Evaluation of DC Sustainable Energy Utility FY2019 Programs

FINAL

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Executive Summary

NMR Group, EcoMetric Consulting, Demand Side Analytics, BluePath Labs, and Setty – collectively referred to as *the NMR team* – were contracted by the DC Department of Energy and Environment (DOEE) to evaluate the energy-efficiency and renewable energy programs implemented by the DC Sustainable Energy Utility (DCSEU). This report presents the results of the evaluation of the Fiscal Year 2019 (FY2019) programs.

In FY2019, the commercial sector represented 81% of tracked electric and gas savings across the DCSEU portfolio. This was largely driven by three custom programs, in particular the Retrofit Custom program (Table 1). Lighting measures contributed 29% of portfolio savings, while heating measures contributed 23% of portfolio savings.

Evaluation Methodology

For the FY2019 evaluation, we completed the following activities:

Gross Savings Verification	Process Evaluation and Net Savings Estimation
• Tracking database review • Desk reviews • On-site visits • Billing analysis • Supplemental analyses	• Interviews with program staff • Interviews with program partners/vendors • Interviews with property managers • Surveys with participating customers

We targeted a subset of 12 programs for evaluation: six commercial programs, three multifamily programs, two retail programs, and one solar program (Table 1). The NMR team selected the programs for the FY2019 evaluation because the programs either represented a large share of portfolio savings; had not recently been evaluated; included a key measure of interest; or contributed to the DCSEU's performance benchmarks. See Section 1.5 for details of our sampling approach.

Appendix A provides descriptions for each of the program tracks offered by DCSEU in FY2019.

Table 1: FY2019 Program Evaluation Summary

Sector	Program Name	Track Number	Percent of FY2019 Tracked Gross Electric & Gas Savings	FY2019 Evaluation		
				Gross Savings Verification	NTG Estimation	Process Evaluation
Solar	Solar PV Market Rate	7101PVMR	4.8%	✓	✓	✓
	Solar Photo Voltaic	7107PV	0.1%			
	Low-income Solar Renewable Credit	7107SREC	0.1%			
Commercial	C&I RX - Equipment Replacement	7511CIRX	9.7%	✓		
	Market Transformation Value	7512MTV	1.3%			
	Commercial Upstream - Lighting	7513UPLT	7.0%	✓	✓	✓
	Retrofit - Commercial Custom	7520CUST	51.8%	✓	✓	✓
	Market Opportunity - Commercial Custom	7520MARO	3.9%	✓	✓	✓
	New Construction - Commercial Custom	7520NEWC	6.9%	✓		
	P4P	7520P4PX	0.4%	✓		✓
Multifamily	Implementation Contractor Direct Install	7610ICDI	0.2%			
	Income Qualified Efficiency Fund	7610IQEF	1.0%	✓		
	Low-income Multifamily Comprehensive	7612LICP	1.7%	✓		✓
	Low-income Prescriptive Rebate	7613LIRX	2.8%	✓		✓
Efficient Products	Retail Efficient Appliances	7710APPL	0.1%			
	Retail Heating and Cooling	7710HTCL	0.4%			
	Retail Lighting	7710LITE	6.5%	✓		
	Nest Seasonal Savings	7710STAT	1.2%	✓		
	Retail Lighting Food Bank	7717FBNK	0.1%			
	Home Energy Conservation Kit - Low-income	7717HEKT	0.2%			
	Residential Upstream	7725RSUP	0.0%			

The NMR team assigned FY2019 programs that did not undergo an evaluation a default gross savings realization rate based on either (1) FY2019 realization rates for similar programs or measures or (2) previous realization rates for the same program. Realization rates are the ratio of evaluated savings to tracked savings. See Section 4.1 for more details.

This report also includes the evaluation of two Solar For All programs administered by DCSEU that are funded outside of the Sustainable Energy Trust Fund. The evaluation approach and results for the Solar For All Low-Income Single-family and Community Solar programs are described in Appendix C.

Evaluation Results

Table 2 displays the FY2019 tracked gross savings, realization rates, and evaluated savings for the DCSEU portfolio at the meter level. The NMR team estimates that the actual portfolio electric savings is 97% of the DCSEU tracked electric savings, the actual portfolio peak demand reduction is 96% of the DCSEU tracked peak demand reduction, and the actual portfolio gas savings is 94% of the DCSEU tracked gas savings.

Table 2: DCSEU FY2019 Portfolio-level Gross Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
Electric Savings (MWh)	147,277	97%	142,967
Peak Demand Savings (MW)	21.4	96%	20.4
Gas Savings (MMBtu)	234,692	94%	221,595

Table 3 displays the portfolio gross savings realization rates over the previous three years. Overall, the realization rates for electric and natural gas savings have remained very consistent, ranging from 97% to 99% for electric savings and 93% to 94% for gas savings. However, the peak demand savings realization rates have varied slightly more – from 96% to 105%.

Table 3: DCSEU Portfolio-level Gross Savings Realization Rates by Year

Savings Type	FY2019	FY2018	FY2017
Electric Savings Realization Rate	97%	99%	99%
Peak Demand Savings Realization Rate	96%	105%	96%
Gas Savings Realization Rate	94%	94%	93%

Table 4 compares the electric and demand savings realization rates for the DCSEU portfolio to those from neighboring utilities, including PECO Energy in Pennsylvania and Baltimore Gas & Electric (BG&E) in Maryland. Each of these utilities serves a large city (Philadelphia for PECO and Baltimore for BG&E), as well as the surrounding, less urban, region. At 97%, the electric savings realization rate for DCSEU is the same as for PECO, which both exceed the 93% value

for BG&E. At 96%, the demand savings realization rate for DCSEU is similar to BG&E, though it is lower than the 118% figure for PECO.

Table 4: Comparison of Portfolio-level Realization Rates

Savings Type	DCSEU FY2019	PECO Energy Program Year 10[1]	Baltimore Gas & Electric 2017[2]
Electric Savings	97%	97%	93%
Peak Demand Savings	96%	118%	95%

Table 5 displays the tracked gross savings, realization rates, and evaluated savings at the meter-level for each program in the DCSEU portfolio. Most of the program-level realization rates range from 95% to 105%, indicating that SEU is accurately estimating savings for most programs. However, we found realization rates less than 90% or greater than 110% for a small number of programs evaluated in FY2019, including the Custom Retrofit, CI RX Equipment Replacement, Low-income Prescriptive, and Seasonal Savings tracks. For these programs, the accuracy of tracked savings could be improved. We offer our resulting recommendations in the following section.

[1] Pennsylvania SWE Annual Report Act 129 Program Year 10. NMR Group, Demand Side Analytics, Brightline Group, EcoMetric Consulting. February 19, 2020.
http://www.puc.state.pa.us/filing_resources/issues_laws_regulations/act_129_information/act_129_statewide_evaluator_swe_.aspx

[2] Verification of the 2017 Empower Maryland Energy Efficiency Program Impact Evaluation. Itron, October 5, 2018.
https://sites.google.com/view/empowermarylandevaluation/home

Table 5: DCSEU Gross Meter-level Program Realization Rates and Savings

Sector	Program Name	Track	FY2019 Electric Savings (MWh)			FY2019 Peak Demand Savings (MW)			FY2019 Gas Savings (MMBtu)		
			Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated
Solar	Solar PV Market Rate	7101PVMR	10,365	102%	10,577	2.3	103%	2.4	-	-	-
	Solar Photo Voltaic	7107PV	165	102%	168	0.0	103%	0.0	-	-	-
	LI Solar Renew Credit	7107SREC	261	102%	267	0.0	103%	0.0	-	-	-
Commercial	C&I RX - Equipment Replace	7511CIRX	20,251	103%	20,864	2.7	109%	2.9	2,080	123%	2,559
	Market Transformation Value	7512MTV	2,972	108%	3,209	0.4	139%	0.5	(737)	107%	(788)
	Commercial Upstream – Light	7513UPLT	16,688	102%	16,950	2.4	102%	2.4	(5,445)	101%	(5,484)
	Retrofit – Custom	7520CUST	49,163	98%	48,205	6.8	77%	5.3	214,375	95%	204,458
	Market Opportunity – Custom	7520MARO	5,255	90%	4,735	0.9	107%	0.9	10,666	100%	10,633
	New Construction – Custom	7520NEWC	7,808	101%	7,914	1.9	103%	2.0	23,946	97%	23,180
	P4P	7520P4PX	655	100%	655	0.0	100%	0.0	879	101%	889
Multifamily	Implementation Contractor DI	7610ICDI	272	100%	272	0.0	99%	0.0	379	100%	379
	Income Qualified Eff. Fund	7610IQEF	1,302	100%	1,302	0.1	100%	0.1	2,610	102%	2,651
	LI Multifamily Comp.	7612LICP	3,666	101%	3,704	0.6	99%	0.6	69	100%	69
	LI Prescriptive Rebate	7613LIRX	6,592	39%	2,569	0.7	100%	0.7	(2,137)	39%	(832)
Efficient Products	Retail Efficient Appliances	7710APPL	114	100%	114	0.0	100%	0.0	101	100%	101
	Retail Heating and Cooling	7710HTCL	303	100%	303	0.1	100%	0.1	2,033	100%	2,033
	Retail Lighting	7710LITE	19,965	100%	19,965	2.3	100%	2.3	(20,340)	100%	(20,340)
	Nest Seasonal Savings	7710STAT	496	42%	209	-	-	-	7,268	43%	3,138
	Retail Lighting Food Bank	7717FBNK	342	100%	342	0.0	100%	0.0	(476)	100%	(476)
	Home Energy Cons. Kit - LI	7717HEKT	572	100%	572	0.0	100%	0.0	(482)	99%	(478)
	Residential Upstream	7725RSUP	70	100%	70	0.0	100%	0.0	(97)	100%	(97)
Portfolio			**147,277**	**97%**	**142,967**	**21.4**	**96%**	**20.4**	**234,692**	**94%**	**221,595**

Table 6 displays the modified gross tracked savings and evaluated savings at the generator-level for each program in the DCSEU portfolio. The modified gross generator-level savings are calculated by increasing gross meter-level electric savings from renewable energy projects by 15% to reflect spillover and increasing all gross meter-level electric savings by 4.609% and all gross meter-level demand savings by 7.707% to adjust for line losses. In addition, modified gross gas savings are calculated from gross gas savings by excluding the cross-fuel interactive effects that reflect the increase or decrease in energy usage due to the installation of an energy-efficiency measure.[3]

[3] A common example is energy-efficient lighting: an LED bulb installed in conditioned space produces less waste heat than an incandescent bulb, which then reduces the energy consumption from cooling equipment but increases consumption from heating equipment. In this case, the cooling savings is a like-fuel interactive effect (the lighting and cooling equipment both use electricity), while the heating penalty is likely a cross-fuel interactive effect (the lighting uses electricity, while the heating equipment likely uses gas).

Table 6: DCSEU Modified Gross Generator-level Program Savings

Sector	Program Name	Track	FY2019 Electric Savings (MWh)		FY2019 Peak Demand Savings (MW)		FY2019 Gas Savings (MMBtu)	
			Tracked	Evaluated	Tracked	Evaluated	Tracked	Evaluated
Solar	Solar PV Market Rate	7101PVMR	12,469	12,724	2.9	3.0	-	-
	Solar Photo Voltaic	7107PV	198	202	0.0	0.0	-	-
	LI Solar Renewable Credit	7107SREC	314	321	0.1	0.1	-	-
Commercial	C&I RX - Equipment Replacement	7511CIRX	21,184	21,826	2.9	3.1	5,066	5,066
	Market Transformation Value	7512MTV	3,109	3,357	0.4	0.5	463	463
	Commercial Upstream - Lighting	7513UPLT	17,458	17,731	2.6	2.6	-	-
	Retrofit - Custom	7520CUST	51,432	50,430	7.3	5.7	216,107	206,109
	Market Opportunity -Custom	7520MARO	5,535	4,988	0.9	1.0	11,104	11,070
	New Construction - Custom	7520NEWC	8,168	8,279	2.1	2.2	24,066	23,296
	P4P	7520P4PX	685	685	0.0	0.0	879	889
Multifamily	Implementation Contractor Direct Install	7610ICDI	285	285	0.0	0.0	494	494
	Income Qualified Efficiency Fund	7610IQEF	1,362	1,362	0.1	0.1	2,965	3,011
	LI Multifamily Comprehensive	7612LICP	3,835	3,875	0.6	0.6	1,243	1,243
	LI Prescriptive Rebate	7613LIRX	6,896	2,687	0.8	0.8	-	-
Efficient Products	Retail Efficient Appliances	7710APPL	120	120	0.0	0.0	101	101
	Retail Heating and Cooling	7710HTCL	317	317	0.1	0.1	2,033	2,033
	Retail Lighting	7710LITE	20,884	20,884	2.4	2.4	-	-
	Nest Seasonal Savings	7710STAT	519	219	-	-	7,268	3,138
	Retail Lighting Food Bank	7717FBNK	357	357	0.0	0.0	-	-
	Home Energy Conservation Kit - LI	7717HEKT	598	598	0.0	0.0	67	67
	Residential Upstream	7725RSUP	74	74	0.0	0.0	-	-
Portfolio			**155,799**	**151,321**	**23.4**	**22.4**	**271,855**	**256,980**

Recommendations

Our evaluation of the FY2019 programs found that DCSEU expended the appropriate amount of effort and rigor on their savings calculations. In general, the documentation provided was sufficient, and the methods and assumptions were suitable. The evaluation team believes the DCSEU calculated energy savings with a reasonable degree of accuracy.

