failed or failing equipment)? [Auditor seeking to understand whether there was some type of systemic failure, or incipient failure, of overall lighting systems]. ____

Describe the pre-existing lighting and its condition? ____

____

What was the date of the last major lighting upgrade at this facility?_____________________________________

____

What was the age of the replaced equipment? ____

____

How many more years would the replaced equipment have operated if left in place? ___________________________

____

Are any of the older fixtures, lamps, and/or ballasts still in operation?_____________________________________

____

5.4.1.3 INTERACTIVE COOLING SYSTEMS

ID	Description	Type	Fuel	Efficiency	Qty	Size (tons)	Age (yrs)
C1		☐ Direct expansion ☐ Chilled water ☐ Heat pump – air / wtr / gnd ☐ ____________________	☐ Electricity ☐ Natural gas ☐ LP gas ☐ _________	_____ kW/ton _____ EER _____ SEER			
Notes:							
C2		☐ Direct expansion ☐ Chilled water ☐ Heat pump – air / wtr / gnd ☐ ____________________	☐ Electricity ☐ Natural gas ☐ LP gas ☐ _________	_____ kW/ton _____ EER _____ SEER			
Notes:							
C3		☐ Direct expansion ☐ Chilled water ☐ Heat pump – air / wtr / gnd ☐ ____________________	☐ Electricity ☐ Natural gas ☐ LP gas ☐ _________	_____ kW/ton _____ EER _____ SEER			
Notes:							
C4		☐ Direct expansion ☐ Chilled water ☐ Heat pump – air / wtr / gnd ☐ ____________________	☐ Electricity ☐ Natural gas ☐ LP gas ☐ _________	_____ kW/ton _____ EER _____ SEER			
Notes:							

Notes:____

____

5.4.1.4 INTERACTIVE HEATING SYSTEMS

ID	Description	Type	Fuel	Efficiency	Qty	Size (Btuh)	Age (yrs)
H1		☐ Hydronic ☐ Steam ☐ Direct fired ☐ Heat pump – air / wtr / fnd ☐ ________________ ______	☐ Electricity ☐ Natural gas ☐ LP gas ☐ #2 / #4 / #6 ☐ __________	_____ % _____ COP			
Notes:							
H2		☐ Hydronic ☐ Steam ☐ Direct fired ☐ Heat pump – air / wtr / gnd ☐ ________________ ______	☐ Electricity ☐ Natural gas ☐ LP gas ☐ #2 / #4 / #6 ☐ __________	_____ % _____ COP			
Notes:							
H3		☐ Hydronic ☐ Steam ☐ Direct fired ☐ Heat pump – air / wtr / gnd ☐ ________________ ______	☐ Electricity ☐ Natural gas ☐ LP gas ☐ #2 / #4 / #6 ☐ __________	_____ % _____ COP			
Notes:							
H4		☐ Hydronic ☐ Steam ☐ Direct fired ☐ Heat pump – air / wtr / gnd ☐ ________________ ______	☐ Electricity ☐ Natural gas ☐ LP gas ☐ #2 / #4 / #6 ☐ __________	_____ % _____ COP			
Notes:							

Notes: ____

APPENDIX F. DNV REVIEW OF 2017 EMPOWER LONG-TERM METERING STUDY

DNV reviewed the 2017 EmPOWER Maryland Commercial and Industrial (C&I) Long-Term Metering Study performed by Navigant to understand the methodologies that were employed and the data that was collected to update the lighting hours of use (HOU) and coincidence factor (CF) assumptions in the Mid-Atlantic Technical Reference Manual (TRM). This review will help shape the current non-residential lighting impact evaluation that DNV is performing of Dominion Energy's DSM Phase VII Non-Residential Lighting Systems & Controls Program, Small Business Improvement Program (DSM Phase V) and the current iteration of this program, the Small Business Improvement Enhanced Program (DSM Phase VIII).

Introduction

The 2017 study sought to capture winter lighting HOU and CFs by metering ~700 lighting circuits in 79 C&I buildings from January through September 2016 and combining this metered data with the metered data from previous studies where metering occurred during only the summer months. Data from previous studies were used by examining the relationship between the summer and winter usage patterns from the 2017 study loggers and applying that relationship to the summer data from previous studies to estimate winter usage. This was particularly important for primary and secondary schools, outdoor lighting, and warehouses since the lighting profiles in such spaces typically experience seasonal variations. The PJM and utility peak periods are defined as follows.

- PJM Summer Peak: Non-holiday weekdays, June 1-August 31, 2pm-6pm.
- EmPOWER Maryland Summer Peak: Non-holiday weekdays, June 1-August 31, 4pm-5pm.
- PJM Winter Peak: Non-holiday weekdays, January 1-February 28, 7am-9am and 6pm-8pm.

Sample design

The 2017 study sample was designed to consist of 80 sites across the six most significant building types (highest energy and demand savings) from 18 months of prescriptive and small business program data as shown in the 'target facilities' column of the table below. Each building type consisted of two sampling strata. One stratum consisted of the top 50% of energy and demand savings, while the other contained the bottom 50%. The final sample was ultimately 79 sites as shown in the last column.

Summary of building types in proposed and final sample

Building type	Expected seasonal variability	PY5 CV[13]	PY5 Population size	Target facilities	2016 Winter metering sample
Schools[14]	High	0.39	10	15	20
Warehouses	Moderate	0.43	23	12	7
Retail	Low	0.16	20	8	9
Health	Low	0.22	5	6	7

[13] CV values are for the summer PJM coincidence factors.
[14] Consisted only of K-12 schools.

Building type	Expected seasonal variability	PY5 CV[13]	PY5 Population size	Target facilities	2016 Winter metering sample
Grocery	Low	0.07	10	6	5
Offices	Low	0.22	18	8	4
Other	Low – Moderate	0.62	55	25	27
Total				**80**	**79**

Site visits

Due to the long-term metering, three visits were performed at each site. The first visit was to install the loggers, the second to download data or replace batteries/loggers that were providing bad data, and the third to remove the loggers. CT state loggers represented more than 95% of all deployed loggers. CT amperage loggers were used for the remaining cases when certain fixtures on a circuit could be switched independently, were controlled by separate daylighting sensors (like outdoor lighting), or if it was not feasible to install a CT state logger. When CT amperage loggers were used, a spot amp measurement was taken at maximum load and used in the analysis.

Hours of use analysis

For each logger, the measured percent for each hour during the metering period was binned by hour of the day and “day type” (weekday, weekend, full holiday, partial holiday) and a simple average was calculated so that each of the four “day types” had percent on estimates for each hour of the day. These estimates were applied to hours of the year that were not logged based on hour of the day and “day type”. It is important to note that since that year metering occurred in (2016) was a leap year, metered hours were extrapolated to represent 8,784 hours; instead of 8,760 hours as is typical in a non-leap year.

Combining 2017 study logger data

Logger data collected as part of the 2017 study were combined as follows.

- Multiple loggers from the same room at the same site: Areas that accounted for a large portion of savings at a site had two loggers installed. In this instance, the simple average HOU and CFs were used in the analysis.
- Multiple loggers from the same space type at the same site: If three different private offices were metered at a site, the simple average HOU and CFs were used in the analysis.
- Individual loggers from the same space type across multiple buildings of the same building type: If one hallway was metered at three different schools, the weighted average HOU and CFs for hallways at schools (weighted by connected watts) were used in the analysis.

Combining 2017 study logger data with logger data from previous studies

HOU and summer CF results from the 2017 study and previous studies were weighted by connected watts and case weighted by building type to represent the program populations from each study to produce overall weighted average HOU and summer CF results.

Since the previous studies did not collect winter data, the winter CFs from these studies were derived using a linear regression model that established the relationship between the winter CFs calculated with actual metered winter data from the current study and a PJM Winter Hours Summer Season Peak[15] CF (calculated using winter peak hours with summer peak period data from the same logger). This model had an R-squared of 0.80 and provided a way to predict winter CF values using only summer data if the building type and space type was known.

Results[16]

Statewide parameters comparison[17]

Study	Hours of use	Utility summer CF	PJM summer CF	PJM winter CF
Current Study	4692	0.73	0.73	0.54
Previous Values	4243	0.73	0.69	NA
Percentage Difference	*10%*	*0%*	*6%*	*NA*

Source: Navigant Consulting, EmPOWER Maryland Final Impact Evaluation Report Evaluation Report

HOU and CF values at building type level

Building type	Hours of use	Utility CF	PJM summer CF	PJM winter CF
Education	2233	0.35	0.36	0.33
Grocery	7272	0.97	0.97	0.93
Health	3817	0.67	0.68	0.51
Office	3044	0.70	0.69	0.49
Other	4058	0.62	0.61	0.46
Retail	4696	0.83	0.83	0.56
Warehouse/Industrial	4361	0.80	0.80	0.50

15 Defined as Non-holiday weekdays from June 1-August 31, 7am-9am and 6pm-8pm.

16 There isn't any text around these tables in the results section of the report.

17 Previous studies had no schools since all metering data was collected in the summer and it was difficult or impossible to get into most schools during the PJM summer months.

HOU and CF values at space level

Building type	Space type	Hours of use	Utility CF	PJM summer CF	PJM winter CF
All	Auto repair workshop	6189	0.88	0.89	0.61
All	Classroom/lecture	1584	0.24	0.24	0.20
All	Comm/Ind work (General High Bay)	4790	0.90	0.91	0.82
All	Comm/Ind work (General Low Bay)	6775	0.95	0.95	0.77
All	Conference room	1201	0.28	0.30	0.16
All	Corridor/hallways	5670	0.86	0.86	0.73
All	Dining area	2962	0.48	0.53	0.51
All	Exercise centers/gymnasium	4833	0.81	0.82	0.60
All	Kitchen/break room & food prep	3522	0.79	0.74	0.42
All	Library	1957	0.44	0.46	0.31
All	Loading dock	7358	0.97	0.97	0.62
All	Lobby (main entry and assembly)	5947	0.83	0.82	0.71
All	Lobby (Office reception/waiting)	3425	0.84	0.87	0.49
All	Mechanical/electrical room	5026	0.73	0.74	0.46
All	Office (executive/private)	1753	0.42	0.44	0.20
All	Office (general)	3001	0.67	0.67	0.43
All	Office (open plan)	3159	0.81	0.82	0.49

Building type	Space type	Hours of use	Utility CF	PJM summer CF	PJM winter CF
All	Other	3438	0.65	0.64	0.40
All	Outside/outdoor area	3604	0.11	0.11	0.58
All	Parking garage	8678	0.98	0.98	0.99
All	Restrooms	2521	0.48	0.42	0.30
All	Retail sales/showroom	6152	0.97	0.97	0.78
All	Storage (conditioned & refrig/frzr)	4672	0.81	0.81	0.44
All	Storage (unconditioned)	2930	0.66	0.64	0.40