However, our evaluation yielded recommendations for most programs, as described below. While DCSEU prescriptive savings estimates were reasonable, in aggregate, for the FY2019 programs, the NMR team believes the DCSEU can continue to improve calculation methods and should prioritize improvements that offer the most cost-effective outcomes. The NMR team provides one recommendation that applies to most prescriptive programs.

- Apply project-specific efficiency levels and other inputs to improve the accuracy of tracked savings when feasible. DCSEU applied deemed values or ranges for efficiency levels, wattages, and other inputs to savings algorithms when site specific information was available. This issue was most prominent for commercial lighting where the DCSEU used default assumptions when the actual wattage values, heating fuel type, and waste heat factors were available. For PV systems, default values for inverter efficiency and locations were input rather than available site-specific data. In addition, building-specific load shapes and hours of use should be utilized for new construction projects. In these cases, project-specific input values were available, which would improve the accuracy of tracked savings. DCSEU should examine how integrating site-specific information within the tracking system can be done efficiently when these data are already collected from customers.

For the Custom Retrofit, Market Opportunities, and PV Market Rate programs, we offer the following recommendation:

- Ensure that enough documentation is available to re-create savings calculations, and that final versions of savings calculations are included in project documentation. For some projects, the data available was not sufficient to fully calculate savings. For example, savings parameters were missing from some custom projects, in particular for heat pumps. Similarly, for some custom projects, tracked savings did not match the calculated savings included in the documentation. In addition, data on system losses, DC to AC size ratio and ground coverage ratio was not available for some PV systems.

For the Custom Retrofit and Market Opportunities programs, we offer the following additional recommendations:

- Request additional information from customers on the rationale behind control changes that result in significant energy savings. Confirm that the control changes will meet the facility's operational requirements to reduce the likelihood of control strategies being reversed in the future, leading to reduced savings.
- Consider collecting more details during post inspections. The post inspection can be used not only to verify the installation of rebated equipment, but also to confirm operational information such as equipment schedules or setpoints.

- Consider establishing guidelines for post inspection timing. For controls changes and other building commissioning measures, completing the post inspection several months after project completion may allow the DCSEU to identify situations where the customers anticipated actions were not fully implemented.

For the Custom Retrofit program, we offer the following additional recommendations:

- Consider labeling savings estimates as “pre-application” or “in-progress” then a separate “finalized” field to avoid situations where final project savings are not updated in the tracking database. In addition, for very large projects, require sign off on the final savings by the responsible analyst or engineer to avert situations where updated savings calculations are not fully communicated.
- Consider secondary calculations and more quality control checks for projects with high uncertainty to ensure that the claimed savings are well below the system’s baseline consumption.
- Calculate demand savings independently of energy savings for projects that operate 8760 hours per year. Computing demand profiles requires additional inputs, which may not be easily derived from the energy savings.
- Consider reassessing whether incentive levels can increase for any measures with limited traction but high potential savings. Furthermore, DCSEU might wish to explore the impact of raising incentive caps.

For the Market Opportunities program, we offer the following additional recommendation:

- Consider establishing a pool of approved vendors to increase engagement among vendors to encourage them to prioritize the program in their sales discussions. Consider listing their contact information and highlight their specialties on the program website and monitoring their participation levels and then connect with less active vendors to identify barriers to participation.

For the CI RX Equipment Replacement program, we offer the following recommendations:

- Calculate a site-specific coincidence factor when site-specific lighting hours of use values are input to ensure that peak demand savings are not understated due to an incongruence in energy and demand load shapes. At a minimum, we recommend using a flag to assign a coincidence factor of 100% to any lighting that operates continuously.
- Change the TRM exterior summer coincidence factor to 0% as most exterior LEDs come standard with integral photocells. Additionally, customers who utilize timers most likely adjust them seasonally for safety and thus will avoid summer peak hours. However, exceptions should be made for 8,760-hour lighting, where the summer coincidence factor would be 100%.
- Ensure that all projects in the CIRX program replace existing equipment and are not new construction which require the baseline to consider the current building energy code.

For the Commercial Upstream Lighting program, we offer the following recommendations:

- Explore the impacts of discounting other measures, such as HVAC equipment and variable frequency drives.

- Ensure there is a strong system in place to track installation locations when engaging a new sector of distributors (i.e., HVAC).

For the Pay for Performance program, we offer the following recommendations:

- Annualize the energy and natural gas savings for each project. In addition, re-evaluate the annualized savings for any projects with less than one year of post-project usage.
- Ensure that the evaluation periods for FY2020 savings begin immediately after the verification period for FY2019 ended to ensure that the persistence of savings is properly accounted for as the program cycle continues.
- Collaborate with the evaluation team to develop a methodology to account for the effects of the COVID-19 pandemic when modeling the FY2020 program savings.
- Explore the impact of increasing incentive rates.
- To further improve program delivery, take steps to improve transparency.
    - Outline modeling approaches in program materials. Possibly devote a webinar with vendors to answer their questions.
    - Clarify program rules about installing other energy-efficiency measures during the participation period.
    - Ensure customers understand the estimated savings and incentives for their projects.
    - Create a strong feedback loop with customers about consumption during and after the performance period.

For the Solar PV Market Rate program, we offer the following recommendations:

- Work closely with participants and installation contractors to develop a common and flexible understanding of project timelines and financial constraints.
- Encourage contractors to assist customers with the DCSEU application process.
- Assess the length of time between system installation and rebate issuance to determine if there is an opportunity to accelerate rebate processing. If delays in rebate issuance are unavoidable, ensure regular communication with participants regarding the timeline.

For the Seasonal Savings program, we offer the following recommendations:

- Ensure that the claimed savings reflect the actual deployment period.
- Estimate separate winter seasonal savings for furnaces and air-source heat pumps, based on fuel type, baseline consumption, average equipment capacity, and savings percentage. In particular, apply the evaluated savings results of 2.55% savings for furnaces and 5.11% for air-source heat pumps.

For the Income Qualified Energy Efficiency Fund and Low-Income Multifamily Comprehensive programs, we offer the following recommendation:

- Ensure that inputs used in savings calculations align with the actual installed equipment. Our evaluation found that, for some projects, the actual equipment installed differed from the quantity, efficiency level, and/or location provided in the project files which all affect the accuracy of savings estimates.

For the Low-Income Multifamily Comprehensive program, we offer the following recommendations:

- Calculate air sealing cooling and peak demand savings for projects heated with heat pumps where air sealing was performed.
- Confirm that the current federal baseline standards are used to accurately compute energy savings.
- Improve the transparency of application and modeling requirements and processes – this may include (1) using clearer descriptions of modeling approaches in materials and (2) conducting more direct outreach during participation to ensure that program processes are fully understood.
- Bolster technical support activities, in particular increase communication around modeling, develop a repository of resources for participants and partners that details best practices and lists recommended vendors, and hold webinar trainings.
- Explore the impact of expanding measure offerings and increasing incentive levels. In addition, clearly identify and communicate the program-eligible measures to both partners and customers.

For the Low-Income Prescriptive Rebate program, we offer the following recommendations:

- Employ prescriptive HOU from recent metering studies instead of HOU estimates provided by applicants. We recommend using the HOU from the Pennsylvania TRM for in-unit installations and from the Mid-Atlantic TRM for common area installations.
- Confirm that lighting installation locations are recorded correctly so that the appropriate hours of use and waste heat factors are applied.
- Explore the impacts of supporting HVAC measures.
- Develop robust case studies with participant testimonials that demonstrate positive participant experiences and the realization of meaningful energy savings.
- Improve the transparency of the pre-approval process and eligibility criteria and ensure participants are aware of the online application option.
- Consider providing property managers more support in completing the required paperwork.

Detailed results and recommendations can be found in each of the individual program sections.

Section 1 Methodology

This section provides an overview of the key activities the NMR team completed for the evaluation of the Fiscal Year 2019 (FY2019) programs, including the evaluation activities:

- Program tracking data review
- Gross savings verification
- Net savings estimation
- Process evaluation

1.1 Program Tracking Data Review

The first evaluation task was to review DC Sustainable Energy Utility's (DCSEU's) FY2019 final program tracking database in order to assess evaluation priorities and identify key programs and measures. The NMR team leveraged the database for multiple tasks, including identifying programs for evaluation, developing the sample design, drawing samples for the desk reviews and surveys, and calculating savings.

In order to identify evaluation priorities and develop sampling plans, the NMR team analyzed the tracking database to conduct a portfolio assessment of all programs. We assigned priorities based on the following metrics:

- Which programs and measures account for the largest share of portfolio savings?
- Which programs contain deep dive measures of interest?
- Which programs and measures have the most and least uncertainty around their estimated savings?
- Which programs and measures contribute to DCSEU performance benchmarks?
- How recently have programs and measures been evaluated?
- Which programs and measures are projected to expand or contract in the future?

1.2 Gross Savings Verification

The gross savings verification included the following tasks:

- Desk reviews
- Participant surveys
- Onsite inspections
- Billing analysis

1.2.1 Desk Reviews

For the residential prescriptive programs, the desk reviews entailed a measure-level review of the Technical Reference Manual (TRM) savings algorithms for each key measure from evaluated programs, covering the entire program tracking database. In addition, we reviewed supporting files for a sample of individual projects from the evaluated programs.

For the commercial and multifamily programs, the NMR team conducted a thorough review of detailed files for a sample of projects. Because custom projects are more complex than the prescriptive projects, the NMR team conducted a more detailed and comprehensive engineering analysis for the custom project file reviews.

1.2.1.1 Prescriptive Measures

For prescriptive measures from the residential, multifamily, and commercial programs, we assessed the accuracy and reasonableness of the savings parameters in accordance with the International Performance Measurement and Verification Protocol (IPMVP) Options A and B, utilizing savings algorithms set forth in DCSEU TRM. In particular, the NMR team assessed the measure quantities, efficiency levels, and capacities. In addition, we re-created the savings calculations using the TRM algorithms to ensure that the savings listed in the tracking database are accurate. Lastly, we reviewed application forms, invoices, and other available documentation for a sample of projects. The NMR team conducted the following evaluation efforts for prescriptive measures:

- Confirmed that the appropriate TRM algorithm is being applied correctly
- Verified key inputs into the algorithms
- Confirmed that the documentation supports the tracking database values
- Developed recommendations on how TRM assumptions can be improved

1.2.1.2 Custom Measures

Custom project analyses involved the review of calculations done by DCSEU and contractors to verify and modify the methods and equations used in the analysis based on engineering judgment and expertise. It also involved the verification of assumptions regarding system parameters and the adjustment of those calculations as necessary to provide a more accurate estimate of energy savings. The NMR team evaluated the custom measures in accordance with IPMVP Options A, B, or C using industry-standard methods, with input from the DCSEU TRM, where applicable.

For custom projects, the NMR team completed the following activities during the savings calculation reviews:

- Reviewed project description, documentation, specifications, and tracking system data
- Reviewed engineering analyses for technical soundness, appropriate baselines, and appropriateness for the specific application
- Reviewed methods of determining demand (capacity) savings to ensure they are consistent with approved methods for determining peak load/savings

- Reviewed input data for appropriate baseline specifications and variables, such as weather data, bin hours, and total annual hours, and to confirm they are consistent with facility operation
- Considered and reviewed for interactive effects with affected systems
- Ensured the measure complies with program rules for eligibility and falls within the parameters outlined by the applicable energy code

1.2.2 Participant Surveys

The NMR team completed telephone surveys with a random sample of participants for selected programs to inform the gross savings verification, net-to-gross (NTG) estimation, and process evaluation tasks. For the upstream lighting program, the surveys verified the installation of LEDs included in the program tracking database.

1.2.3 On-site Inspections

The NMR team conducted on-site verification visits for a sample of projects. We selected these projects either because they exhibit a high degree of savings uncertainty or to serve the broader quality control purposes of the evaluation. Savings uncertainty can come from lack of project documentation or the nature of a project. Lighting projects and one-for-one equipment replacement projects tend to be more straight forward to review, with fewer parameters to verify. Therefore, most of the information can be gleaned from specifications, invoices, and operational hours. Projects that tend to be more holistic in scope (such as controls projects or new construction) can benefit greatly from on-site verification. Interviewing a facilities manager and conducting an on-site assessment to learn how the equipment is operated provides a more accurate assessment of energy consumption than referring to a building plan sequence of operations that may or may not have been implemented.

Projects may also be selected for on-site visits in order to serve the broader quality control purposes of the evaluation, by ensuring that program savings are delivered across all programs.

There are several purposes for the on-site inspections, as follows:

- Confirm measure installations and controls operations
- Collect information on baseline/pre-existing conditions
- Confirm information on efficiency level, operating hours, equipment quantity, and operation
- Conduct an in-person interview with the on-site contact person

1.2.4 Billing Analysis

A meter-based billing regression analysis (IPMVP Option C) is effective where measures are higher impact, weather-sensitive, and have the potential for significant interactive effects. Meter based analysis is also the measurement and verification (M&V) method of choice for whole building programs, such as the Pay for Performance (P4P) program. Regression analysis statistically correlates energy usage to one or more variables that change over time. A typical equation for a regression analysis using billing data and weather data is shown below.

$$Usage = \alpha * HDD + \beta * CDD + \theta$$

Where:

α = correlation coefficient for HDD

HDD = Heating Degree Days

β = correlation coefficient for CDD

CDD = Cooling Degree Days

θ = correlation constant

The NMR team incorporated weather-normalized consumption as the dependent variable and heating- and cooling-degree days, or another explanatory variable describing the weather, directly into the models. Other variables that are often correlated with consumption include fuel prices, occupancy changes, and behavior changes (set-points, schedules, and frequency of use).

We analyzed changes in energy consumption records to estimate savings for P4P projects. Billing analysis is extremely useful for programs where the same premise installs multiple numbers of measures that have interactive effects, such as whole building programs. For other measures, or for situations where whole building billing analysis is not suitable (i.e., replace-on-burnout projects, analyses yielding poor R-squared statistics), billing analysis may be used to corroborate results produced by the engineering analysis.

1.2.5 Realization Rate Calculation

Realization rates are the ratio of evaluated savings to tracked savings. Realization rates are typically calculated at the measure-level or project-level and applied to the appropriate tracked savings. After completing our savings analyses, we calculated a gross savings realization rate for each program across the sampled projects. We then applied these realization rates to the tracked savings for each program and then summed the program-level savings across the entire portfolio.

For programs that do not undergo a gross savings verification, the NMR team assigned a default gross savings realization rate based on either (1) current realization rates for similar programs or measures or (2) previous realization rates for the same program. See Section 4.1 for more details.

1.3 Net Savings Estimation and Process Evaluation

In this section, we provide a description of the activities we undertook to estimate net savings and to conduct a process evaluation. The NMR team leveraged the participant surveys to estimate the NTG ratio and to collect data for the process evaluation. We also used the participant surveys to assist with gross savings verification.

1.3.1 Net Savings Estimation

The NMR team calculated net savings that are attributable to each program by multiplying the gross verified savings by the NTG ratio. This equation and general methodology are used for estimating both the net energy and demand savings. The NMR team estimated the net savings by multiplying the verified gross savings by the NTG ratio as specified below:

$$\text{Net Savings} = \text{Verified Gross Savings} \times \text{NTG ratio}$$

The NTG ratio is based on measurement of free-ridership and participant spillover rates. The NTG ratio is defined as follows:

$$\text{NTG ratio} = 1 - \text{Free-ridership \%} + \text{Participant Spillover \%}$$

We estimated free-ridership and spillover based on self-reports from participant surveys. We asked a series of questions related to the influence of program elements on their decision to install the measures and developed a final savings-weighted average free-ridership and participant spillover values. The NMR team combined these estimates to develop an overall savings-weighted NTG estimate for each evaluated program.

Because commercial customers may be involved in multiple projects with multiple measures within the same fiscal year, we asked free-ridership questions about the primary measure from the primary project. If a customer has multiple projects, we selected the project with the most savings, then, within that project, the measure with the most savings. This approach allows us to provide NTG ratios at the measure-level when sample sizes are sufficient.

For programs that do not undergo net savings estimation, the NMR team assigned a default NTG ratio based on either (1) current NTG ratios for similar programs or measures or (2) previous NTG ratios for the same program. See Section 4.2 for more details.

1.3.1.1 Free-ridership

Free-ridership is the proportion of participants who would have implemented the program measure (a) within a specified period, (b) at the same efficiency level, and (c) in the absence of the program. The survey estimated free-ridership based on two key components:

- Intention or the expected behavior in the absence of the program
- The influence of various program elements on the decision to participate in the program

Each component produces scores ranging from 0% to 50%; the two components are summed to produce a total free-ridership score, ranging from 0% (not a free rider) to 100% (complete free rider).

1.3.1.1.1 Intention

The intention component of the free-ridership score asks participants how the purchase decision would have been different in the absence of the program. The two key questions that determine the intention score are as follows:

Q1.If you had never learned you could receive information about and a $[XX] rebate for the [MEASURE] from DCSEU, which of the following best describes what you would have done? You would have...

1. *Delayed the purchase/installation of the [MEASURE] for at least one year*
2. *Not purchased/installed a new [MEASURE] at all*
3. *Purchased/installed a different [MEASURE] instead or scaled back the scope or efficiency*
4. *Purchased/installed the same [MEASURE] with the exact same scope and efficiency*

98. *(Don't know)*
99. *(I'd rather not answer)*

[ASK Q2 ONLY IF RESPONSE TO QUESTION 1=4: Purchased the same measure anyway]

Q2.If you had not received the $[XX] rebate from DCSEU, would you say you definitely would have, might have, or definitely would NOT have had enough money to purchase the exact same [MEASURE]?

1. *Definitely would have*
2. *Might have*
3. *Definitely would NOT have*

98. *(Don't know)*
99. *(I'd rather not answer)*

Table 7 indicates the possible intention scores a respondent could have received depending on their responses to these two questions. When asked the first question, if a respondent provides an answer of 1 or 2 (would postpone or cancel the purchase), the respondent receives a free-ridership intention score of 0% (on a scale of 0% to 50%, where 0% is associated with no free-ridership and 50% is associated with high free-ridership). If a respondent provides an answer of 3 (would have purchased a different measure without the incentive), or if they said they did not know or refused the question, the respondent receives a free-ridership intention score of 25% (associated with moderate free-ridership). If the respondent provides an answer of 4 (would have purchased the same measure without program rebate), they are asked the second question before a free-ridership intention score can be assigned.

The second question asks the participants who had said they would have purchased the same measure without the program rebate whether they would have had sufficient funds available to cover the entire purchase. If the respondent provides an answer of 1 (definitely would have the funds), the respondent receives a score of 50% (associated with high free-ridership). If the respondent provides an answer of 2 (might have had the funds available), they receive a slightly

lower free-ridership score of 37.5%. If the respondent provides an answer of 3 (definitely would not have the funds), or if they said they did not know or refused the question, the respondent receives a free-ridership intention score of 25% (associated with moderate free-ridership).

Table 7: Free-ridership Intention Scoring

Question 1 Response	Question 2 Response	Free-ridership Intention Score (%)	Free-ridership Intention Level
1 or 2	Not asked	0%	Low
3, 98 (Don't Know), or 99 (Refused)	Not asked	25%	Moderate
4	3, 98 (Don't Know), or 99 (Refused)	25%	Moderate
4	2	37.5%	Moderate-High
4	1	50%	High

1.3.1.1.2 Influence

The influence component of the free-ridership score asks each respondent to rate how much of a role various program-related influence factors had on their decision to purchase the measure. Influence is scored using a scale from 1 to 5, where 1 means "it played no role at all" and 5 means "it played a great role." The influence factors assessed are as follows:

- The financial incentive or rebate of $[REBATE]
- Information or recommendations provided to you by a DCSEU representative
- The results of any audits, energy modeling, or technical studies done through a program offered by DCSEU
- Information or recommendations provided from contractors or suppliers associated with the program
- Marketing materials or information provided by DCSEU about the program (email, direct mail, etc.)
- Previous experience with a DCSEU program
- Others (identified by the respondent)

Table 8 indicates the possible influence scores a respondent could have received depending on how they rated the influence factors above. For each respondent, the program influence is set equal to the maximum influence rating that a respondent reports across the various factors. For example, if the respondent provided a score of 5 (great role) to at least one of the influence factors, then the program is considered to have had a great role in their purchase decision and the influence component of free-ridership is set to 0% (not a free rider).

Table 8: Free-ridership Influence Scoring

Maximum Influence Rating	Influence Score (%)	Free-ridership Influence Level
5 - program factor(s) highly influential	0%	Low
4	12.5%	Low-Moderate
3	25%	Moderate
2	37.5%	Moderate-High
1 - program factor(s) not influential	50%	High
98 - Don't know, 99 - Refused	25%	Moderate

The intention and program influence scores for each respondent were summed to generate a free-ridership score ranging from 0% to 100%. A score of 0% free-ridership means the participant was not a free rider, a score of 100% free-ridership means the participant was a complete free rider, and a score between 0% and 100% means the participant was a partial free rider.

1.3.1.2 Participant Spillover

Spillover is a reduction in energy consumption and/or demand caused by the presence of an energy-efficiency program, beyond the program-related gross savings of the participants and without financial assistance from the program. Participant spillover can manifest in participants who take actions beyond the program.

The participant survey estimated spillover for each respondent through questions about purchases of energy-efficient equipment outside of the DCSEU programs. In these situations, the survey asked about the equipment participants purchased and the impact the program had on the decision to purchase that equipment.

For each equipment type the respondent reports purchasing without a program rebate, the survey asked about the extent of influence that earlier involvement in the program had on their decision. Influence is reported using a scale from 1 to 5, where 1 means "it played no role at all" and 5 means "it played a great role." For each respondent, the program influence rating is converted to an influence score ranging from 0% to 100% (Table 9).

Table 9: Spillover Influence Scoring

Maximum Influence Rating	Influence Score (%)	Spillover Influence Level
Maximum rating of 1 (no influence)	0%	Low
Maximum rating of 2	25%	Low-Moderate
Maximum rating of 3	50%	Moderate
Maximum rating of 4	75%	Moderate-High
Maximum rating of 5 (great influence)	100%	High
Respondent does not know how much influence any factor had	50%	Moderate

We calculated the participant spillover rate as follows:

- Multiply the estimated unit energy savings for each equipment type by the influence percentage to calculate the program-attributable energy savings. We leveraged the DCSEU TRM and/or program tracking data to estimate typical unit energy savings for each measure type.
- Sum program-attributable energy savings across all survey respondents to calculate the total spillover savings.
- Divide the total spillover savings by the total tracked project-level savings across all survey respondents to calculate the participant spillover rate.

1.3.2 Process Evaluation

The NMR team undertook the following activities to inform the process evaluation of selected programs:

- In-depth telephone interviews (IDIs) with program staff to update the NMR team's understanding of the program and to identify any current issues for consideration in interviews with participating vendors and surveys of participants
- IDIs with participating vendors to learn about the following topics:
  - Experience with and perception of the program and its offerings
  - Program awareness and satisfaction
  - Participation drivers and barriers
  - Opportunities for program improvement
  - Questions specific to program issues identified by program staff
- Telephone surveys of a sample of participants to collect information about their program experience, including questions on topics such as the following:
  - Program awareness and satisfaction
  - Decision-making process
  - Participation drivers and barriers
  - Opportunities for program improvement
  - Program issues identified by program staff
  - Firmographic or demographic characteristics

The NMR team sent an advance notification of the survey by email to sampled participants whose email addresses were available.

1.4 PROGRAM SAVINGS OVERVIEW

In this section, we provide an overview of the FY2019 tracked savings by sector, program, and measure type.

Table 10 displays the percent of FY2019 tracked overall energy, electric, and gas savings by sector. The commercial sector programs contributed the large majority of savings across each savings category. Note that the Efficient Products programs yielded negative gas savings due to the heating penalty associated with efficient lighting.

Table 10: FY2019 Tracked Gross Savings Summary by Sector

Sector	Percent of FY2019 Tracked Savings		
	Total Energy Savings (MMbtu)	Electric Savings (MWh)	Gas Savings (MMbtu)
Commercial	80.9%	69.8%	104.7%
Efficient Products	8.5%	14.8%	-5.1%
Multifamily	5.6%	8.0%	0.4%
Single-family Residential	0.0%	0.0%	0.0%
Solar	5.0%	7.3%	0.0%
Total	**737,201**	**147,277**	**234,691**

Table 11 displays the percent of FY2019 tracked overall energy, electric, and gas savings by program track. The commercial Custom Retrofit program contributed over one-half of the total energy savings (51.8%) to the portfolio. The next largest programs include the Equipment Replacement program (9.7%), commercial Upstream Lighting program (7.0%) and commercial New Construction program (6.9%), followed by the Retail Lighting program (6.5%).