HOU and CF values at building type-space type level

Building type	Space type	Hours of use	Utility CF	PJM summer CF	PJM winter CF
Education	Classroom/lecture	1505	0.21	0.22	0.20
Education	Corridor/hallways	5052	0.77	0.78	0.75
Education	Office (executive/private)	2084	0.42	0.57	0.26
Education	Office (general)	4252	0.66	0.67	0.46
Education	Office (open plan)	2888	0.62	0.70	0.54
Education	Other	2032	0.33	0.34	0.35
Grocery	Other	6027	0.84	0.84	0.82
Grocery	Retail sales/showroom	7374	0.98	0.98	0.93
Grocery	Storage (conditioned & refrig/frzr)	5851	1.00	0.99	0.98

DNV

Building type	Space type	Hours of use	Utility CF	PJM summer CF	PJM winter CF
Health	Corridor/hallways	6191	0.90	0.90	0.77
Health	Other	2964	0.59	0.61	0.41
Office	Corridor/hallways	4092	0.65	0.64	0.71
Office	Lobby (main entry and assembly)	6569	0.93	0.91	0.80
Office	Office (general)	3009	0.70	0.70	0.48
Office	Other	2897	0.70	0.69	0.48
Retail	Lobby (main entry and assembly)	6417	0.99	0.99	0.63
Retail	Office (general)	3175	0.72	0.73	0.40
Retail	Other	4393	0.74	0.74	0.51
Retail	Restrooms	5816	0.94	0.94	0.70
Retail	Retail sales/showroom	5192	0.98	0.98	0.64
Warehouse/Industrial	Auto repair workshop	5482	0.94	0.93	0.49
Warehouse/Industrial	Comm/Ind work (general high bay)	5103	0.92	0.94	0.86
Warehouse/Industrial	Comm/Ind work (general low bay)	7110	0.98	0.98	0.78
Warehouse/Industrial	Office (general)	2868	0.74	0.74	0.36
Warehouse/Industrial	Other	3338	0.71	0.69	0.44
Warehouse/Industrial	Restrooms	4213	0.53	0.53	0.47
Warehouse/Industrial	Storage (conditioned & refrig/frzr)	4530	0.81	0.82	0.40

Precision[18]

HOU and CF relative precision at 90% C.I. at building type level

Building type	N (# of site-spaces)	Hours of use RP	Utility CF RP	PJM summer CF RP	PJM winter CF RP
Education	92	13%	20%	17%	18%
Grocery	23	10%	11%	9%	8%
Health	23	19%	13%	12%	18%
Office	51	17%	9%	10%	11%
Other	207	9%	7%	7%	8%
Retail	57	12%	9%	9%	12%
Warehouse/Industrial	71	9%	7%	7%	10%

HOU and CF relative precision at 90% C.I. at space type level

Building type	Space type	N (# of site-spaces)	Hours of use RP	Utility CF RP	PJM summer CF RP	PJM winter CF RP
All	Auto repair workshop	18	12%	10%	9%	32%
All	Classroom/lecture	28	17%	28%	22%	32%
All	Comm/Ind work (general high bay)	14	13%	14%	10%	14%
All	Comm/Ind work (general low bay)	11	19%	18%	14%	21%
All	Conference room	20	38%	40%	38%	39%

[18] There isn't any text around these tables in the precision appendix of the report.

Building type	Space type	N (# of site-spaces)	Hours of use RP	Utility CF RP	PJM summer CF RP	PJM winter CF RP
All	Corridor/hallways	70	10%	8%	8%	7%
All	Dining area	24	17%	23%	19%	16%
All	Exercise centers/gymnasium	6	33%	27%	25%	21%
All	Kitchen/break room & food prep	42	21%	12%	11%	21%
All	Library	14	26%	30%	25%	27%
All	Loading dock	4	28%	20%	14%	22%
All	Lobby (main entry and assembly)	14	15%	14%	13%	12%
All	Lobby (office reception/waiting)	8	30%	19%	15%	21%
All	Mechanical/electrical room	19	19%	24%	19%	21%
All	Office (executive/private)	43	32%	27%	22%	37%
All	Office (general)	68	14%	9%	9%	13%
All	Office (open plan)	25	14%	15%	11%	15%
All	Other	47	16%	13%	13%	19%
All	Outside/outdoor area	10	18%	137%	152%	11%
All	Parking garage	14	9%	10%	10%	17%
All	Restrooms	50	27%	27%	28%	23%
All	Retail sales/showroom	59	10%	8%	7%	10%

Building type	Space type	N (# of site-spaces)	Hours of use RP	Utility CF RP	PJM summer CF RP	PJM winter CF RP
All	Storage (conditioned & refrig/frzr)	63	16%	12%	11%	20%
All	Storage (unconditioned)	24	23%	15%	14%	24%

HOU and CF relative precision at 90% C.I. at building type-space type level

Building type	Space type	N (# of site-spaces)	Hours of use RP	Utility CF RP	PJM summer CF RP	PJM winter CF RP
Education	Classroom/lecture	19	18%	37%	26%	40%
Education	Corridor/hallways	17	14%	7%	7%	10%
Education	Office (executive/private)	14	33%	26%	18%	80%
Education	Office (general)	10	22%	27%	24%	32%
Education	Office (open plan)	12	18%	26%	28%	29%
Education	Other	20	16%	29%	26%	21%
Grocery	Other	5	30%	26%	26%	22%
Grocery	Retail sales/showroom	15	9%	3%	4%	5%
Grocery	Storage (conditioned & walk-in refrig/frzr)	3	10%	11%	7%	10%
Health	Corridor/hallways	9	24%	16%	15%	22%
Health	Other	14	33%	19%	19%	27%
Office	Corridor/hallways	7	38%	34%	32%	21%

Building type	Space type	N (# of site-spaces)	Hours of use RP	Utility CF RP	PJM summer CF RP	PJM winter CF RP
Office	Lobby (main entry and assembly)	5	34%	17%	22%	26%
Office	Office (general)	19	15%	9%	9%	16%
Office	Other	20	28%	16%	17%	22%
Retail	Lobby (main entry and assembly)	3	34%	2%	1%	24%
Retail	Office (general)	6	37%	34%	34%	39%
Retail	Other	15	20%	14%	13%	20%
Retail	Restrooms	7	30%	28%	28%	29%
Retail	Retail sales/showroom	25	13%	11%	10%	13%
Warehouse/Industrial	Auto repair workshop	8	21%	17%	17%	34%
Warehouse/Industrial	Comm/Ind work (general high bay)	9	20%	23%	14%	27%
Warehouse/Industrial	Comm/Ind work (general low bay)	7	26%	22%	15%	25%
Warehouse/Industrial	Office (general)	7	36%	20%	20%	37%
Warehouse/Industrial	Other	18	22%	15%	14%	16%
Warehouse/Industrial	Restrooms	7	38%	33%	34%	26%
Warehouse/Industrial	Storage (conditioned & refrig/frzr)	15	25%	16%	13%	27%

APPENDIX G. SITE-LEVEL IMPACT RESULTS

Sites highlighted in green are the metering sites. Note that these are “pre-extrapolation” results, so they do not match up with the weighted results in the body of the report.

Table G-1. Site-level impact results

		Retrospective kWh results						
Site ID	Program	Tracking kWh	Doc Adj	Tech Adj	Qty Adj	Op Adj	Interactive Adj	Evaluation savings
S760029886_CLT3	CLT3	22,280	0	0	0	-3,898	0	18,382
S917467013_CLT3	CLT3	4,089	0	0	0	-956	0	3,133
S247484200_CLT3	CLT3	24,125	0	0	0	-12,898	0	11,227
S804440521_CLT3	CLT3	56,731	0	0	0	-27,747	2,647	31,630
S965850000_CLT3	CLT3	64,789	0	0	0	8,621	7,551	80,961
S621964000_CLT3	CLT3	8,394	0	0	0	1,387	231	10,013
S60817641_CLT3	CLT3	145,008	-61,226	28,349	0	9,569	18,270	139,971
S940248100_CLT3	CLT3	19,183	0	3	0	7,912	198	27,297
S716814744_CLT3	CLT3	90,685	0	0	0	-40,506	0	50,180
S965911264_CLT3	CLT3	209,317	0	0	0	106,877	0	316,194
S158078100_SBI2	SBI2	34,728	0	0	0	0	-2,001	32,727
S463835516_CLT3	CLT3	83,137	0	0	0	-2,652	-13,202	67,283
S486332395_CLT3	CLT3	49,982	0	0	0	0	0	49,982
S790080200_SBI2	SBI2	16,434	0	0	0	4,963	0	21,398
S224862976_SBI2	SBI2	44,053	0	0	0	2,996	7,241	54,290
S711334200_CLT3	CLT3	8,559	0	0	0	9,909	0	18,468
S158579100_CLT3	CLT3	82,635	0	0	0	13,166	-17,028	78,773
S729774200_CLT3	CLT3	73,176	-47,521	35,488	0	6,049	10,753	77,946
S60975578_SBI2	SBI2	28,832	0	0	-721	8,707	0	36,819
S252432000_CLT3	CLT3	112,431	0	0	0	17,913	-8,385	121,959
S796420200_SBI2	SBI2	7,146	0	-590	0	1,420	-786	7,189
S324040200_CLT3	CLT3	11,918	0	-145	0	985	1,682	14,440
S178194200_SBI2	SBI2	51,400	0	-12,392	0	9,467	6,953	55,428
S78874200_CLT3	CLT3	143,944	0	0	0	73,497	0	217,441
S317320347_CLT3	CLT3	22,187	0	0	0	3,228	-5,661	19,754
S559185200_SBI2	SBI2	4,325	0	0	0	1,306	0	5,631
S685181000_CLT3	CLT3	49,892	0	0	-590	7,259	54	56,615
S20935200_CLT3	CLT3	8,322	0	0	0	-712	0	7,610
S400065652_CLT3	CLT3	664,144	0	180	0	183,383	55,176	902,883
S70253877_CLT3	CLT3	193,016	0	0	0	98,554	0	291,569
S215432100_CLT3	CLT3	75,366	0	0	0	0	-4,922	70,444
S254126000_CLT3	CLT3	27,578	0	-337	0	1,876	-1,075	28,042
S599712223_CLT3	CLT3	3,957	0	0	-1,979	-339	0	1,640
S458812000_CLT3	CLT3	17,545	0	0	0	3,882	0	21,427

		Retrospective kWh results						
S759440200_CLT3	CLT3	18,885	0	0	0	1,561	2,454	22,900
S100612200_CLT3	CLT3	24,262	0	0	0	0	0	24,262
S270284200_CLT3	CLT3	6,617	0	0	0	0	0	6,617
S144835000_SBI2	SBI2	66,966	0	0	0	15,126	2,526	84,617
S481935000_SBI2	SBI2	96,645	0	0	0	47,284	309	144,238
S273835000_SBI2	SBI2	6,249	0	0	0	517	-470	6,296
S480935000_SBI2	SBI2	987	0	0	0	82	-74	994
S799941200_SBI2	SBI2	6,371	0	0	0	1,015	335	7,721
S25531200_SBI2	SBI2	3,902	0	0	0	0	621	4,524
S467288100_CLT3	CLT3	3,004	0	0	0	-38	0	2,966
S78782345_CLT3	CLT3	58,379	0	-25,302	0	-9,435	-885	22,757
S105679736_CLT3	CLT3	30,643	0	0	0	6,780	0	37,423
S982431200_SBI2	SBI2	21,624	0	0	0	0	0	21,624
S17531200_SBI2	SBI2	16,578	0	0	0	0	0	16,578
S912949100_CLT3	CLT3	6,159	0	0	0	3,886	0	10,045
S475042433_CLT3	CLT3	5,164	0	0	0	3,258	0	8,422
S205125222_CLT3	CLT3	10,516	0	0	0	-900	0	9,617
S634664761_CLT3	CLT3	528,109	0	0	0	163,543	50,311	741,963

APPENDIX H. PERSISTENCE STUDY SAMPLING METHODOLOGY

Approach

Sample design

The proposed sample design aimed to collect sufficient measure persistence data to develop effective useful life (EUL) estimates for the lighting measures. The lighting program is dominated by LEDs, which account for 93% of savings.

Technology	Number of measures	Savings (kWh)	% of Program savings
CFLS	36	469,741	0.1%
LED LAMPS	27,365	371,528,411	92.9%
OCCUPANCY SENSORS	1,458	10,535,822	2.6%
T8/T5 LAMPS	1,031	17,504,561	4.4%

To estimate measure persistence, the study employed a method referred to as a "survival analysis." For a survival analysis, it is necessary to have data collected over a range of installation years to model at what age measures stop working. For the sample design, age bins of 1-2 years, 3-5 years, 6-7 years, and 8 years were defined. For the 1-2 year age bin, strata sites from the impact analysis of the CLT3 and SBI2 were also leveraged for the persistence study. For all other age bin strata, a separate sample from the CLT2 and SBIP programs was selected.

Apart from the age of the measure, occupancy sensors are identified to have different characteristics than the lighting measures of bulbs, so explicit domains were created for measures with occupancy sensors and those without. A domain was also created to separate projects by CLT2/SBIP program consistent with what was done for the impact analysis. Within each age bin, occupancy sensor, and program, the domain of the sample was stratified by gross savings. Table 5-4 presents the sample design summary including strata cut-point, accounts, total energy savings, and number of sample points.

Table 5-4. Persistence sample design stratification for installation age of 3 or more years

Program	Installed age	Measure type	Stratum	Maximum	Accounts	Energy savings (kWh)	Sample
CLT2	3 to 5 yrs	OCC SENSOR	1	143,299	290	12,455,466	3
		OCC SENSOR	2	3,419,860	40	21,611,600	3
		OTHER	1	40,540	1126	16,352,348	5
		OTHER	2	96,849	328	21,040,604	5
		OTHER	3	209,356	175	24,743,901	5
		OTHER	4	353,882	100	28,080,815	5
		OTHER	5	4,452,235	49	35,415,928	4
	6 to 7 yrs	OCC SENSOR	1	268,525	378	10,815,663	4
		OCC SENSOR	2	2,509,460	28	19,052,779	3
		OTHER	1	32,204	1302	13,105,121	5
		OTHER	2	59,702	364	16,902,436	5
		OTHER	3	102,794	242	18,780,460	5
		OTHER	4	229,358	146	21,294,656	4
		OTHER	5	1,637,797	60	27,490,301	4
	8 yrs	OCC SENSOR	1	557,348	2	670,796	2
		OCC SENSOR	2	1,833,900	1	1,833,900	1
		OTHER	1	22,784	72	504,025	4
		OTHER	2	57,370	17	705,001	4
		OTHER	3	100,947	10	790,264	3
		OTHER	4	199,360	7	932,295	3
		OTHER	5	342,892	3	1,010,310	3
SBIP	3 to 5 yrs	OTHER	1	27,030	807	10,246,783	4
		OTHER	2	66,976	308	12,664,268	3
		OTHER	3	4,684,075	117	18,298,595	3
	6 to 7 yrs	OTHER	1	15,289	13	127,661	3
		OTHER	2	19,059	8	140,028	3
		OTHER	3	75,426	5	187,857	3
		OTHER	4	239,558	1	239,558	1

About DNV

DNV is a global quality assurance and risk management company. Driven by our purpose of safeguarding life, property and the environment, we enable our customers to advance the safety and sustainability of their business. We provide classification, technical assurance, software and independent expert advisory services to the maritime, oil & gas, power and renewables industries. We also provide certification, supply chain and data management services to customers across a wide range of industries. Operating in more than 100 countries, our experts are dedicated to helping customers make the world safer, smarter and greener.

Appendix L

Residential Smart Cooling Rewards Program Impact Evaluation

Dominion Energy

Date: April 6, 2023

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DNV

EXECUTIVE SUMMARY

This report presents the load impacts of the 2022 Residential AC Cycling Program, marketed to customers as Smart Cooling Rewards and administered by Dominion Energy (the Company) in Virginia and North Carolina. The Smart Cooling Rewards program closed on December 31, 2022. The AC Cycling Program has been operating for 13 years, enrolled 166,461 customers during that time, and at peak participation in June 2016, provided 104,783 kW of summer demand reduction potential. Over the course of the program there were 278 events called representing 855 event hours.

The results presented here represent the impacts realized by approximately 59,400 customers during the summer of 2022. Some customers from the 2021 analysis have transitioned to the demand response Smart Thermostat Rewards Program and this trend is expected to accelerate following program closure.

In 2022, the evaluated load impact for weather conditions observed during Dominion Energy's peak day conditions was 0.49 kW per participant.

Program background

When an AC Cycling demand response event (event) is initiated by Dominion's supply department, a one-way radio frequency (RF) paging signal is broadcast to load curtailment switches installed on central air conditioners (AC) and heat pumps of participating residential customers. The load curtailment switch reduces the duty cycle of the registered AC units by up to 50% during an event. DNV evaluates the AC Cycling Program annually. In 2022, the AC Cycling Program called 23 events over 67 event hours that were distributed across June (6), July (10), and August (7).

Project objectives

The objectives of the evaluation are:

1. To estimate the average kW impacts of demand reduction for each event hour (ex post analysis)
2. To forecast the kW impacts by event hour delivered by the AC Cycling resource in varying temperature and humidity conditions including the Company's summer peak planning conditions

This report summarizes the event history between 2018 and 2022, reviews the 2022 event impacts across the Company's service areas, and presents the results of the hourly ex post and ex ante impact analyses. It also presents sample event-day plots showing the hourly progression of events with high and low impacts and discusses the weighting strategy that allocates impacts calculated for advanced metering infrastructure (AMI) to non-AMI participants.

Key findings

- In 2022, the per-participant demand reduction is forecast to be 0.49 kW at the Company's peak planning conditions.
- Ex post impacts over the 67 event hours in 2022 ranged from 0.30 kW to 0.64 kW per participant. The lowest average event impact occurred on June 30 and the highest occurred on August 4 and August 10. Load profiles for a high and low case are shown in Figure 4-2 and Figure 4-3.
- The proportion of AMI to total participants increased from 10% in 2020 to 27% in 2021 and to 63% in 2022 due to the accelerated deployment of AMI meters in 2021 and 2022. As a result, the number of accounts included in the regression analysis has quadupled since 2020 with most of the expansion in occurring in the Central and Eastern Divisions.

1 INTRODUCTION

This report summarizes the event history from 2018–2022, reviews event participation in 2022, and presents the results of the ex post and ex ante impact analyses. It also presents sample event-day plots for events with high and low impacts, hourly impact estimates, and modeled impacts for varying weather conditions and times of day.

The AC Cycling event season spans June 1 through September 30 on non-holiday weekdays.[1] Events typically last between two and four hours. In 2022, the first event occurred on June 1 and the last occurred on August 30. Under the program, when AC Cycling events are called, a one-way RF paging signal is broadcast throughout the Company's service area. The signal is received by load curtailment switches installed on central ACs and heat pumps of participating residential customers. The dispatch of the RF signal to the load curtailment switch reduces the duty cycle of the registered AC units by up to 50%.

When the AC Cycling Program was launched in 2010, the estimated impacts were based on a statistical regression model of consumption data from other utilities in the region. Since 2011, the modeled impact estimates have used site-level interval data from AMI meters, AC switch control data from the implementer, and customer-specific weather data. In compliance with the order from the Virginia State Corporation Commission (the Commission), the sampling strategy transitioned from a random sample of participants with AMI meters to using consumption data from every AMI-enabled AC Cycling participant.[2]

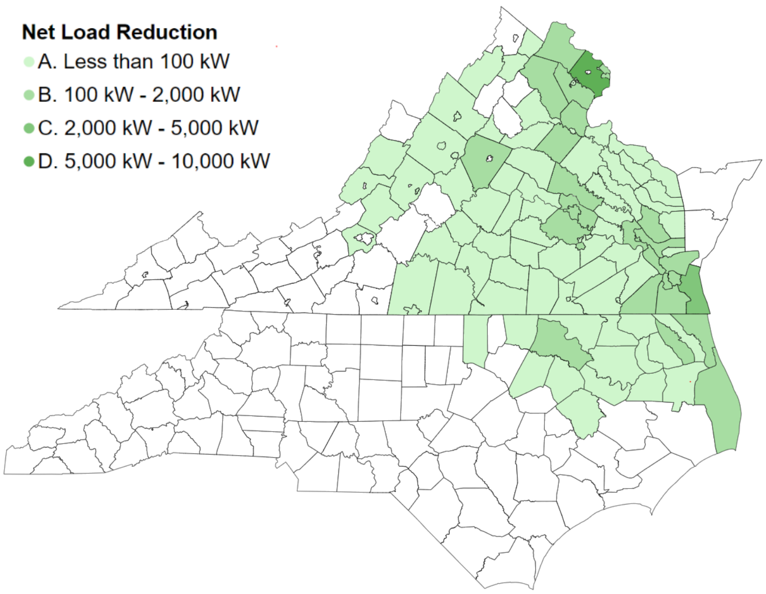
In 2022, 37,182 (63%) of all participants were AMI-enabled and included in the analysis. This is a substantial increase over the 27% sample in 2021. The effect of this larger analysis sample is discussed in more detail later in the report.

Figure 1-1 shows the amount of AC Cycling demand reduction potential as of December 31, 2022. As with the Company's energy efficiency programs, the Virginia regions with the highest demand reduction potential are Northern Virginia, Virginia Beach/Norfolk, and Richmond.

[1] Events may be called after September 30 under extenuating circumstances.

[2] Required as part of the Final Order, State Corporation Commission of Virginia, Case #PUE-2015-00089, April 19, 2016.