Table 11: FY2019 Tracked Gross Savings Summary by Program

Sector	Program Name	Percent of FY2019 Tracked Savings		
		Total Energy Savings (MMbtu)	Electric Savings (MWh)	Gas Savings (MMbtu)
Solar	Solar PV Market Rate	4.8%	7.0%	0.0%
	Solar Photo Voltaic	0.1%	0.1%	0.0%
	Low-income Solar Renewable Energy Credit	0.1%	0.2%	0.0%
Single-family	Refresh the District Low-income Single-family	0.0%	0.0%	0.0%
	Emergency Heating and Cooling Assistance	0.0%	0.0%	0.0%
Commercial	C&I RX - Equipment Replacement	9.7%	13.7%	0.9%
	Market Transformation Value	1.3%	2.0%	-0.3%
	Commercial Upstream - Lighting	7.0%	11.3%	-2.3%
	Retrofit - Commercial Custom	51.8%	33.4%	91.3%
	Market Opportunity - Commercial Custom	3.9%	3.6%	4.5%
	New Construction - Commercial Custom	6.9%	5.3%	10.2%
	P4P	0.4%	0.4%	0.4%
Multifamily	Implementation Contractor Direct Install	0.2%	0.2%	0.2%
	Income Qualified Efficiency Fund	1.0%	0.9%	1.1%
	Low-income Multifamily Comprehensive	1.7%	2.5%	0.0%
	Low-income Prescriptive Rebate	2.8%	4.5%	-0.9%
Efficient Products	Retail Efficient Appliances	0.1%	0.1%	0.0%
	Retail Heating and Cooling	0.4%	0.2%	0.9%
	Retail Lighting	6.5%	13.6%	-8.7%
	Nest Seasonal Savings	1.2%	0.3%	3.1%
	Retail Lighting Food Bank	0.1%	0.2%	-0.2%
	Home Energy Conservation Kit - Low-income	0.2%	0.4%	-0.2%
	Residential Upstream	0.0%	0.0%	0.0%
Total		**737,201**	**147,277**	**234,691**

Table 12 displays the percent of FY2019 tracked overall energy, electric, and gas savings by measure type. Lighting represented nearly 30% of all energy savings and 50% of electric savings. It also resulted in negative gas savings (-16%) due to the heating penalty associated with efficient

lighting. Space heating measures represented 23% of total energy savings and most of the gas savings.

Table 12: FY2019 Tracked Gross Savings Summary by Measure Type

Measure Type	Percent of FY2019 Tracked Savings		
	Total Energy Savings (MMbtu)	Electric Savings (MWh)	Gas Savings (MMbtu)
Lighting	29.3%	50.3%	-15.8%
Space Heating	23.1%	2.2%	67.9%
Commissioning	11.8%	10.3%	15.1%
Process	9.8%	3.2%	23.8%
Air Conditioning	6.9%	10.1%	0.0%
Code Compliance	5.6%	7.2%	2.0%
Solar	5.1%	7.5%	0.0%
Motors	2.9%	4.2%	0.1%
Design Assistance	2.0%	2.0%	2.1%
Water Heating	1.3%	0.5%	2.9%
Other	1.0%	1.5%	0.0%
Cooking	0.7%	0.2%	1.6%
Refrigeration	0.5%	0.7%	0.1%
Appliances	0.1%	0.2%	0.0%
Total	**737,201**	**147,277**	**234,691**

1.5 Program Sampling Plan

In this section, we outline our sampling plan for the FY2019 evaluation activities.

1.5.1 Gross Savings Verification Sampling Plan

We applied a staggered impact evaluation approach, in which some programs will be evaluated annually and others will be evaluated less frequently, with default realization rates being applied in years without evaluation activities.

1.5.1.1 Commercial and Renewable Programs

We allocated the rigor of evaluation methods by end-use on a rotating annual schedule, with annual deep-dives into specific measures of interest or high uncertainty. The deep dive measures of interest include refrigeration, motors/drives, water heating, and appliances, which contributed approximately 5% of overall savings in FY2019. The NMR team oversampled for projects that contain these measure categories. This will allow us to refocus on lighting and HVAC – two measure categories with larger savings contribution – in future evaluations.

Table 13 lists the number of projects and the sample sizes for desk reviews and onsite visits. All sampled projects included desk reviews, a portion of which also included a follow-up interview with the customer to verify key input parameters. In addition, a nested sample of projects that undergo a desk review received an on-site visit.

Table 13: Commercial Gross Savings Verification Sampling

Program	FY2019 Participation (Projects)	Number Sampled for Desk Review Only	Number Sampled for Onsite + Desk Review	Total Number Sampled for Desk Reviews
C&I RX - Equipment Replacement	154	8	3	11
P4P	3	2	1	3
Retrofit - Custom	64	17	9	26
Market Opportunities - Custom	38	5	4	9
Commercial Upstream Lighting	130	11	0	11
Solar PV Market Rate	15	5	2	7
Solar for All Community Renewable PV Energy	84	7	0	7
New Construction - Custom	22	5	3	8
All Evaluated Commercial Programs	**510**	**60**	**22**	**82**

The NMR team stratified most programs based on key measure types, a certainty cutoff, and then a probability strata based on savings levels. The certainty cutoff ensures the largest projects are included in the sample. Further details of the sampling plan for each program are provided in the individual program sections.

1.5.1.2 Residential, Retail, and Low-income Multifamily Programs

Table 14 provides the number of FY2019 projects and the sample size of projects selected for gross savings verification. Further details of the sampling plan for each program are provided in the individual program sections.

Table 14: Residential Gross Savings Verification Sampling

Program	FY2019 Participation (Projects)	Number Sampled for Desk Review Only	Number Sampled for Onsite + Desk Review	Total Number Sampled for Desk Reviews
Retail Lighting	264,933*	18**	0	18
Solar for All Low-income Single-family PV	87	7	0	7
Low-income Prescriptive Rebate	37	8	3	11
Low-income Multifamily Comprehensive	29	7	2	9
Income Qualified Efficiency Fund	28	9	0	9
All Evaluated Residential Programs	**265,114**	**49**	**5**	**54**

* Number of measures rather than projects for the Retail Lighting program.
** A sample of invoice records were reviewed.

1.5.2 Net Savings Estimation and Process Evaluation Sampling Plan

In this section, we outline our sampling plan for the participant surveys and interviews that served the gross savings verification, NTG estimation, and process evaluation efforts (Table 15). We selected programs for the participant surveys that represent a large share of portfolio savings, and thus would have the largest impact on net portfolio savings and cost-effectiveness test results. In addition, we selected programs that have not recently undergone a process evaluation or were recently launched and may therefore benefit from a process evaluation. At the 80% confidence level, the sample precision varies between ±9% and ±22% for each program. The overall sample precision achieves the 90% ± 9% level.

Given the small participant population for some of the commercial programs, the response rate for the surveys was relatively high, ranging from 21% for the Commercial Upstream Lighting program to 83% for the Solar PV Market Rate program.

Table 15: FY2019 Participant Survey Sampling

Program	Number of Unique Participating Customers	Number of Customers Sampled*	Number of Completed Surveys	Response Rate	Estimated Sample Precision
Solar PV Market Rate	7	6	5	83%	80% ± 22%
Custom - Retrofit	53	30	8	27%	80% ± 21%
Market Opportunity - Commercial Custom	38	22	12	55%	80% ± 16%
Commercial Upstream - Lighting	653	230	48	21%	80% ± 9%
All Evaluated Programs	**751**	**288**	**73**	**25%**	**90% ± 9%**

*In order to limit the evaluation burden on customers, we excluded commercial program participants who were targeted for on-site visits from the survey sample. In addition, we sampled enough Commercial Upstream Lighting participants to complete a sufficient number of surveys.

In addition to the participant surveys, we conducted interviews with SEU program managers to improve our understanding of the programs, markets, and key issues (Table 16). The NMR team also completed interviews with key program partners (contractors, distributors, architects, engineers, etc.) who are active in the targeted programs. For the multifamily programs, we also

completed interviews with property managers or developers whose buildings participated in the programs.

Table 16: In-depth Interview Sampling Plan

Program	DCSEU Staff Interviews	Program Partner Interviews	Property Manager Interviews
Commercial Upstream - Lighting	1	7	0
Market Opportunity - Commercial Custom	1	0	0
P4P	1	1	0
Low-income Multifamily Comprehensive	1	1	3
Low-income Prescriptive Rebate	1	1	4
All Evaluated Programs	**5**	**10**	**7**

Section 2 Commercial & Solar Programs

In this section, we present a brief program summary, as well as the methodology, findings, and recommendations from our evaluation of each of the seven Commercial and Solar programs selected for the FY2019 evaluation:

- Retrofit – Custom
- New Construction – Custom
- Market Opportunities – Custom
- CI RX – Equipment Replacement
- Commercial Upstream Lighting
- P4P
- Solar PV Market Rate

2.1 Retrofit – Custom (7520CUST)

The Custom Retrofit Program provides incentives to owners of large buildings to replace equipment in their building with more efficient equipment or make operational changes to their facility that would result in energy savings. The program offers incentives for a variety of equipment types, including lighting, chillers, boilers, heat pumps, steam systems, insulation, refrigeration, and various building or equipment controls. Through this program, DCSEU provides technical assistance to help decision makers design, scope, and fund their projects. Funding is available through a traditional rebate structure, where participants are paid flexible amounts per project, but also through partnerships with lenders in the District who may finance up to 100% of a project's cost.

DCSEU staff provide project support from inception, when possible. Account managers focus on relationship building, especially for large federal accounts. DCSEU provides input on measure implementation. The economic/lifecycle analysis provided by DCSEU staff allows customers to make informed decisions on their projects. As a custom program, DCSEU staff are able to tailor the financial and technical assistance provided to each project with a focus on the long-term customer experience. Quality assurance is implemented for custom projects on a monthly basis. As the program matures and these relationships are cultivated, custom projects find their way to DCSEU, so less outreach is required.

With a limited marketing budget, the program marketing efforts have been focused on supporting customers and disseminating best practices and technologies. For larger customers, DCSEU may participate in engineering meetings and planning. The program formed cohorts with customers, which meet on a quarterly basis to discuss topics, measures, and lessons learned. The cohorts provide a platform for customers to share and gain insights on energy-efficiency measures with their peers. To introduce customers to new technologies, DCSEU holds brown bag meetings to introduce and vet new energy-efficiency technologies.

In FY2019, the program provided incentives for 60 projects. Table 17 provides the breakdown of tracked savings by measure type. The bulk of total energy savings and total electric savings come

from the HVAC and lighting measures. HVAC measures included boilers, heat pumps, unitary air conditioners, chillers, steam trap replacements, furnaces, scheduling, variable refrigerant flow systems, demand control ventilation, comprehensive building commissioning, exhaust fans, and pipe insulation.

Table 17: Custom Retrofit Program Savings Contributions

Measure Type	Percent of FY2019 Combined Energy Savings	Percent of FY2019 Electric Savings	Percent of FY2019 Gas Savings	Percent of FY2019 Peak Demand Savings
HVAC	42%	24%	57%	37%
Lighting	10%	25%	-1%	25%
Motors & Drives	4%	8%	-	7%
Water Heating	0%	-	1%	-
Refrigeration & Appliances	-	1%	-	1%
Comprehensive	24%	33%	17%	23%
Solar PV	-	-	-	-
Industrial	19%	10%	26%	8%

For the FY2019 Custom Retrofit program, we completed the following evaluation activities:

- Gross Savings Verification
- Net Savings Estimation
- Process Evaluation

2.1.1 Gross Savings Verification

Table 18 shows the tracked savings, realization rate, and evaluated savings for the Custom Retrofit program.