Figure 1-1. DR Potential (kW) for AC Cycling Participants in Virginia and North Carolina as of December 31, 2022



Understanding why results change from year to year is difficult without additional in-depth analysis because although the relationships between temperature, humidity, and demand reduction are strong, other factors drive demand reduction. Long hot periods and/or stretches of consecutive event days affect AC usage and the response to events. Conversely, a single hot day during an otherwise cool period also produces different demand reductions. Because demand reduction is a function of both the amount of cooling demanded at the time of an event (i.e., potential demand reduction) and the customer response (i.e., the customer turning on their AC equipment), the complex relationship between demand reduction, long-term temperature trends, and event schedules is difficult to predict from event to event or season to season. To further complicate matters, there are unknown effects of the protracted Covid-19 pandemic.

2 2022 AC CYCLING EVENTS AND PARTICIPATION

AC Cycling event seasons are distinguished from year to year by the number of events, the number of controlled hours, and the number of controlled participants. This section summarizes the 2022 events, including event hours (Table 2-1) and the number of controlled participants. Data from prior years are provided for comparison.

Table 2-1. Summary of 2019–2022 Events

	2019	2020	2021	2022
Number of events	23	20	25	23
Controlled event hours	66	56	71	67

2.1 Frequency

There were 23 events spanning a total of 67 hours in the summer of 2022. This is two fewer events and four fewer hours than was called in 2021. The 23 events were spread across June (6), July (10), and August (7).

2.2 Participation

Approximately 59,400 participants (accounts) and 62,400 AC and heat pumps were controlled in 2022. The number of participants dropped approximately 8% from 2021 due to attrition, partially influenced by participants that migrated to the new Smart Thermostat Rewards Program or joined the "1G TOU Rate."[3]

Before 2021, AMI data was available for approximately 10% of participants and has since quadrupled to 57% in 2022. The distribution of AMI across the service territory has also improved. Up through 2020, almost 90% of all AMI data came from the Northwest Division, but in 2022, 53% of AMI data was from the Eastern Division and 24% from the Central Division. See Appendix II, Table II-6 for an expanded view of all participants relative to AMI participants by division.

[3] 190 AC Cycling participants transitioned to the Smart Thermostat Rewards Program and 71 joined the 1G TOU Rate, rendering them ineligible to participate in either AC Cycling or Smart Thermostats Rewards.

3 IMPACT ANALYSIS

The following sections describe the consumption, tracking, and weather data, the evaluation methodology, and the ex post and ex ante results. The ex post impact analysis describes what happened during the 2022 event season. The ex ante analysis predicts impacts under a variety of conditions based on demand reduction in the ex post analysis (or what occurred during the 2022 events).

The ex post analysis estimates per-participant kW impacts (demand reduction) realized at the end of each event hour for each event and reports the time the event begins and ends, along with the length of each event (Section 4.2).

The ex ante analysis uses the kW impacts of the ex post analysis to forecast kW impacts by hour, temperature, and humidity conditions (Section 4.3). For example, 0.49 kW is the estimated impact from a demand response event for the Company's peak planning conditions, which are 95°F and 43% RH at 17:00.[4]

3.1 Data

Four sources of data are used in the impact analysis:

1. **AMI data**: Half-hourly whole-house consumption data collected from customer AMI meters
2. **Event control data**: A record of controlled participants for each event provided by the implementer, including opt-outs
3. **Tracking data**: Program tracking data is used to link the customer to their consumption data and to confirm that switch control records match the Company's list of active participants.
4. **Weather data**: Hourly temperature and humidity data collected at the weather station designated by the company for the account address[5]

Descriptions and results of the data quality control (QC) procedures are provided in Appendix I.

3.2 Methodology

The following steps are used to calculate demand reduction impacts for the program:

1. DNV receives and performs QC on 30-minute interval data for each participant.
2. AMI data are merged with the event control data provided by the implementer.
3. Using AMI data, event control data, and weather data, regression analysis is used to predict event-day baseline consumption for each controlled AMI-enabled account.
4. To ensure that the AMI population is representative of the program population, the AMI accounts are assigned weights based on state, connected load, and location. The weighting method and final weights for the June 1, 2022 event are included in Appendix II.

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[4] Dominion Energy's peak planning condition is hour-ending 17 at 95°F at 43% RH, or 83.4 THI. Temperature Humidity Index = THI = Td – (0.55 – 0.55*RH) * (Td – 58) where Td is dry bulb temperature and RH is relative humidity. Source: PJM Glossary: http://www.pjm.com/Glossary.aspx

[5] National Oceanic and Atmospheric Association (NOAA), National Centers for Environmental Information, Climate Data Online.

5. The predicted and actual consumption for AMI-enabled accounts is weighted to the full program population and the difference between baseline predicted consumption and actual consumption is the calculated ex post impact. The results of the ex post analysis are provided in Section 4.1.
6. Ex ante estimates are then calculated using a regression analysis of the ex post impacts for each event-hour as the dependent variable and temperature humidity index (THI) as the independent variable. Ex ante results are the predicted impacts for each event hour and THI and are used to estimate the program impacts at the Company's peak planning conditions. The ex ante results are provided in Section 4.3.

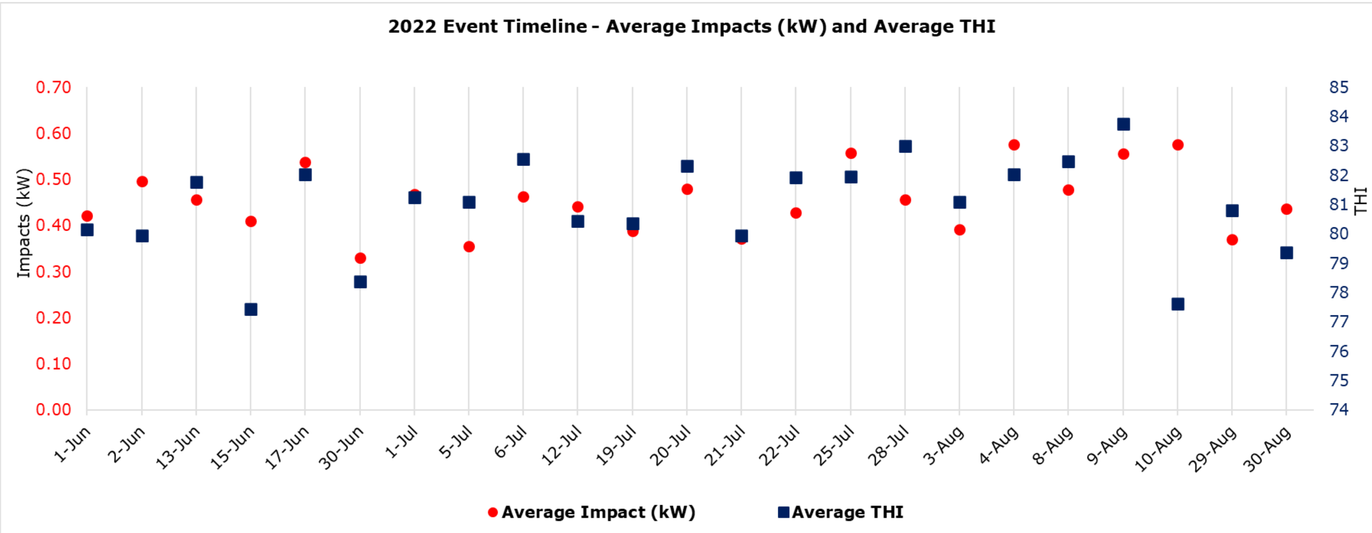
4 RESULTS

This section presents the results of the 2022 ex post and ex ante analyses. Figure 4-1 is a seasonal timeline showing the impacts and THI for each event. Figure 4-2 and Figure 4-3 show event-level plots illustrating the event days with the highest and lowest impacts. Table 4-1 and Table 4-2 show the ex post impacts calculated for each event hour.

4.1 Ex post impacts

The 2022 timeline in Figure 4-1 shows the average impact (in kW) and maximum THI for each event. In general, higher THI events are associated with higher kW impacts, and lower THI events are associated with lower kW impacts because of the relationship between temperature and cooling demand.

Figure 4-1. Timeline of 2022 Events by Average Impacts (Red) and Maximum Event-day THI (Blue)



4.1.1 Event-day plots

The ex post plots in Figure 4-2 and Figure 4-3 on the following pages illustrate events with relatively high and low impacts, respectively. The plots are described briefly below.

The ex post estimate, or the load reduction that occurred during the event, is the difference between the adjusted baseline during the event (solid red line) and the load (blue line). Impacts are calculated for each event hour and the hour ending time (HE) is used to refer to specific intervals. Impacts are estimated by calculating the difference between the adjusted baseline load and the actual load during the event. The results are illustrated in time-series representations of:

- ***Event-day load profile for the AC Cycling Program participant population (solid blue line).*** The beginning of the event is clearly visible as a decrease in load and is typically followed by a post-event load spike (snapback or rebound) before the load resumes to non-event levels.
- ***Reference load outside the event (thin red line).*** This line plots the baseline load profile before and after the event taken from participant AMI data. The baseline is modeled from the non-event days and represents the estimated load for that day in the absence of an event.

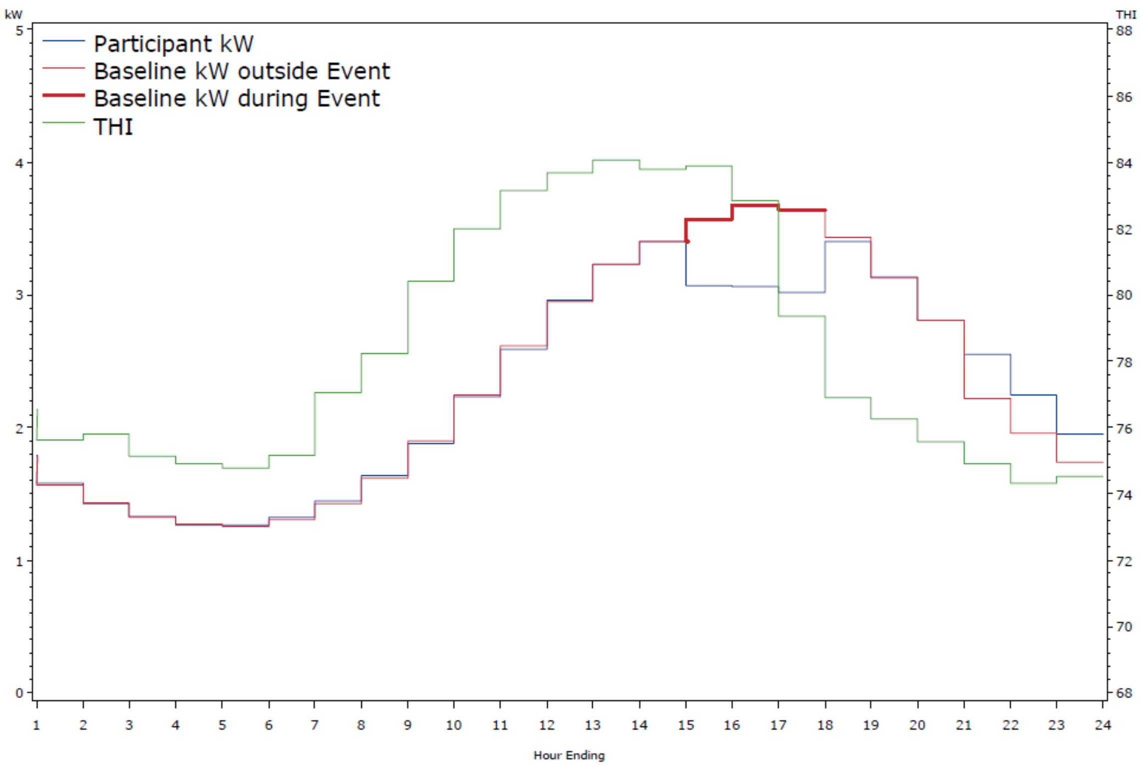
- ***Baseline during the event (thick red line)***. The thick red line plots the baseline for the event-day load curve during the event. The baseline during the event hours is adjusted to account for overpredicting or underpredicting actual consumption on event days.
- ***Event-day THI* (green line)**. Hourly THIs are plotted to give context to the load curves and the relationship between load, temperature, and humidity.

Load Profile with High Impacts

The highest per-event impacts occurred on August 4, 2022, and August 10, 2022, with both events having an average impact of 0.58 kW. The August 4, 2022 event contained one of the highest weighted THI values (84) of the event season at 14:00 and was also the second event day in a row.

The event was called at 15:00 with demand reduction clearly visible as the gap between the red and blue lines at hours ending 16, 17, and 18 (Figure 4-2). The estimated average impact was 0.58 kW per participant. For a future comparison with the following low-impact event, the baseline consumption at the start of this high-impact event was approximately 3.4 kW probably because of the high cooling load associated with the high THI conditions.

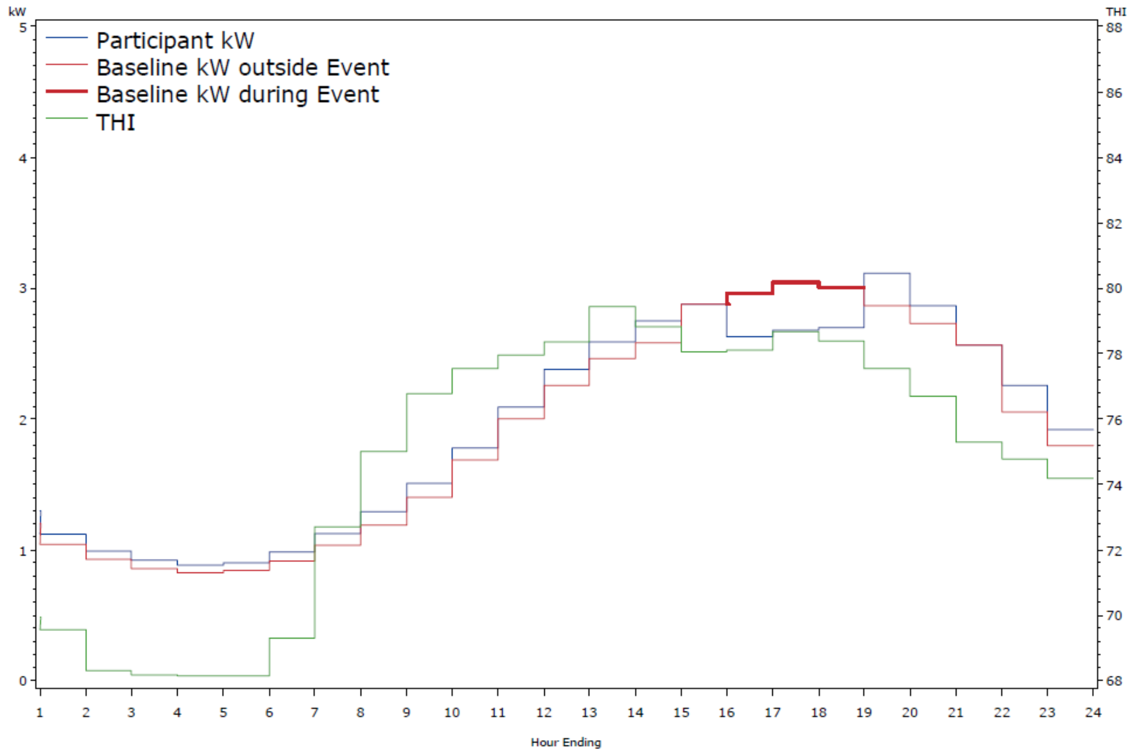
Figure 4-2. Load Profile for the Event Day with the Highest Impacts (August 4, 2022)



Load Profile with Low Impact

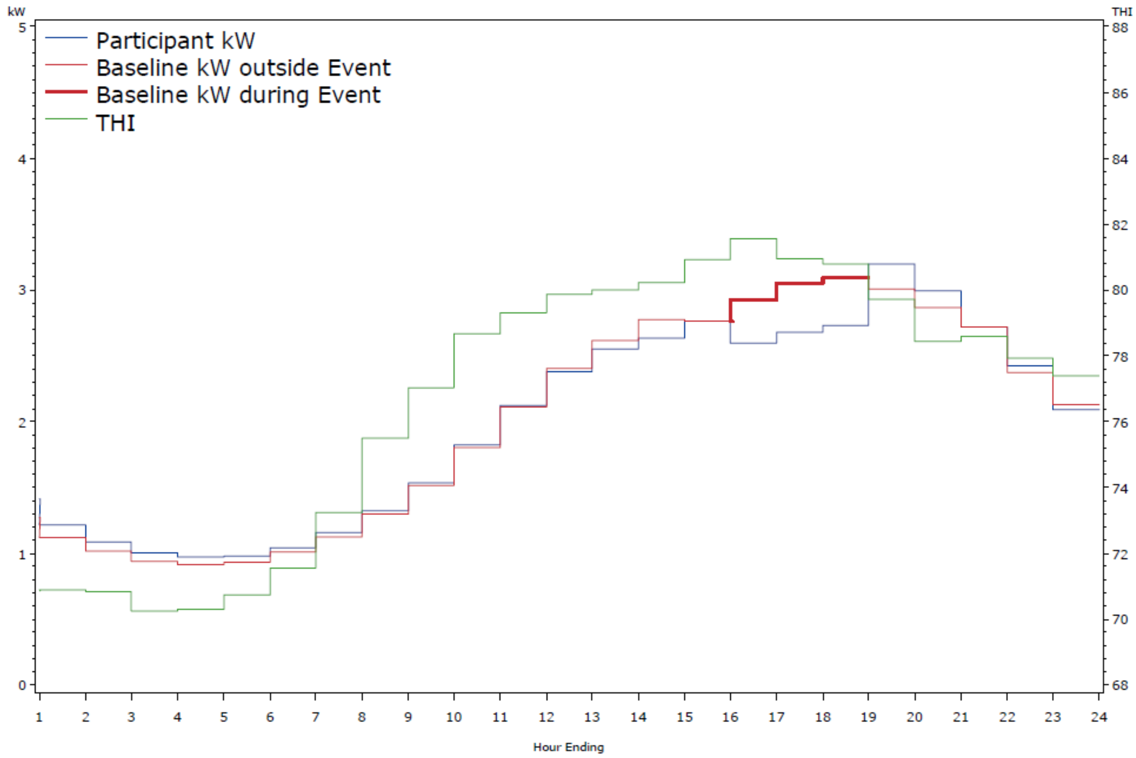
The lowest event impact for 2022 occurred on June 30, 2022, the event day with the second-lowest event-average THI (78). The event was called at 16:00 with demand reduction clearly visible at hours ending 17, 18, and 19. The estimated average impact across event hours was 0.33 kW per participant. This was the first in a two-day series of events. Weighted THI was low during the morning and peaked at 79.43 at HE 14. In this low case, the baseline consumption at the beginning of the event was 2.88 kW at HE16

Figure 4-3. Load Profile for the Event Day with the Low Impacts (June 30, 2022)



The second lowest average event impact occurred on July 5. Similar to the June 30 event, THI was relatively low during the morning of July 5 and increased to 80.93 for HE 16. In the last hour before the event (HE16), the average customer load was approximately 2.76 kW.

Figure 4-4. Load Profile for an Event Day with Low Impacts (July 5, 2022)



4.2 Ex post impacts

Ex post impacts by day and hour are presented in Table 4-1 and Table 4-2. Also shown are the maximum recorded event day THIs, Richmond daily high temperature (ºF), the opt-out percentage, and a day number indicating the event's order for consecutive event days.[6]

The events with the highest average impact (0.58 kW) occurred on August 4 and August 10, and the lowest (0.33 kW) on June 30. The maximum impact for a single interval in 2022 was 0.64 kW on July 25. The average opt-out percentage for 2022 was 0.01% and the maximum number of opt-outs for any given single event were 18 out of 61,869 switches.

Table 4-1. AC Cycling Impacts by Event-Day and Hour (June 1 through July 22, 2022)

Event Date	1-Jun	2-Jun	13-Jun	15-Jun	17-Jun	30-Jun	1-Jul	5-Jul	6-Jul	12-Jul	19-Jul	20-Jul	21-Jul	22-Jul
Consecutive Event-days		2					2		2			2	3	4
Opt-out Percentage	0.02%	0.02%	0.01%	0.01%	0.03%	0.00%	0.01%	0.00%	0.01%	0.01%	0.01%	0.00%	0.02%	0.02%
Weighted Average THI Across Event Hrs	80	80	82	77	82	78	81	81	83	80	80	82	80	82
Richmond Daily High Temp	95	94	95	89	96	88	91	90	93	93	92	95	95	94
HE15		0.42												
HE16	0.40	0.51			0.48		0.43		0.41			0.42		0.38
HE17	0.43	0.55	0.43	0.40	0.56	0.33	0.48	0.33	0.48	0.38	0.39	0.51	0.36	0.45
HE18	0.44		0.48	0.44	0.57	0.36	0.49	0.37	0.50	0.47	0.40	0.51	0.38	0.46
HE19			0.46	0.39		0.30		0.37		0.47	0.37			
Average Impact (kW)	**0.42**	**0.50**	**0.46**	**0.41**	**0.54**	**0.33**	**0.47**	**0.36**	**0.46**	**0.44**	**0.39**	**0.48**	**0.37**	**0.43**

Table 4-2. AC Cycling Impacts by Event-Day and Hour (July 25 through August 30, 2022)

Event Date	25-Jul	28-Jul	3-Aug	4-Aug	8-Aug	9-Aug	10-Aug	29-Aug	30-Aug
Consecutive Event-days				2		2	3		2
Opt-out Percentage	0.02%	0.01%	0.01%	0.01%	0.02%	0.02%	0.02%	0.00%	0.01%
Weighted Average THI Across Event Hrs	82	83	81	82	82	84	78	81	79
Richmond Daily High Temp	94	95	94	95	93	95	92	92	94
HE15	0.45								
HE16	0.59			0.50	0.44	0.48	0.51	0.34	0.37
HE17	0.64	0.44	0.38	0.61	0.49	0.59	0.63	0.38	0.47
HE18		0.47	0.41	0.62	0.51	0.60	0.60	0.39	0.47
HE19			0.38						
Average Impact (kW)	**0.56**	**0.46**	**0.39**	**0.58**	**0.48**	**0.56**	**0.58**	**0.37**	**0.44**

[6] The THI reported in Tables 5-1 and 5-2 is the AMI participant THI at the NOAA weather station designated by the Company, weighted to the population of AC Cycling participants and averaged across the event hours.