Table 18: Custom Retrofit Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2019 Electric Savings (MWh)	49,163	98.1%	48,205
FY2019 Peak Demand Savings (MW)	6.81	77.2%	5.26
FY2019 Gas Savings (MMBtu)	214,375	95.4%	204,458

2.1.1.1 Sampling

Due to the heterogeneous makeup of the program, we assumed a coefficient of variation (C_v) of 0.5 for our initial sample design. With a precision target of ±11% at 80% confidence, this required a selection of 26 unique sample sites. The NMR team designed the sampling plan using stratified random sampling to ensure the evaluation included a diverse mix of measure types. We created a certainty stratum, which ensured that we reviewed the largest projects from the program. The NMR team assigned projects with >4,000,000 kWh of electric savings or >7,000 MMBtu of gas savings to the certainty stratum. We also created a large probability stratum for electric projects with over 500,000 kWh savings, a small probability stratum for the remaining electric projects,

and a small probability gas stratum for smaller gas only projects. We randomly sampled projects from each of the probability strata. The evaluation team created these strata in order to capture as much gross savings as possible with the limited number of sample points. Strategically dividing the sample into size and fuel-based strata ensured that the evaluation team reviewed as many larger projects as possible, while still allowing a random selection of smaller projects. Table 19 presents the final sample for the Custom Retrofit program.

Table 19: Custom Retrofit Sampling Plan

Stratum	Stratum Criteria	Percent of Program Energy Savings	FY2019 Participation	Number of Sampled Sites
Certainty: Electric or Gas	>4,000,000 kWh or >7,000 MMBtu	81%	9	9
Large Probability: Electric only	500,000 kWh to 4,000,000 kWh	9%	7	4
Small Probability: Electric only	≤500,000 kWh	7%	37	10
Small Probability: Gas only	≤7,000 MMBtu	3%	7	3

2.1.1.2 Methodology

The NMR team conducted a desk review for each of the 26 selected sample sites, through which we calculated the evaluated savings. Nine of the 26 desk reviews used additional information gathered from onsite verifications. Each project was analyzed using one of two evaluation methodologies:

- For measures that exist in the TRM, desk reviews used algorithms and assumptions presented in the TRM as a reference for analysis, making methodological adjustments as appropriate for the site-specific information provided. TRM assumptions were overwritten with site-specific data when reliable information was provided to justify the change.
- For measures that did not exist in the TRM, engineers reviewed all submitted documentation and determined the suitability of the equations and assumptions used to calculate the tracked savings. If equations or assumptions were deemed unsuitable, the NMR team overrode them with more appropriate inputs.

The evaluation team used a custom savings calculator designed by the NMR team to facilitate the savings calculations. The custom calculator used the SEU's tracked savings database to look up project-specific inputs based on project number for reported electric, demand, and natural gas savings. The calculator allows for manual input of savings algorithms and provides a table that compares inputs between those used in the tracked savings, those used in the TRM (if applicable), and those deemed appropriate by the evaluating engineer. Figure 1 shows an example of the calculator for a packaged terminal heat pump.

Figure 1: Example of Custom Savings Calculation

Measure 1

Measure: ACEHPPTL
Description: Package terminal heat pump
TRM:
TRM Reference Page:

TRM Algorithms

Energy (kWh):	Cooling Savings + Heating Savings
Demand (kW):	Cooling Savings / cooling hours * QTY * CF
Gas (MMBTU):	

Inputs	TRM	Reported	Verified
Cooling Cap Btu/h		11,800	
Heating Cap Btu/h		10,600	
Baseline IECC 2012			
SEER	13.00		
HSPF	7.7		
EER	10.8		
Proposed			
EER		11.6	
Heating COP		3.16	
HSPF		10.78	
Cooling hours	1275		
Heating hours	667		
CF		0.677	
QTY		28	
kWh savings per unit cooling			96.07
kWh savings per unit heating			262.46
Total kWh saved per unit			359
Total kWh saved		**9,271**	**10,039**
peak kW saved		**2.10**	**1.43**
Cooling Savings Formula			
Savings = (Cooling kBtus/hr)*(1 / EERbase - 1 / EERee)*Coolhrs			
Heating Savings Formula			
Savings = (Heating kBtus/hr)*(1 / HSPFbase - 1 / HSPFee)*Heathrs			

Calculate Savings Below
(Formulae should match those above and use inputs from the verified column)

Energy (kWh)	Summer Demand (kW)	Natural Gas (MMBTU)	Total Savings (MMBTU)
10,039	1.43		34

During the desk review process, our engineers created a custom calculation for each project within the sample. We reviewed all available project documentation and assessed the method of savings analysis used by the DCSEU. If we agreed with the methodology of the analysis, we relied on the same algorithms and verified the inputs. We reviewed each input variable to determine whether it was accurate. We made adjustments to input variables such as hours of use (HOU) or equipment efficiencies if needed, based on the project documentation or site visits. Savings calculations ultimately relied on the verified values. In some cases, the NMR team used a differently methodology to calculate savings, using site specific input variables.

2.1.1.3 Results

The program-wide impact evaluation results for the Custom Retrofit Program are shown in Table 20. The findings that contributed to the realization rates are detailed in the text that follows.

Table 20: Custom Retrofit Program Impact Results

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2019 Electric Savings (MWh)	49,163	98.1%	48,205	±1.3% @ 80%
FY2019 Peak Demand Savings (MW)	6.81	77.2%	5.26	±13.4% @ 80%
FY2019 Gas Savings (MMBtu)	214,375	95.4%	204,458	±0.4% @ 80%

The program-level realization rates are 98% for electric savings, 77% for demand savings, and 95% for natural gas savings. The selected sample ultimately achieved ±1.3% precision at the 80% confidence for electric savings, ±13.4% precision for demand savings, and ±0.4% precision at the 80% confidence level for gas savings.

The evaluation team concluded that significant review went into the custom savings calculations. The documentation provided was thorough, and the methods and assumptions used were suitable.

Custom projects utilized a calculation method prescribed in the SEU tracker. The NMR team calculated savings within the tracker based on the provided inputs. The documentation for the input variables was not consistently included in the project files, though the NMR team was able to locate it in the online tracker. However, the SEU tracker was missing inputs for some projects; therefore, the NMR team could not reproduce savings using equations and assumptions from the DCSEU TRM or the Mid Atlantic TRM. The missing inputs were more common for heat pump measures. As needed, the NMR team performed independent engineering calculations for such projects based on the inputs verified from the project files, supplemented by telephone interviews or site visits performed by our engineers.

The majority of the gas savings adjustments are due to a single certainty stratum project (Project ID 15883). This project achieved an 85% realization rate accounting for 3.8% of the 4.4% reduction in the programs gas savings. This project involved upgrading the burner controls for a large district steam boiler. Program implementation staff initially estimated the savings using the efficiency of the burner measures before and after the upgrades in conjunction with estimated boiler loads from the customer. After further review, the SEU collected some gas meter data for the affected boiler and determined a more accurate loading profile of the affected boiler. However, the claimed savings in the tracking data were not updated to reflect the updated analysis. The evaluation team revised the savings calculation based on actual natural gas usage.

The majority of the demand savings adjustments are due to a single large stratum project (Project ID 15742). This project included the installation of two new chillers. The demand savings achieved a 32% realization rate due to two issues. First, the peak demand savings were calculated by the DCSEU by applying the part load efficiency instead of the full load efficiency of the chiller. Second, the demand savings equation inadvertently included the quantity of boilers, which doubled the calculated demand savings. This one project accounted for 18.6% of all the Custom Retrofit program's demand savings.

Some other observations included a lighting project (Project ID 16497) with coincidence factors (CFs) reduced by nearly one-half based upon the reported operating hours. Another project (Project ID 16857) installed VFDs on pumps. Based on the information collected during a site inspection, the evaluation team found that only one of the two pumps operate at any one time. The *ex ante* savings assumed both pumps would operate simultaneously, thereby overstating the energy and demand savings for this project.

Our sample included three projects with air source heat pumps (Project IDs 15910, 16433, 16434). This measure uses the SEU tracker to calculate savings and the NMR team could not replicate the claimed savings with the default or recorded inputs. Therefore, we estimated savings using the available project documentation and the Mid Atlantic TRM's algorithms. The changes reduced the energy savings and, for some projects, changed the claimed demand penalty to demand savings for heat pumps.

2.1.2 Net Savings Estimation

The NMR team calculated the NTG ratio, which is composed of free-ridership and participant spillover. We estimated free-ridership and participant spillover based on question responses from eight telephone surveys completed with participating Custom Retrofit customers.

2.1.2.1 Free-ridership

We estimated free-ridership based on the following two factors:

- Intention or the expected behavior in the absence of the program; and
- The influence of various program elements on the decision to participate in the program.

Intention

As shown in Table 21, the eight Custom Retrofit program participants received the following scores:

- Two participants reported they would have delayed the measure installation by at least one year. We assigned these respondents a low free-ridership intention score (0%).
- Two other participants said they would have installed the measure but scaled back the scope or efficiency in the absence of the program. We assigned these respondents a moderate free-ridership intention score (25%).
- The other four respondents reported they would have installed the measure with the exact same scope and efficiency in the absence of the program.
    - Three of these four respondents indicated they would have had the funds to cover the entire cost of the measure, so we assigned them a high free-ridership intention score (50%).
    - The other respondent said they might have had the funds available, so we assigned them a moderate-high free-ridership intention score (37.5%).

The overall free-ridership intention score across all eight respondents is 30%.

Table 21: Free-ridership Intention Scoring for Custom Retrofit Program

Intention in the Absence of the Program	Funds Available to Cover the Entire Cost	Assigned Free-ridership Intention Score (%)	Count of Respondents
• Delayed the installation of the measure for at least one year OR • Cancelled the installation of the measure altogether	• Not Asked	0%	2
• Installed the measure but scaled back the scope or efficiency OR • Don't know OR • I'd rather not answer	• Not Asked	25%	2
• Installed the measure with the exact same scope and efficiency	• Definitely would not have had the funds OR • Don't know OR • I'd rather not answer	25%	-
	• Might have had the funds	37.5%	1
	• Definitely would have had the funds	50%	3
Total		**30%**	**8**

Influence

Table 22 displays the influence rating of various program features on participants' decision to install the measure, using a 1 to 5 scale, where 1 means it "played no role at all" and 5 means it "played a great role." The Custom Retrofit program features with the highest average ratings include the rebate (4.6, on average), prior program experience (4.3) and information or recommendations from contractors/suppliers (3.2).

Table 22: Influence of DCSEU program features for Custom Retrofit Program

Features	n[1]	1 Played no role at all	2	3	4	5 Played a great role	Average Rating
The financial incentive/rebate	7	-	-	1	1	5	4.6
Previous experience with a DCSEU program	7	1	-	-	1	5	4.3
Information or recommendation from contractors or suppliers associated with the program	6	1	2	-	1	2	3.2
Information provided by a DCSEU representative	5	1	1	1	2	-	2.8
DCSEU program marketing materials about the program	5	2	-	2	1	-	2.4
Results of DCSEU audits or technical studies	4	2	1	1	-	-	1.8

[1] Sample sizes exclude those who said, “Not applicable” or “I’m not sure.”

The NMR team assigned each respondent a free-ridership influence score based on the highest rating they provided for any of the above program features. Most Custom Retrofit program respondents (6 of 8) indicated that at least one program feature played a great role in their decision, so we assigned them a free-ridership influence score of 0% (Table 23). A single respondent provided a maximum rating of 4.0, so we assigned them a free-ridership influence score of 12.5%. Another respondent gave a maximum rating of 1.0, resulting in a free-ridership influence score of 50%.

The overall free-ridership influence score across all eight respondents is 8%.

Table 23: Free-ridership Influence Scoring for Custom Retrofit Program

Maximum Influence Rating	Assigned Free-ridership Influence Score (%)	Count of Respondents
5 - program feature played a great role	0%	6
4	12.5%	1
3	25%	-
2	37.5%	-
1 - program feature played no role OR Not Applicable	50%	1
Don’t know OR Refused	25%	-
Total	**8%**	**8**

For each respondent, we summed the free-ridership intention score and the free-ridership influence score to yield a cumulative free-ridership rate. We calculated both unweighted and savings-weighted free-ridership values, where we applied a weight based on the measure with the most tracked total energy savings associated with the project. The average unweighted free-ridership rate was 38% and the average weighted free-ridership rate for the Custom Retrofit program was 30% (Table 24).

Table 24: FY2019 Free-ridership Rate for Custom Retrofit Program

	Average	Minimum	Maximum
Free-ridership (unweighted)	38%	0%	100%
Free-ridership (savings-weighted)	30%	0%	100%

The FY2018 free-ridership rate (56%) for the Custom Retrofit program was 26 points higher than the FY2019 free-ridership rate presented above (30%); however, the sample size in FY2018 was three times larger (25 respondents versus 8 respondents). Given the small sample sizes, in particular for FY2019, we recommend combining the results from both years through a savings-weighted approach. This approach produces a recommended free-ridership rate of 48% (Table 25).