4.3 Ex ante impacts

The primary metric of the impact analysis is the ex ante impact estimate for the program year for the Company's peak planning conditions. The ex ante analysis models event impacts for a range of THI values and event hours by fitting a regression model of the ex post impacts for each of the event hours ending 15, 16, 17, 18, and 19, with a weighted customer-specific THI as a predictor variable. Using the regression parameters from the HE 17 model and 83.4 as THI, the ex ante impact for the Company's peak planning conditions was estimated to be 0.49 kW. Like prior years, the 2022 ex ante model was based solely on 2022 ex post impacts.

Table 4-3 shows the predicted kW per participant impacts from the regression models for event hours ending at 15, 16, 17, 18, and 19, across a range of THIs. The predicted impact of 0.49 kW at the Company's peak conditions of 83.4 THI falls within the thick-bordered box at HE17.

Table 4-3. Ex Ante Per Participant Impacts by THI and Hour Ending (2022)

THI	HE15	HE16	HE17	HE18	HE19
76	0.38	0.34	0.34	0.35	0.37
77	0.39	0.36	0.36	0.37	0.38
78	0.40	0.38	0.38	0.39	0.38
79	0.41	0.40	0.40	0.42	0.39
80	0.42	0.41	0.42	0.44	0.39
81	0.43	0.43	0.44	0.46	0.40
82	0.44	0.45	0.46	0.49	0.41
83	0.45	0.46	0.49	0.51	0.41
84	0.46	0.48	0.51	0.53	0.42
85	0.47	0.50	0.53	0.56	0.42
86	0.48	0.52	0.55	0.58	0.43
87	0.49	0.53	0.57	0.60	0.43
88	0.50	0.55	0.59	0.63	0.44

APPENDIX I. AC CYCLING EVALUATION DATA

AMI data – quality control

Four sources of data are used in the impact analysis:

1. Half-hourly AMI customer consumption data
2. A record of controlled participants for each event
3. Program tracking data
4. Regional weather data.

A series of QC procedures are performed on the AMI data and the event control logs. This section describes these QC procedures that include a review of the AMI data and a cross-reference between the account level AMI data, the implementers' event control logs, and Dominion Energy's business intelligence (BI) data.

The following specific conditions must be met for a participant to be included in the impact analysis:

- AMI accounts must include consumption data for the event season, June 1st through August 30th.
- An AMI account must be associated with a corresponding account in the event control log.
- An account in the event control log must be associated with an active participant in the BI data.

The event control log lists all dispatched accounts and the start and stop times of the event. Only dispatched participants are included in the event control log. A participant will not be included if they opted out of an event or were not dispatched during a partial-dispatch event. However, there were no partial-dispatch events in 2022.

QC results

Table I-4 summarizes QC results for the AMI data.

Table I-4. Attrition of participant AMI data (2022)

Data Prep	Number of Accounts
Participant AMI accounts	38,342
Data out of range or missing intervals	-26
Number of accounts that appeared in the AMI data before June 1, 2022, only, or after September 30, 2022, only	-1,107
Accounts removed because the AMI and event data did not overlap (new AMI meters)	-27
Accounts included in the analysis	37,182

APPENDIX II. EXTRAPOLATING THE AMI-ENABLED ACCOUNT IMPACTS TO THE PROGRAM POPULATION

The distribution of the AMI participants (the sample for analysis) among divisions and connected loads is not a random sample of the participant population. However, the AC Cycling AMI sample increased from 10% in 2020 to 27% in 2021 to 57% for the first event in 2022 of all participants because of the accelerated deployment of AMI meters across Dominion's service territory.[7] To extrapolate the AMI account impacts on the participant population, the AMI-enabled accounts are assigned weights based on their division and connected load relative to all participants in the population. The distribution of AMI-enabled participants to all participants by division is shown in Table II-5.

Table II-5. Total and AMI Participants by Division[8]

Division	Total Participants by Division	AMI Participants by Division	Percentage AMI by Division
Eastern	23,648	17,812	53%
Northwest	19,193	6,938	21%
Central	14,148	8,973	27%
North Carolina	2,384	88	0%
Total	**59,373**	**33,811**	

The weights assigned to the AMI-enabled group for the June 1 event are listed in Table II-6. The weights are unique to each event to reflect slight differences in participation levels. The weight can be understood as the number of program participants represented by each account in the AMI group. The following steps were taken to build the 2022 weights:

1. Construct a list of all event participants by division and connected load. The program tracking BI data is the source of the division and connected loads.
2. Stratify the participants based on state, division, and connected load.
3. Calculate weights based on the number of AMI participants for each event relative to all participants within each stratum.[9]

[7] Due to the non-random sample of AMI meters in the analysis, the Company commissioned a customer load modeling analysis, a new recruit trend study, and a non-AMI comparison. In turn, all were included in the Final Order of the State Corporation Commission on April 19, 2016. The results of these studies are found in the 2016 evaluation of dispatch events.

[8] The table shows total participants and AMI participants in the first event on June 1, 2022. Although 37,182 AMI accounts are included in the overall analysis only 33,811 participated on June 1, 2022.

[9] The weight within each stratum is the population divided by the total number of AMI meters in the study group.

Table II-6. Weights by State, Division, and Connected Load for June 1, 2022

State	Division	Load (kW)	No. AMI meters	No. Participants	Weight
VA	Northwest	Not Available	1,001	4,750	4.75
VA	Northwest	< 4kW	3,451	8,033	2.33
VA	Northwest	≥4kW	2,486	6,410	2.58
VA	Eastern	Not Available	3,449	4,361	1.26
VA	Eastern	< 4 kW	9,381	12,476	1.33
VA	Eastern	>= 4 kW	4,982	6,811	1.37
VA	Central	Not Available	1,037	1,849	1.78
VA	Central	< 4kW	4,975	7,525	1.51
VA	Central	≥4kW	2,961	4,774	1.61
NC	NC	< 4kW	38	1,462	38.47
NC	NC	≥4kW	50	922	18.44
		Total	**33,811**	**59,373**	

About DNV

DNV is a global quality assurance and risk management company. Driven by our purpose of safeguarding life, property, and the environment, we enable our customers to advance the safety and sustainability of their business. We provide classification, technical assurance, software, and independent expert advisory services to the maritime, oil & gas, power, and renewables industries. We also provide certification, supply chain and data management services to customers across a wide range of industries. Operating in more than 100 countries, our experts are dedicated to helping customers make the world safer, smarter, and greener.

Appendix M

Non-Residential Distributed Generation Program Impact Evaluation

Dominion Energy

February 13, 2023

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EXECUTIVE SUMMARY

This report presents the results of the annual impact analysis of Dominion Energy Virginia's (the Company's) Non-residential Distributed Generation (DG) Program for 2022.

In 2022, the program achieved an overall realization rate of 104%, exceeding the 95% target

The program began in June 2012 with the objective of curtailing peak load during periods of high demand. The Company calls upon participating large non-residential customers to provide it with a supply resource by operating backup power to curtail load on the grid. Customers must meet specific eligibility requirements to participate in the program and receive an incentive from the Company in exchange for their participation.

The three objectives of the impact analysis are to:

- Compute the aggregate and site-level curtailed load, in kilowatts (kW), for each event hour and event day
- Compute program realization rates annually, seasonally, and for each event interval by comparing dispatched generation to measured generation
- Report monthly program performance and planned values

From January 1, 2022, to December 31, 2022, the program achieved a winter realization rate of 57% and a summer realization rate of 114%, resulting in an overall realization rate of 104% (shaded area), exceeding its planned realization rate of 95%. Monthly realization rates ranged from 57% in December to 116% in July.

Figure ES-1. Non-residential DG seasonal realization rates by year, 2014–2022

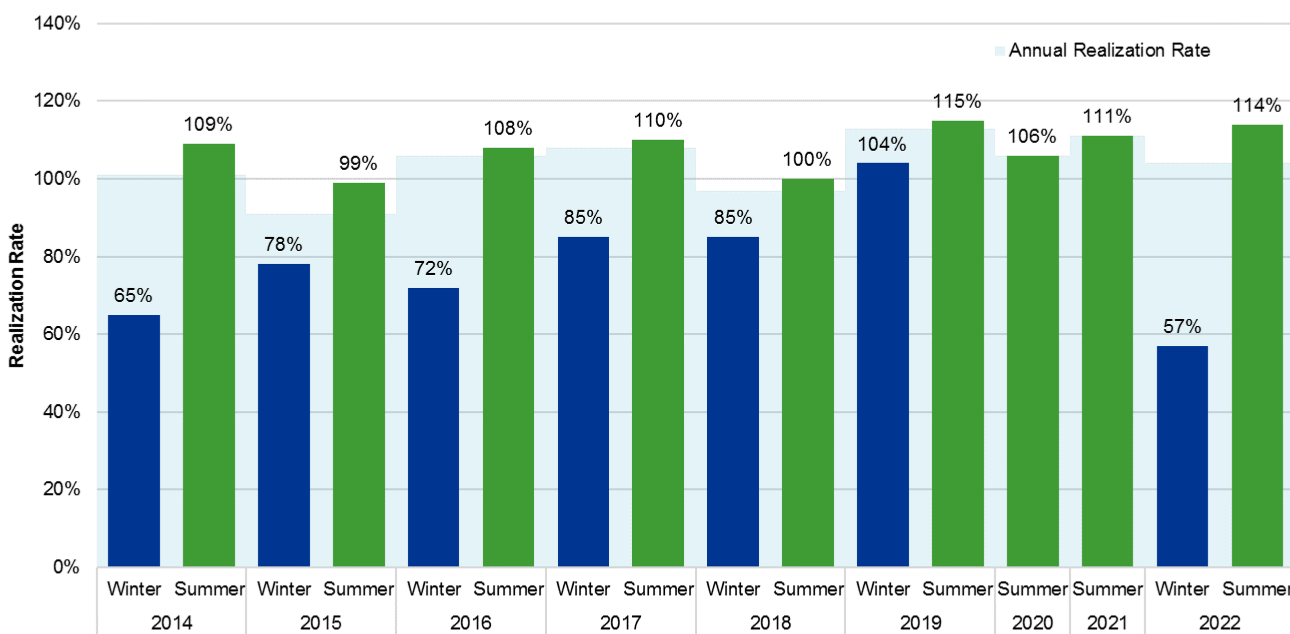


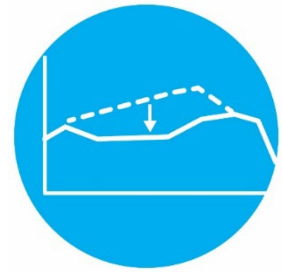
Table ES-1 shows DG Program performance and planned values for 2022. The table provides the planned and actual participants in megawatts (MW), and the average dispatched and measured generation in kW.