Table 25: FY2018-FY2019 Free-ridership Rate for Custom Retrofit Program

	Sample Size	Percent of Sampled Energy Savings	Free-ridership Rate
FY2018	25	70%	56%
FY2019	8	30%	30%
Weighted Average			**48%**

2.1.2.2 Participant Spillover

None of the FY2019 Custom Retrofit program participants reported installing energy-efficient or renewable energy equipment at a DC location after their Custom Retrofit program project, so the spillover rate for FY2019 alone is 0% (Table 26). However, in FY2018, spillover savings represented 1% of the cumulative tracked savings across both FY2018 and FY2019. Therefore, we recommend a spillover rate of 1% for FY2019.

Table 26: FY2018-FY2019 Spillover Rate for Custom Retrofit Program

	Sample Size	Percent of Sampled Energy Savings	Spillover Rate
FY2018	25	70%	1%
FY2019	8	30%	0%
Weighted Average			**1%**

2.1.2.3 NTG Ratio

The savings-weighted NTG ratio for the Custom Retrofit program equals 53% (Table 27).

Table 27: FY2018-FY2019 NTG Ratio for Custom Retrofit Program

	Free-ridership	Participant Spillover	NTG (1 – FR + PSO)
Net-to-Gross Ratio	48%	1%	53%

2.1.3 Process Evaluation

For the process evaluation of the Custom Retrofit program, the NMR team completed telephone surveys with eight program participants (Table 28). The results from this evaluation activity are presented below.

Table 28: Custom Retrofit Process Evaluation Activities

Stakeholder	Completed
Participant surveys	8

2.1.3.1 Key Findings

The process evaluation of the Custom Retrofit program produced the following key findings:

- Program satisfaction is high. On a scale from 1 to 5, where 1 is "not at all satisfied" and 5 is "very satisfied," participants rated the program a 4.5, on average.
- We asked participating end users to rate the likelihood of recommending the program to others using a scale of 0 to 10, where 0 means "extremely unlikely" and 10 means "extremely likely." This rating, or net-promoter score (NPS), is a well-established measure of customer loyalty. First, respondents are grouped as *promoters* (score 9-10), *passives* (7-8), and *detractors* (0-6). The NPS is calculated by subtracting the percentage of detractors from the percentage of promoters and is presented as a whole number. The NPS for the Custom Retrofit program was 88, with nearly all respondents (7 of 8) providing *promoter* ratings. This was a ten-point increase from FY2018, where NPS was 78.
- Participants were satisfied with the technical assistance they received from DCSEU (4.6, on average). DCSEU staff take an active role in helping participants with their applications – a concern from the FY2018 evaluation. Moreover, respondents overall had a fairly positive experience with the preapproval and application process, finding the application easy to complete and providing strong satisfaction ratings.
- Similar to findings in FY2018, the FY2019 respondents were least satisfied with incentive amounts compared to other features, rating it a 3.8. In fact, two respondents recommended increasing program incentive levels and/or caps.
- Aside from increasing incentive levels, participants had only two recommendations for improving the program. One respondent suggested expanding the pool of vendors.[4] The second respondent felt that program staff should respond to participant inquiries more quickly. All participants indicated that they would consider involving DCSEU in future energy-efficiency or renewable energy projects, further affirming participants' overall positive experience with the program.

2.1.3.2 Program Satisfaction

Program satisfaction is high:

- On a scale from 1 to 5, where 1 is "not at all satisfied" and 5 is "extremely satisfied," the eight participants rated the program a 4.5, on average. This is consistent with FY2018, where the average satisfaction rating was a 4.6. Table 29 shows their satisfaction ratings in detail.

[4] Though, program documentation does not indicate that the program limits who customers can work with. Program staff confirmed that DCSEU might send vendor information at a customer's request, but the program is vendor neutral and sends the customer at least three vendor recommendations.

- On a scale from 0 to 10, where 0 is "extremely unlikely" and 10 is "extremely likely," the eight participants rated their likelihood to recommend the program to someone else a 9.5, on average. The NPS for the program among participating end users was 88. This is a ten-point increase from FY2018 where the NPS was 78. Overall, seven of the eight FY2019 respondents were *promoters* – that is, these participating end users may actively promote the program to other potential participants by word of mouth. The other respondent was *passive*, rating their likelihood to recommend the program to someone else an 8.0.
- Participants rated their satisfaction with the incentive amount a 3.8, on average – the lowest-rated satisfaction score among all program features measured (Table 29). In FY2018, satisfaction with the incentive amount was also the lowest rated feature (4.2, on average).

Table 29: Participant Satisfaction with the Custom Retrofit Program

Feature	n[1]	1 Not at all satisfied	2	3	4	5 Very Satisfied	Average Rating
Your experience overall	**8**	**-**	**-**	**1**	**2**	**5**	**4.5**
Assistance from the installation contractor	3	-	-	-	-	3	5.0
Technical assistance from DCSEU	7	-	-	1	1	5	4.6
Energy savings from new equipment	8	-	-	-	3	5	4.6
Time to receive the rebate or incentive	6	-	-	1	1	4	4.5
Performance of the new equipment	8	-	-	1	2	5	4.5
The application process	7	-	-	1	2	4	4.4
The preapproval process	7	-	-	1	2	4	4.4
The type of eligible equipment	8	-	-	1	4	3	4.3
Information about DCSEU offerings	7	-	-	2	3	2	4.0
The rebate or incentive amount	8	-	-	4	2	2	3.8

[1] Sample size varies because results exclude those who said, "Not applicable" or "I'm not sure."

2.1.3.3 Program Administration

Participants had a relatively positive experience with the application process, rating their satisfaction with it a 4.4, on average. Six of the eight participants completed their own applications. On a scale from 1 to 5, where 1 is "very difficult" and 5 is "very easy," they rated their ease of completing the application a 4.3, on average. Five of these six respondents received help from DCSEU.[5]

[5] In FY2018, program partners recommended that DCSEU staff play a more active role in helping participants through the application process.

Two participants recommended ways to improve program administration:

- One participant recommended that the program recruit a broader pool of vendors.
- One participant recommended that DCSEU staff respond more quickly to inquiries.

The respondent who recommended faster response time was less satisfied with many of the program features compared to other participants. This respondent rated most aspects of program administration, such as the application and preapproval processes and technical assistance provided by DCSEU staff, as a 3.0. Nonetheless, participants on the whole rated the technical assistance they received from DCSEU a 4.6, on average.

2.1.3.4 Incentives

Participants had the same concerns as they did in the FY2018 evaluation. Participants were least satisfied with incentive amounts, with four of the eight respondents rating it a 3.0. When we asked them if they had any suggestions for improving the program, two out of eight participants specifically recommended increasing incentives. One respondent believed that the incentive cap should increase.

2.1.3.5 Drivers of and Barriers to Participation

Participants reported the reasons they were driven to participate:

- All eight participants were driven to participate to save money on equipment, energy costs, or maintenance costs. All eight respondents reported that they realized equipment and maintenance cost savings, though one participant did not realize savings on energy costs.
- Six participants were also driven by a goal to install more reliable equipment; all six (plus one other) reported that they realized this goal.
- Six participants also sought to increase productivity; two reported achieving that goal.
- Six participants hoped to improve the work environment through participation in the program; four (plus two others) reported that they realized this goal.

None of the eight participants reported facing any hurdles when deciding to implement the primary measure through the Custom Retrofit program. Looking forward, participants were eager to continue their involvement with DCSEU:

- Four of the eight participants had plans for energy-efficient or renewable energy improvements in the next two years.
- All eight participants indicated that they would consider involving DCSEU in any future plans. Three of the eight participants requested information on other programs.
- Three participants also requested that DCSEU continue offering programs and rebates. One participant reiterated a preference for higher rebates.

2.1.4 Recommendations

Based on the findings of our analysis, we offer the following recommendations for the Custom Retrofit program:

- Although the provided documentation and level of M&V rigor was adequate for the majority of the projects, the NMR team discovered some errors. We recommend that the DCSEU review the issues identified in this report to ensure a satisfactory level of review for all projects and investigate larger projects in greater detail.
- Consider secondary calculations and more quality control checks for projects with greater uncertainty to ensure that the claimed savings are reasonable and are not near or greater than the system's baseline consumption.
- Calculate demand savings independently of energy savings for projects that operate 8760 hours per year. Computing demand profiles requires additional inputs, which may not be readily available or easily derived from the energy savings.
- Request additional information from customers on the rationale behind control changes that result in significant energy savings. Ensure that the control changes will satisfy the facility's operational requirements to reduce the likelihood of control strategies being rolled back in the future, leading to reduced savings.
- Ensure that the SEU tracker includes sufficient documentation on both standard and nonstandard inputs required to reproduce the saving calculations.
- Consider developing and labeling savings estimates as "pre-application" or "in-progress" and a separate "finalized" field to avoid scenarios where final project savings are not updated in the tracking database. Similarly, for very large projects, requiring sign off on the final savings by the staff analyst responsible for the project can help avoid situations where updated savings calculations are not fully communicated.
- Consider collecting more details during post inspections. The post inspection can be used not only to verify the installation of rebated equipment, but also to confirm operational information such as equipment schedules or setpoints.
- Consider establishing guidelines for post inspection timing. For controls changes and other building commissioning measures, completing the post inspection several months after project completion may allow the DCSEU to identify situations where the customers anticipated actions were not fully implemented.
- Incentive amounts continue to be an area of concern. The program may wish to reassess whether incentive levels can increase for any measures with limited traction but high potential savings. Furthermore, DCSEU might wish to explore the impact of raising incentive caps.
- Only one respondent expressed disappointment with program staff's responsiveness; however, this feedback merits attention. The technical support that the program provides has been well received and is a cornerstone of the Custom Retrofit program. DCSEU should ensure frequent and clear communication with all participants so that its strong technical assistance efforts are available to all.

2.2 NEW CONSTRUCTION – CUSTOM (7520NEWC)

The new construction program provides incentives to building owners who build new facilities that exceed energy code standards. Through this program, DCSEU provides technical assistance to help decision makers design, scope, and fund their projects. New construction projects cover a multitude of building systems, including lighting; HVAC; building controls; building envelope elements, such as insulation and windows; and plug loads, such as icemakers, refrigerators, and freezers. Most of the buildings applying for funding also seek LEED certification.

Program staff focus on the long-term customer experience and aim to provide technical assistance during the project design phase. The DCSEU's role in these projects is primarily to provide guidance and direction. Account managers cultivate customer relationships, which enable DCSEU to be brought in early on projects. As the program has matured and these relationships developed, custom projects find their way to DCSEU, so less outreach is required.

With a limited marketing budget, outreach efforts for the Commercial New Construction program have been focused on supporting customers and disseminating best practices and technologies. To introduce customers to new technologies, DCSEU holds brown bag meetings with interested stakeholders to introduce and vet new energy-efficiency technologies. The DCSEU also collaborates with other DC government programs to spread the word about this program. Customers may be directed to the DCSEU program from the DC Department of Regulatory Affairs (DCRA), the DC Department of Energy and Environment (DOEE), or the DC PACE program.

In FY2019, the program provided incentives for 22 projects. Table 30 provides the breakdown of tracked savings by measure type. The bulk of total energy savings and total electric savings reside with HVAC and lighting measures. HVAC measures included boilers; heat pumps; unitary air conditioners; chillers; steam trap replacements; furnaces; scheduling, including controls for lighting and HVAC; variable refrigerant flow systems; demand control ventilation; comprehensive building commissioning; exhaust fans; and pipe insulation.

Table 30: New Construction Custom Program Savings Contributions

Measure Type	Percent of FY2019 Combined Energy Savings	Percent of FY2019 Electric Savings	Percent of FY2019 Gas Savings	Percent of FY2019 Peak Demand Savings
HVAC	56%	51%	62%	48%
Lighting	11%	21%	-1%	10%
Motors & Drives	1%	3%	-	8%
Water Heating	8%	4%	14%	-
Refrigeration & Appliances	11%	6%	16%	3%
Comprehensive	12%	15%	8%	32%

For the FY2019 New Construction Custom program, we completed the following evaluation activity:

- Gross Savings Verification

2.2.1 Gross Savings Verification

Table 31 shows the tracked savings, realization rate, and evaluated savings for the program. The electric savings realization rate was 101%, the demand savings realization rate was 103%, and the natural gas savings realization rate was 97%.

Table 31: New Construction Custom Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2019 Electric Savings (MWh)	7,808	101.4%	7,914
FY2019 Peak Demand Savings (MW)	1.95	103.4%	2.01
FY2019 Gas Savings (MMBtu)	23,946	96.8%	23,180

2.2.1.1 Sampling

Due to the heterogeneous makeup of the program, we assumed a coefficient of variation (C_v) of 0.5 for our initial sample design. With a precision target of ±20% at 80% confidence, this required a selection of eight unique sample sites. The NMR team designed the sampling plan utilizing a stratified random sample to ensure the evaluation included a diverse mix of measure types. We created a certainty stratum, which ensured that we reviewed the largest projects from the program. Projects that had more than 5,000 MMBTU of total energy savings were assigned to the certainty stratum. We also had a probability stratum, from which we drew a random sample. Table 32 presents the final sample for the program.