Table ES-1. DG program performance for 2022 events

2022	Planned (MW)	Enrolled (MW)	Net kW planned	Net kW enrolled	Event days	Average dispatched (kW)	Average generation (kW)	Average realization rate
May	7.13	5.88	7,130	5,880	2	5,500	6,102	111%
June	7.13	5.88	7,130	5,880	6	5,297	5,900	111%
July	7.13	5.88	7,130	5,880	13	4,609	5,342	116%
August	7.13	5.88	7,130	5,880	7	3,640	4,103	113%
September	No Events							
October	No Events							
November	No Events							
December	7.13	5.88	7,130	5,880	2	5,782	3,284	57%

1 INTRODUCTION AND BACKGROUND

The Virginia State Corporation Commission approved the Non-residential Distributed Generation (DG) Pilot Program on January 17, 2008. The DG Pilot achieved program status on April 30, 2012. In September 2021, the DG program was extended for an additional two years through May 31, 2024.[1]



Large non-residential customers with at least 200 kW of demand are eligible to participate in the program. Dominion Energy may initiate a control event at any time during the year for any duration up to a total of 120 hours per calendar year, subject to the physical constraints and environmental permitting requirements of the backup generation unit. The Company will pay an incentive payment each month based on the amount of load curtailment enrolled and delivered during control events. As of December 31, 2022, there were 21 enrolled sites, representing a resource potential of 5.88 MW to the Company.

Details of the DG program are as follows:

- A participant is defined by their enrolled capacity, and one participant equals 1,000 kW of enrolled generation. A customer with greater than 1,000 kW of enrolled capacity is counted as more than one participant.[2] The level of incentive corresponds with the kW of enrolled generation capacity.
- Participating customers are compensated if the average annual measured on-site generation is at least 95% of the dispatched target generation for each event day
- The Company has the right to adjust the incentive paid to customers based on historical performance if the average annual realization rate falls below the 95% target

1.1 Program terminology and metrics

Any day on which an event is called is considered an event day. A given event day may include multiple events. The length of each event varies by event, and events are reported in one-hour intervals at the end of the hour. For example, the interval hour ending 17 corresponds to an event between 16:00 and 17:00. The number of dispatched sites during a given event day may vary.

For the non-residential DG program, total and average dispatched generation is the amount of load curtailment, in kW, requested by the Company, per event hour, aggregated and reported at the daily, monthly, seasonal, and yearly levels. Total and average measured generation is metered on-site and is the amount of load curtailed by the participant per event-hour interval.

1.1.1 Realization rate

The program's key performance indicator is the realization rate. The realization rate is calculated by dividing the average monthly measured generation by the average monthly dispatched generation for participating sites, expressed as a percentage. The measured generation before or following an event is not attributed to the program.

From January 1 through December 31, 2022, the program achieved an overall realization rate of 104%, exceeding its planned realization rate of 95%. The 2022 monthly realization rates shown in Table 1-1 highlight the months with call events (May–August, December).

[1] Case No. PUR-2020-00274, Commonwealth of Virginia, State Corporation Commission, Petition of Dominion Energy Virginia for approval of its 2020 DSM Update, Final Order September 2021.

[2] Customers who do not have exact multiples of 1,000 kW of on-site generation are credited with fractional levels of participation and incentive, e.g., 1,500 kW is considered 1.5 participants.

Table 1-1. DG program performance for 2022 events

2022	Planned (MW)	Enrolled (MW)	Net kW planned	Net kW enrolled	Event days	Average dispatched (kW)	Average generation (kW)	Average realization rate
May	7.13	5.88	7,130	5,880	2	5,500	6,102	111%
June	7.13	5.88	7,130	5,880	6	5,297	5,900	111%
July	7.13	5.88	7,130	5,880	13	4,609	5,342	116%
August	7.13	5.88	7,130	5,880	7	3,640	4,103	113%
September	No Events							
October	No Events							
November	No Events							
December	7.13	5.88	7,130	5,880	2	5,782	3,284	57%

Performance indicators for DG pilot participants were reported through the end of the pilot (2014). Therefore, results reported in 2015–2022 are not directly comparable to the results of the combined pilot and program reported in 2013 and 2014.

2 IMPACT ANALYSIS METHODOLOGY

For the non-residential DG program, dispatched generation is the amount of load curtailment, in kW, requested by the Company per event-hour interval, aggregated to the day, month, season, or year. Measured generation, which is site-metered generation, is the amount of load delivered to the Company per event-hour interval, aggregated to the day, month, season, or year. Both dispatched and measured generation is presented in total (cumulative) and average (mean) aggregates. The realization rate is calculated by dividing the measured generation by the dispatched generation for participating sites.

2.1 Data

The Company provides measured generation data to DNV every month. If a site is not dispatched for a given event, it is not recorded. Each record includes the enrolled (dispatchable) generation for every site called for the event, as well as the measured generation for each hour ending during the event duration (in kW). Observations are recorded at the event-hour level for each site called on a given event day for each event.

2.2 Evaluation metrics

The key performance indicator used to measure program performance is the realization rate. The site-level realization rate for a given event interval is the on-site measured generation during that interval divided by the dispatched generation for the interval. The program realization rate during an event interval is the total measured generation divided by the total dispatched generation for all sites. For participants indexed by *i*, and for an event interval *j*,

$$Realization\ Rate_j = \frac{\sum_i Measured\ Generation\ (kW_{i,j})}{\sum_i Dispatched\ Generation\ (kW_{i,j})}$$

The aggregate dispatched and measured generation across the program is calculated by event interval and day.

Results are reported seasonally for some parts of the analysis. The winter season spans from October–March, and the summer season spans from April–September.

3 RESULTS

This section summarizes program performance from 2013 to 2022 and presents a detailed impact analysis for the 2022 events.

A total of 30 events were called in 2022, with one event per event day. Thirteen of the 30 events occurred in July. Table 3-1 presents an annual summary of the number of event days, average dispatched generation, average measured generation, and realization rates for event days through December 31, 2022.

Table 3-1. Program participant impacts and realization rates per year

Year	Number of event days	Average dispatched (kW)	Average measured generation (kW)	Realization rate
2013	12	6,239	6,306	102%
2014	23	5,862	5,978	101%
2015	26	5,899	5,457	93%
2016	37	5,215	5,524	106%
2017	27	5,603	6,054	108%
2018	31	5,296	5,140	97%
2019	25	5,619	6,368	113%
2020	29	5,932	6,293	106%
2021	27	5,695	6,314	111%
2022	30	4,749	4,927	104%

Table 3-2 presents an overview of yearly DG program impacts broken out by season. In 2022, summer’s 104% realization rate exceeded the 95% target for 2022.

Table 3-2. DG performance indicators for summer and winter (2014–2022)

Year	Number of event days		Average dispatched (kW)		Average generation (kW)		Realization rate	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
2014	14	9	5,798	6,060	6,305	3,954	109%	65%
2015	20	6	5,958	5,846	5,903	4,515	99%	77%
2016	34	3	5,171	5,911	5,602	4,281	108%	72%
2017	24	3	5,564	6,130	6,114	5,234	110%	85%
2018	27	4	5,438	4,757	5,432	4,026	100%	85%
2019	23	2	5,565	6,085	6,376	6,302	115%	104%
2020	29	0	5,932	–	6,293	–	106%	–
2021	27	0	5,695	–	6,314	–	111%	–
2022	28	2	4,576	5,782	5,201	3,284	114%	57%

Section 3.1 reports dispatched and measured generation by event hour and day. Section 3.2 reports realization rates by event hour and day. Section 3.3 provides site-level realization rate details by event day and month.

3.1 Program event impacts

The total dispatched generation for all DG participants during the 2022 winter and summer event intervals are shown in Table 3-3 and Table 3-4. The total and average dispatched generation is summarized by event day. The total hourly dispatched capacity ranged from 5,660 to 5,880 in winter (2 events) and between 3,040 kW and 5,530 kW in summer (28 events). The fully enrolled program capacity is 5,880 kW.

Dispatched kW is the amount of load curtailment requested (called) by the Company during an event. It is not a measure of participants' committed load and can vary by event.

Table 3-3. Dispatched generation by event day and hour ending (winter kW)

Event day	Hour ending								
	17	18	19	20	21	22	23	Total	Average
23-Dec-22			5,880	5,880	5,880	5,880	5,880	29,400	5,880
24-Dec-22	5,660	5,660	5,660	5,660				22,640	5,660

Table 3-4. Dispatched generation by event day and hour ending (summer kW)

Event day	Hour ending					
	15	16	17	18	Total	Average
20-May-22			5,500	5,500	11,000	5,500
31-May-22			5,500	5,500	11,000	5,500
1-Jun-22		5,500	5,500		11,000	5,500
2-Jun-22	5,280	5,280			10,560	5,280
13-Jun-22			5,250	5,250	10,500	5,250
15-Jun-22			4,990	4,990	9,980	4,990
17-Jun-22		5,230	5,230		10,460	5,230
30-Jun-22			5,530	5,530	11,060	5,530
1-Jul-22		5,530	5,530		11,060	5,530

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Event day	Hour ending				Total	Average
	15	16	17	18		
5-Jul-22			5,300	5,300	10,600	5,300
6-Jul-22		4,980	4,980		9,960	4,980
12-Jul-22			4,980	4,980	9,960	4,980
18-Jul-22			4,720	4,720	9,440	4,720
19-Jul-22			4,980	4,980	9,960	4,980
20-Jul-22		4,860	4,860		9,720	4,860
21-Jul-22			5,090		5,090	5,090
22-Jul-22		5,410	5,410		10,820	5,410
23-Jul-22			3,440	3,440	6,880	3,440
24-Jul-22			3,440	3,440	6,880	3,440
25-Jul-22	3,600	3,600			7,200	3,600
28-Jul-22			3,040		3,040	3,040
3-Aug-22			3,470	3,470	6,940	3,470
4-Aug-22		3,230	3,230		6,460	3,230
8-Aug-22		3,470	3,470		6,940	3,470
9-Aug-22		3,440	3,440		6,880	3,440
10-Aug-22		3,670	3,670		7,340	3,670
29-Aug-22		4,160	4,160		8,320	4,160
30-Aug-22		4,040	4,040		8,080	4,040

Table 3-5 and Table 3-6 report the program level measured generation by event day and interval for winter and summer events, respectively.

Total and average measured generation are given across all events during each event day. The average measured generation was 3,284 kW in winter and 5,201 kW in the summer months.