Table 32: New Construction Custom Sampling Plan

Stratum	Percent of Program Energy Savings	FY2019 Participation	Number of Sampled Sites
Certainty	46%	4	4
Probability	54%	18	4

2.2.1.2 Methodology

The NMR team conducted a desk review for each of the selected sample sites, through which we calculated the evaluated savings. Some of the desk reviews used additional information gathered from onsite verifications. Each project was analyzed using one of two evaluation methodologies:

- The NMR team modeled the majority of new construction projects using a building simulation software, such as EQuest or OpenStudio. For these types of projects, the NMR team reviewed the modeling inputs and building systems against available construction and design documents. The NMR team compared the HVAC and lighting systems to the information provided in the project documentation and checked the systems against applicable building codes to confirm that they were more efficient than code minimums by the claimed amount.
- The NMR team used a custom savings calculator to aggregate the savings derived from building models. For lighting measures that provided detailed information on individual lighting fixtures, such as HOU, location, and wattages, the NMR team created the savings calculations using the calculator. A sub-set of sampled projects also received onsite verification. For the FY2019 evaluation, the NMR team selected three projects for site

verifications from within the certainty stratum. While onsite, the NMR team verified that the efficiencies, capacities, and quantities of the equipment matched the inputs for these systems in the simulation models. The NMR team also confirmed the date of the building construction documents to ensure that the correct code baselines were applied.

The measures included in the sampled projects included lighting, space heating, air conditioning, motor efficiency, ventilation, comprehensive building-wide savings and hot water conservation, refrigeration, and water flow fixtures.

2.2.1.3 Results

The program-wide impact evaluation results are shown in Table 33. The findings that contributed to deviations in the realization rates are described in the text that follows.

Table 33: New Construction Custom Program Impact Results

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2019 Electric Savings (MWh)	7,808	101.4%	7,914	±1.8% @ 80%
FY2019 Peak Demand Savings (MW)	1.95	103.4%	2.01	±9.2% @ 80%
FY2019 Gas Savings (MMBtu)	23,946	96.8%	23,180	±1.8% @ 80%

The program-level realization rates are 101% for electric savings, 103% for demand savings, and 97% for natural gas savings. The selected sample ultimately achieved a ±1.8% precision at 80% confidence for electric savings, ±9.2% precision for demand savings, and ±1.8% precision gas savings.

The evaluation team concluded that significant review went into the new construction models and calculations. The documentation provided was thorough, and the methods and assumptions used were suitable.

The DCSEU made several scaling adjustments to the models to account for changes to codes for projects that were not grandfathered into older codes, specifically from ASHRAE 90.1 2007 to 2010. Scaling adjustments account for efficiency changes between building codes. As an example, between 2007 and 2010, more efficient lighting power density is required, so a scaling factor would be applied to the lights to adjust the lighting power density accordingly. If a project submitted initial building construction documents within one year of the date when a new code took effect, the DC building codes commission deemed it acceptable for the project to be grandfathered into the older building codes. The NMR team believes these analyses were handled with the correct amount of rigor and that the tracked energy savings are calculated with a high degree of accuracy.

All eight sampled new construction projects had a total energy realization rate that was between 95% and 101%. However, the NMR team's verification uncovered three project-level errors that resulted in electric, demand, or gas realization rates less than or greater than 100%. The findings for these three projects are described below.

- One project appeared to use a single facility-wide operating hours value to calculate lighting savings instead of specific HOU by space type based on the data provided by the customer (Project ID 16859).
- A large difference between the reported and evaluated lighting and custom ventilation peak demand savings could not be explained (Project ID 16677). It is possible the peak savings differ due to load shape differences.
- One project (Project ID 15467) had lower evaluated savings for VFDs on air handling unit fans because, during a site visit, the evaluator found that VFDs were not installed on supply fans. The project's statement of work stated VFDs were installed on supply and return air fans.

2.2.2 Recommendations

Based on the findings of our evaluation, we offer the following recommendations for the New Construction Custom program:

- Verify that the appropriate building specific load shapes are applied to each new construction project and that this information is properly documented.
- Apply site specific parameters when available, such as HOU values.

2.3 Market Opportunities – Custom (7520MARO)

The Market Opportunities program provides incentives to owners of large buildings who replace equipment in their building with more efficient equipment or make operational changes to their facility that would result in energy savings. The program offers incentives for a variety of equipment types, including lighting, chillers, boilers, heat pumps, steam systems, insulation, refrigeration, and various building or equipment controls. Through this program, DCSEU provides technical assistance to help decision makers design, scope, and fund their projects. Funding is available through a traditional rebate structure where participants are paid per unit of energy saved.

In FY2019, the program provided incentives for 32 projects. Table 34 provides the breakdown of tracked savings by measure type. The bulk of total energy savings and total electric savings reside with HVAC measures, which included heat pumps, boilers, whole-building insulation, window improvements, unitary air conditioners, and chillers.

Table 34: Market Opportunities Program Savings Contributions

Measure Type	Percent of FY2019 Combined Energy Savings	Percent of FY2019 Electric Savings	Percent of FY2019 Gas Savings	Percent of FY2019 Peak Demand Savings
HVAC	57%	30%	102%	35%
Lighting	15%	26%	-4%	46%
Motors & Drives	17%	27%	-	9%
Water Heating	3%	3%	2%	1%
Refrigeration & Appliances	4%	6%	-	1%
Comprehensive	1%	2%	-	2%
Solar PV	3%	5%	-	7%

For the FY2019 Market Opportunities program, we completed the following evaluation activities:

- Gross Savings Verification
- Net Savings Estimation
- Process Evaluation

2.3.1 Gross Savings Verification

Table 35 shows the tracked savings, realization rate, and evaluated savings for the Market Opportunities program. Overall, the evaluation found the tracked savings to be calculated with a high degree of accuracy with the exception of a single project. The electric realization rate was 90%, the demand realization rate was 108%, and the gas realization rate was 100%.

Table 35: Market Opportunities Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2019 Electric Savings (MWh)	5,255	90.0%	4,735
FY2019 Peak Demand Savings (MW)	0.87	107.7%	0.93
FY2019 Gas Savings (MMBtu)	10,666	99.7%	10,633

2.3.1.1 Sampling

Due to the heterogeneous makeup of the program, we assumed a coefficient of variation (C_v) of 0.5 for our initial sample design. With a precision target of ±20% at 80% confidence, this required a selection of nine unique sample sites. The NMR team designed the sampling plan using stratified random sampling to ensure the evaluation included a diverse mix of savings magnitudes and measure types – including refrigeration, motors, and appliances. We created a certainty stratum, which ensured that we reviewed the largest projects. The NMR team assigned projects with more than 1,000,000 kWh savings or 5,000 MMBTU in gas savings to the certainty stratum. We also had a large and small probability stratum from which we drew a random sample. The large probability stratum included non-certainty projects with more than 500,000 kWh of electric savings or 1,000 MMBTU of gas savings. Stratifying by size allowed the evaluation team to capture as much of the gross energy and fuel savings as possible with the limited number of sample points allocated to the program. Table 36 presents the final sample.

Table 36: Market Opportunities Sampling Plan

Stratum	Stratum Criteria	Percent of Program Energy Savings	FY2019 Participation	Number of Sampled Sites
Certainty	>1,000,000 kWh or >5,000 MMBtu	38%	2	2
Large Probability	500,000 to 1,000,000 kWh or 1,000 to 5,000 MMBtu	27%	3	2
Small Probability	<500,000 kWh or <1,000 MMBtu	35%	27	5

2.3.1.2 Methodology

The NMR team conducted a desk review for each of the selected sample sites, through which we calculated the evaluated savings. The NMR team analyzed each project using one of two evaluation methodologies:

- For measures that exist in the TRM, desk reviews used algorithms and assumptions presented in the TRM as a reference for analysis, making methodological adjustments as appropriate for the site-specific information provided. The NMR team overwrote the TRM assumptions with site-specific data when enough information was provided to justify the change.
- For measures that did not exist in the TRM, engineers reviewed all submitted documentation and determined the suitability of the equations and assumptions used to calculate the tracked savings. If the NMR team deemed equations or assumptions unsuitable, we overrode them with more appropriate inputs.

The NMR team used a custom savings calculator to facilitate the savings calculations. The custom calculator used the SEU's tracked savings database to look up project-specific inputs based on project number for reported electric, demand, and natural gas savings. The calculator allows for manual input of savings algorithms and provides a table that compares inputs between those used in the tracked savings, those used in the TRM (if applicable), and those deemed appropriate by the evaluating engineer. Figure 2 shows an example of the calculator used for a package terminal heat pump.

Figure 2: Example of Custom Savings Calculation

Measure 1

Measure: ACEHPPTL
Description: Package terminal heat pump
TRM:
TRM Reference Page:

TRM Algorithms

Energy (kWh):	Cooling Savings + Heating Savings
Demand (kW):	Cooling Savings / cooling hours * QTY * CF
Gas (MMBTU):	

Inputs	TRM	Reported	Verified
Cooling Cap Btu/h		11,800	
Heating Cap Btu/h		10,600	
Baseline IECC 2012			
SEER	13.00		
HSPF	7.7		
EER	10.8		
Proposed			
EER		11.6	
Heating COP		3.16	
HSPF		10.78	
Cooling hours	1275		
Heating hours	667		
CF		0.677	
QTY		28	
kWh savings per unit cooling			96.07
kWh savings per unit heating			262.46
Total kWh saved per unit			359
Total kWh saved		**9,271**	**10,039**
peak kW saved		**2.10**	**1.43**
Cooling Savings Formula			
Savings = (Cooling kBtus/hr)*(1 / EERbase - 1 / EERee)*Coolhrs			
Heating Savings Formula			
Savings = (Heating kBtus/hr)*(1 / HSPFbase - 1 / HSPFee)*Heathrs			

Calculate Savings Below
(Formulae should match those above and use inputs from the verified column)

Energy (kWh)	Summer Demand (kW)	Natural Gas (MMBTU)	Total Savings (MMBTU)
10,039	1.43		34

During the desk review process, our engineers created a calculator for each project within the sample. The engineer reviewed all available project documentation and assessed the method of analysis. If we agreed with the methodology of the analysis, then we relied on the same algorithms. We reviewed each variable to determine whether it was accurate. We also made adjustments to variables such as HOU or equipment efficiencies that we were able to find throughout the project documentation. Savings calculations ultimately relied on the verified values.

2.3.1.3 Results

The program-wide impact evaluation results for the Market Opportunities Program are shown in Table 37. The findings that contributed to the realization rates are described in the text that follows.

Table 37: Market Opportunities Program Impact Results

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2019 Electric Savings (MWh)	5,255	90.0%	4,735	±3.5% @ 80%
FY2019 Peak Demand Savings (MW)	0.87	107.7%	0.93	±12.2% @ 80%
FY2019 Gas Savings (MMBtu)	10,666	99.7%	10,633	±0.3% @ 80%

The program-level realization rates are 90% for electric savings, 108% for demand savings, and 100% for natural gas savings. The selected sample ultimately achieved a ±3.5% precision for electric savings, ±12.2% for demand savings, and ±0.3% for gas savings with an 80% confidence level.

The evaluation team concluded that significant review went into the custom savings calculations. The documentation provided was thorough, and the methods and assumptions used were suitable. The evaluation team believes these analyses were handled with the correct amount of rigor and that the tracked energy savings were calculated with a high degree of accuracy.

Custom projects utilizing a prescribed calculation method used the SEU online tracking application. The tracking application is an electronic record keeping, file storage, and savings calculation platform that the SEU utilizes across the portfolio. The savings are calculated within the tracker based on the provided inputs. The sources of the inputs were not provided in the project documentation, though the NMR team was able to locate the inputs in the online tracker for most projects. However, for several sampled projects, the evaluation team found the SEU tracker was missing inputs. The evaluation team attempted to reproduce the savings using the regional Mid Atlantic TRM as a guide, but was not able to for most heat pump projects. As needed, the NMR team performed independent engineering calculations for such projects based on the inputs verified from the project files, SEU tracker, and supplemented by telephone interviews or site visits performed by our engineers.

The majority of the electric savings adjustments to this program are from a single certainty strata project (Project ID 17539). This project accounted for 20% of the electric savings for the program and achieved a 55% realization rate accounting for 8.9% of the 10% reduction in the programs electric savings. This project installed VFDs on numerous supply and return fans. The fans were to reduce from 24 hours per day of full speed operation to only eight hours per day of full speed operation. Upon completion of the site visit and review of the control system, the NMR team found that the fans operate at full speed for 13 hours per day and, when they do reduce speed, we found that they reduce to a lesser extent than assumed.