Table 3-5. Measured generation by event day and hour ending—winter (kW)

Event day	Hour ending								
	17	18	19	20	21	22	23	Total	Average
23-Dec-22			250	3,157	4,640	4,434	4,173	16,654	3,331
24-Dec-22	684	4,411	4,175	3,632				12,902	3,226

Table 3-6. Measured generation by event day and hour ending—summer (kW)

Event day	Hour ending					
	15	16	17	18	Total	Average
20-May-22			6,151	6,081	12,232	6,116
31-May-22			6,097	6,077	12,174	6,087
1-Jun-22		5,976	5,937		11,913	5,957
2-Jun-22	6,154	6,069			12,222	6,111
13-Jun-22			5,773	5,915	11,688	5,844
15-Jun-22			5,329	5,199	10,528	5,264
17-Jun-22		6,139	6,212		12,351	6,175
30-Jun-22			6,057	6,039	12,095	6,048
1-Jul-22		6,463	6,510		12,973	6,486
5-Jul-22			6,025	5,697	11,722	5,861
6-Jul-22		5,813	5,699		11,511	5,756
12-Jul-22			5,867	5,722	11,589	5,794
18-Jul-22			5,819	5,814	11,633	5,816
19-Jul-22			5,490	5,422	10,913	5,456
20-Jul-22		5,694	5,495		11,189	5,594
21-Jul-22			5,531		5,531	5,531
22-Jul-22		5,923	5,994		11,918	5,959
23-Jul-22			4,376	4,341	8,716	4,358
24-Jul-22			4,426	4,358	8,784	4,392
25-Jul-22	4,075	4,055			8,130	4,065
28-Jul-22			3,609		3,609	3,609
3-Aug-22			3,833	3,739	7,573	3,786
4-Aug-22		3,582	3,515		7,097	3,548
8-Aug-22		3,721	3,871		7,592	3,796
9-Aug-22		4,390	4,390		8,780	4,390
10-Aug-22		4,340	4,165		8,505	4,253
29-Aug-22		4,210	4,599		8,809	4,404
30-Aug-22		4,552	4,538		9,090	4,545

3.2 Realization rates

The average realization rates for winter and summer events are provided in Table 3-7 and Table 3-8, showing measured generation as a percentage of the dispatched generation for each event interval.

Neither of the two event days in the winter met the 95% realization rate target (Table 3-7). Twenty-eight of 28 summer event days (100%) met or exceeded the 95% target average (Table 3-8). The highest-performing summer event days occurred July 24 and August 9, generating 128% of the dispatched load on each of those days. The lowest-performing summer event occurred on June 15, generating 105% of the dispatched load on that day, which still exceeds the 95% target average. Average realization rates that meet or exceed the 95% target are bolded in Table 3-8.

Table 3-7. Realization rates by event day and hour ending—winter

Event day	Hour ending							
	17	18	19	20	21	22	23	Average
23-Dec-22			4%	54%	79%	75%	71%	57%
24-Dec-22	12%	78%	74%	64%				57%

Table 3-8. Realization rates by event day and hour ending—summer

Event day	Hour ending				
	15	16	17	18	Average
20-May-22			112%	111%	**111%**
31-May-22			111%	110%	**111%**
1-Jun-22		109%	108%		**108%**
2-Jun-22	117%	115%			**116%**
13-Jun-22			110%	113%	**111%**
15-Jun-22			107%	104%	**105%**
17-Jun-22		117%	119%		**118%**
30-Jun-22			110%	109%	**109%**
1-Jul-22		117%	118%		**117%**
5-Jul-22			114%	107%	**111%**
6-Jul-22		117%	114%		**116%**
12-Jul-22			118%	115%	**116%**
18-Jul-22			123%	123%	**123%**
19-Jul-22			110%	109%	**110%**
20-Jul-22		117%	113%		**115%**
21-Jul-22			109%		**109%**
22-Jul-22		109%	111%		**110%**
23-Jul-22			127%	126%	**127%**
24-Jul-22			129%	127%	**128%**
25-Jul-22	113%	113%			**113%**
28-Jul-22			119%		**119%**
3-Aug-22			110%	108%	**109%**
4-Aug-22		111%	109%		**110%**
8-Aug-22		107%	112%		**109%**
9-Aug-22		128%	128%		**128%**
10-Aug-22		118%	113%		**116%**
29-Aug-22		101%	111%		**106%**
30-Aug-22		113%	112%		**112%**

3.3 Site-level detail

Table 3-9 and Table 3-10 show the average realization rates by participant site for each event day. Each site is assigned a unique identifier. If a participant site was not dispatched during an event, the corresponding cell is blank. Realization rates greater than or equal to 95% are highlighted green, less than 95% and greater than or equal to 50% are lilac, and rates less than 50% are red. Site ID 10 was the only site that met or exceeded the 95% target in every event, and site 11 met the 95% target in every event in which it was called.

Table 3-9. Average realization rates by site and event day (January 1–July 31, 2022)

Site ID	May		June						July												
	20	31	1	2	13	15	17	30	1	5	6	12	18	19	20	21	22	23	24	25	28
1	93%	89%	92%	94%	95%	88%	94%	101%	102%	100%	100%	102%	104%	103%	103%	104%	104%				
2	108%	105%	0%		116%	99%	123%	103%	115%	100%	102%	110%	119%	114%	119%	117%	115%	110%	113%	114%	
3	105%	106%	108%	120%	28%	97%	102%	0%	104%	97%	101%	99%	101%	97%	104%	109%	102%	101%	102%	104%	107%
4							106%	104%	105%	104%	104%	107%	116%	104%	108%	100%	106%	112%	114%	112%	114%
5	90%	87%	88%	98%	85%	84%	95%	87%	92%	34%							0%	92%	91%	92%	93%
6	111%	124%	126%	104%	118%	112%	119%	113%	112%	105%	112%	114%	123%	111%	115%	116%	114%	116%	119%	122%	118%
7																0%	125%	125%	127%	129%	122%
8	129%	136%	140%	149%	130%	132%	141%	134%	140%	137%	136%	141%	137%	129%	129%	43%	141%	141%	146%	147%	139%
9	90%	88%	95%	107%	89%	17%	102%														
10	135%	137%	128%	144%	155%	143%	156%	143%	146%	153%	140%	155%	158%	135%	140%	148%	135%	156%	150%	141%	143%
11	210%	220%	214%	210%	208%	195%	211%	202%	204%	204%	209%	209%	216%	213%	236%	224%	226%				
12	93%	92%	98%	101%	95%	93%	100%	93%	93%	87%	103%	92%	101%	101%	101%	95%	98%	99%	100%	107%	101%
13	137%	133%	136%	152%	133%	133%	134%	129%	135%	132%	137%	133%	133%	120%	133%	131%	137%	136%	139%	139%	137%
14	114%	116%	114%	116%	113%	107%	113%	110%	112%												
15	141%	136%	138%	148%	143%	130%	145%	129%	143%	128%	133%	149%	145%	146%	133%	113%	136%	139%	152%	129%	124%
16	75%	79%	79%	99%				98%	102%	97%	97%	92%	96%	88%	99%	102%	97%	97%	94%	98%	100%
17	98%	100%	101%	70%	95%			94%	95%	92%	63%	60%		82%	64%	99%	96%	102%	102%	103%	101%
18	141%	157%	162%	169%	168%	159%	176%	163%	163%	166%	161%	156%	158%	150%	165%	162%	175%	178%	179%	184%	183%
19	265%	253%	258%	258%	261%	232%	273%	247%	259%	252%	261%	257%	264%	0%				274%	269%	269%	137%
20																				0%	
21	194%	187%	184%	188%	184%	157%	183%	175%	181%	172%	176%	174%	179%	157%	180%	188%	176%	188%	184%	0%	

Legend ≥ 95% | < 95% ≥50% | < 50% | No event called

Table 3-10. Average realization rates by site and event day (August 1–December 31, 2022)

Site ID	August							December	
	3	4	8	9	10	29	30	23	24
1								32%	35%
2	11%	0%	120%	122%	122%	110%	0%	26%	
3	101%	108%	108%	108%	101%	100%	105%	47%	51%
4	107%	111%	114%	112%	105%	108%	111%	44%	42%
5	89%	89%	91%	89%	91%	87%	88%	38%	39%
6	113%		38%	127%	107%	114%	114%	44%	45%
7	118%	124%	121%	123%	114%	112%	122%	69%	76%
8	133%	128%	139%	157%	18%	136%	140%	120%	102%
9	75%	73%	0%			72%	68%	78%	56%
10	144%	148%	146%	149%	145%	135%	132%	114%	107%
11	225%	223%	228%	226%	228%	226%	223%	129%	134%
12	98%	95%	106%	101%	99%	96%	95%	80%	45%
13	137%	145%	138%	137%	130%	127%	123%	82%	85%
14					115%	114%	117%	81%	87%
15	140%	126%	130%	134%	132%	138%	121%	76%	75%
16	92%	97%	98%	101%	95%	106%	95%		
17	96%	100%	99%	102%	92%	87%	96%	34%	31%
18	173%	180%	180%	180%	174%	12%	139%	102%	98%
19						4%		106%	117%
20						105%	193%	77%	86%
21				191%	181%	177%	179%	68%	80%

Legend ≥ 95% | < 95% ≥50% | < 50% | No event called

Table 3-11 shows the monthly average realization rate for each site. Four sites achieved or exceeded the program target of 95% every month.

Table 3-11. Average realization rates by site and event month (2022)

Site ID	May	June	July	Aug	Dec
1	91%	94%	103%		33%
2	107%	88%	112%	69%	26%
3	105%	76%	102%	105%	49%
4		105%	108%	110%	44%
5	89%	90%	69%	89%	39%
6	117%	115%	115%	102%	44%
7			113%	119%	72%
8	132%	138%	135%	122%	112%
9	89%	82%		58%	68%
10	136%	145%	146%	143%	111%
11	215%	207%	215%	226%	131%
12	92%	96%	98%	99%	65%
13	135%	136%	134%	134%	84%
14	115%	112%	112%	115%	84%
15	138%	139%	138%	131%	76%
16	77%	92%	97%	98%	
17	99%	90%	87%	96%	33%
18	149%	166%	167%	148%	100%
19	259%	255%	229%	4%	111%
20			0%	149%	81%
21	191%	178%	162%	182%	73%

Legend	≥ 95%	< 95% ≥50%	< 50%	No event called

4 CONCLUSIONS

The objective of each DG event is to provide the Company with a supply resource during periods of high demand. The performance goal of the DG program is that measured generation be at least 95% of the dispatched load. The 2022 realization rate of 104% exceeded the program's performance goals.

About DNV

DNV is a global quality assurance and risk management company. Driven by our purpose of safeguarding life, property, and the environment, we enable our customers to advance the safety and sustainability of their business. We provide classification, technical assurance, software, and independent expert advisory services to the maritime, oil & gas, power, and renewables industries. We also provide certification, supply chain, and data management services to customers across a wide range of industries. Operating in more than 100 countries, our experts are dedicated to helping customers make the world safer, smarter and greener.