The demand savings were increased by two small probability projects. The first (Project ID 16945) is a lighting project, where we reduced verified fixture wattages based upon the provided specification sheets. The CF was also changed from 0.61 to 1.0 based on the lights being on from 6:00 AM to 8:00 PM, thereby increasing the peak demand savings.

The second project (Project ID 17191) has multiple measures with small adjustments to the peak demand savings though the largest adjustment is from the air source heat pump. This measure uses the SEU tracker to calculate the savings; however, several of the inputs were inconsistent with the calculated ex ante savings. The NMR team could not reproduce the heat pump savings, so we estimated savings using the available project documentation and technical assumptions from the Mid Atlantic TRM. Applying the Mid Atlantic TRM technical assumptions resulted in the evaluation team reducing the energy savings but changing the demand penalty to demand savings.

2.3.2 Net Savings Estimation

The NMR team calculated the NTG ratio, which is composed of free-ridership and participant spillover. We estimated free-ridership and participant spillover based on question responses from 12 telephone surveys completed with participating Market Opportunities customers.

2.3.2.1 Free-ridership

We estimated free-ridership based on the following two factors:

- Intention or the expected behavior in the absence of the program; and
- The influence of various program elements on the decision to participate in the program.

Intention

As shown in Table 38, the 12 Market Opportunities program participants received the following scores:

- Four participants reported they would have delayed the measure installation by at least one year or canceled the installation in the absence of the program. We assigned these respondents a low free-ridership intention score (0%).
- Three other participants said they would have installed the measure but scaled back the scope or efficiency in the absence of the program. We assigned these respondents a moderate free-ridership intention score (25%).
- The other five respondents reported they would have installed the measure with the exact same scope and efficiency in the absence of the program but would have had the funds to cover the entire cost of the measure, so we assigned them a high free-ridership intention score (50%).

The overall free-ridership intention score across all 12 respondents is 27%.

Table 38: Free-ridership Intention Scoring for Market Opportunities Program

Intention in the Absence of the Program	Funds Available to Cover the Entire Cost	Assigned Free-ridership Intention Score (%)	Count of Respondents
• Delayed the installation of the measure for at least one year OR • Cancelled the installation of the measure altogether	• Not Asked	0%	4
• Installed the measure but scaled back the scope or efficiency OR • Don't know OR • I'd rather not answer	• Not Asked	25%	3
• Installed the measure with the exact same scope and efficiency	• Definitely would not have had the funds OR • Don't know OR • I'd rather not answer	25%	-
	• Might have had the funds	37.5%	-
	• Definitely would have had the funds	50%	5
Total		**27%**	**12**

Influence

Table 39 displays the influence rating of various program features on participants' decision to install the measure, using a 1 to 5 scale, where 1 means it "played no role at all" and 5 means it "played a great role." The Market Opportunities program features with the highest average ratings include prior program experience (3.9, on average) and the rebate (3.6).

Table 39: Influence of DCSEU Program Features for Market Opportunities Program

Features	n	1 Played no role at all	2	3	4	5 Played a great role	Average Rating
Previous experience with a DCSEU program	8	1	-	2	1	4	3.9
The financial incentive/rebate	11	2	1	1	2	5	3.6
DCSEU program marketing materials about the program	10	4	-	1	1	4	2.9
Information provided by a DCSEU representative	11	4	1	1	2	3	2.9
Information or recommendation from contractors or suppliers associated with the program	11	3	-	-	2	6	3.7
Results of DCSEU audits or technical studies	9	7	-	1	-	1	1.7

[1] Sample sizes exclude those who said, “Not applicable” or “I’m not sure.”

The NMR team assigned each respondent a free-ridership influence score based on the highest rating they provided for any of the above program features (Table 40):

- Most Market Opportunities program respondents (9 of 12) indicated that at least one program feature played a great role in their decision, so we assigned them a free-ridership influence score of 0%.
- Two respondents provided a maximum rating of 4.0, so we assigned them a free-ridership influence score of 12.5%.
- The other respondent said that all program features were inapplicable to them because they installed the measure before applying for the program rebate. Therefore, we assigned 50% for their free-ridership influence score.

The overall free-ridership influence score across all 12 respondents is 6%.

Table 40: Free-ridership Influence Scoring for Market Opportunities Program

Maximum Influence Rating	Assigned Free-ridership Influence Score (%)	Count of Respondents
5 - program feature played a great role	0%	9
4	12.5%	2
3	25%	-
2	37.5%	-
1 - program feature played no role OR Not Applicable	50%	1
Don’t know OR Refused	25%	-
Total	**6%**	**12**

For each respondent, we summed the free-ridership intention score and the free-ridership influence score to yield a cumulative free-ridership rate. We calculated both unweighted and savings-weighted free-ridership values, where we applied a weight based on the measure with the most tracked total energy savings associated with their project. The average unweighted free-ridership rate was 33% and the average weighted free-ridership rate for the Market Opportunities program was 36% (Table 41).

Table 41: Free-ridership Rate for Market Opportunities Program

	Average	Minimum	Maximum
Free-ridership (unweighted)	33%	0%	100%
Free-ridership (savings-weighted)	36%	0%	100%

2.3.2.2 Participant Spillover

One participant reported installing energy-efficient or renewable energy equipment at a DC location after their Market Opportunities project (Table 42). These installations did not receive an incentive, according to the respondent. The respondent reported installing 2,000 light bulbs[6] and rated the program's influence on their decision at a 5.0 on a 1 to 5 scale, where 1 means "no influence at all" and 5 means "great influence." Based on that rating, we assigned them a spillover influence score of 100%.

Table 42: Spillover Influence Scores for Market Opportunities Program

Influence Rating	Assigned Influence Score (%)	Spillover Measures	Count of Respondents
Rating of 2 (some influence)	25%	-	-
Rating of 3	50%	-	-
Rating of 4	75%	-	-
Rating of 5 (great influence)	100%	Light bulbs	1
Respondent does not know how much influence	50%	-	-

We estimated the savings associated with these light bulbs (assuming they were LEDs) and applied the spillover influence score (100%) to estimate the total spillover savings. We then divided that estimate by the cumulative tracked savings across all 12 survey respondents to calculate the spillover rate for the program. This resulted in a spillover rate of 14% for the Market Opportunities program (Table 43).

Table 43: Spillover Rate for Market Opportunities Rate Program

	Average	Minimum	Maximum
Spillover Rate	14%	0%	389%

[6] We reviewed the survey data for this organization and found the reported facility size was 200,000 s.f. to 500,000 s.f. In addition, a website search revealed the organization has a campus with multiple buildings. Therefore, the estimate of 2,000 bulbs seems credible. We also confirmed the organization did not receive incentives for LEDs through any DCSEU programs in FY2019 or FY2020 (to date).

2.3.2.3 NTG Ratio

The savings-weighted NTG ratio for the Market Opportunities program equals 79%, after rounding (Table 44).

Table 44: NTG Ratio for Market Opportunities Program

	Free-ridership	Participant Spillover	NTG (1 – FR + PSO)
Net-to-Gross Ratio	36%	14%	79%

2.3.3 Process Evaluation

For the process evaluation of the Market Opportunities program, the NMR team conducted IDIs with program staff and surveyed 12 participants via a telephone survey (Table 45).

Table 45: Market Opportunities Program Evaluation Activities

Stakeholder	Completed
Program staff interview	1
Participant surveys	12

2.3.3.1 Key Findings

These were the key findings from the process evaluation of the Market Opportunities program:

- Program satisfaction was high. On a scale from 1 to 5, where 1 is "not at all satisfied" and 5 is "very satisfied," the 12 participants rated their satisfaction with the program overall a 4.6, on average. The NPS[7] for the Market Opportunities program was 83, with nearly all participants (11 of 12) providing *promoter* ratings.
- Participants typically enter the program following participation in other DCSEU programs; however, vendors are a key mechanism for increasing participation levels. In fact, according to program staff, vendors were critical in the success of a recent program campaign.
- While program staff expressed concerns that some customers may be deterred by the effort and documentation required to participate, participants reported positive experiences. On a scale from 1 to 5, where 1 is "very difficult" and 5 is "very easy," they rated the ease of completing the application a 4.0, on average.
- The Market Opportunities' technical support efforts are comprehensive and seek to connect with participants at a variety of levels and stages. Program staff believed that technical assistance is a highlight of the program. The seven participants who recalled receiving DCSEU technical support agreed, rating their satisfaction as a 4.9 – the highest average satisfaction rating for any program feature.

[7] The NPS is a well-established measure of customer loyalty. Using a scale of 0 to 10, where 0 is "extremely unlikely" and 10 is "extremely likely," respondents are asked how likely they are to recommend the program to someone else. Respondents are then grouped as promoters (score 9-10), passives (7-8), and detractors (0-6). The NPS is calculated by subtracting the percentage of detractors from the percentage of promoters and is presented as a whole number.

- Participants are fairly satisfied with program incentive amounts (4.3 rating, on average). However, program staff wondered if incentive rates would be able to keep pace with increasing levels of program saturation once the low-hanging fruit have been captured. Two participants who were dissatisfied with incentive amounts explained that returns on investment seem inadequate.

2.3.3.2 Program Satisfaction

Participants were satisfied with the program. On a scale from 1 to 5, where 1 is "not at all satisfied" and 5 is "very satisfied," participants rated their satisfaction with the program overall a 4.6, on average (Table 46). Participants gave high satisfaction ratings for the technical assistance they received from DCSEU (4.9, on average), the types of eligible equipment (4.8), assistance from the installation contractor (4.8), performance of the new equipment (4.8), and the energy savings from it (4.8).

Participants also indicated that they were likely to recommend the program to someone else, giving an average rating of 9.1 on a scale from 0 to 10, where 0 is "extremely unlikely" and 10 is "extremely likely." The NPS for the program among participating end users was 83. Overall, 11 of the 12 respondents were *promoters* – that is, these participating end users may actively promote the program to other potential participants by word of mouth. The one *detractor*, rating their likelihood to recommend the program a 2.0, had provided poor satisfaction ratings for the application process and rebate amounts.

Table 46: Participant Satisfaction with the Market Opportunities Program

Feature	n[1]	1 Not at all satisfied	2	3	4	5 Very Satisfied	Average Rating
Your experience overall	**12**	**-**	**1**	**-**	**2**	**9**	**4.6**
Technical assistance from DCSEU	7	-	-	-	1	6	4.9
The type of eligible equipment	11	-	-	-	2	9	4.8
Assistance from the installation contractor	4	-	-	-	1	3	4.8
Performance of the new equipment	11	-	-	-	2	9	4.8
Energy savings from new equipment	12	-	-	-	3	9	4.8
Information about DCSEU offerings	11	-	-	1	3	7	4.5
Time to receive the rebate or incentive	12	-	-	1	5	6	4.4
The rebate or incentive amount	12	1	-	1	3	7	4.3
The preapproval process	9	-	1	1	1	6	4.3
The application process	10	1	-	1	2	6	4.2

[1] Sample size varies because results exclude those who said, "Not applicable" or "I'm not sure."

2.3.3.3 Marketing & Outreach

Program staff described how they draw new participants into the Market Opportunities program by building on existing relationships with key accounts. Three-quarters of Market Opportunities program participants (8 of 12) recalled previously participating in another DCSEU program.

Program staff described how vendors play an important role in channeling participants into the program by informing clients about the program, identifying potential participants and sharing that information with program staff, and connecting interested customers with program staff. Further, the interviewee asserted that their relationships with vendors and the vendors' relationships with clients have been very helpful for a recent refrigeration campaign, especially in light of a temporary staffing gap at that time. DCSEU does not limit participation to an approved vendor pool for the Market Opportunities program. The interviewee said that the program needs to be more involved with managers and continue leveraging their interactions with customers.

Program staff would like to be more proactive in their outreach; for example, identifying potential participants by compiling a list of buildings in DC that likely have older boilers (30-years or older) to target.

2.3.3.4 Program Administration

On a scale from 1 to 5, where 1 is "very difficult" and 5 is "very easy," participants rated the ease of completing the application a 4.0, on average. Two of the 12 respondents found the application difficult to complete. One was the *detractor* mentioned above; this respondent found the application time-intensive and the communication poor during the preapproval process.[8]

When asked, most participants did not recommend any changes to the program administration. One suggested speeding up the pre-approval of projects and another suggested allowing applicants to conduct the energy analysis, rather than DCSEU.

2.3.3.5 Technical Support

In some cases, DCSEU provides technical support directly to the customer (versus the vendor). Seven of the participants recalled receiving technical support from DCSEU; they rated their satisfaction at a 4.9, the highest average satisfaction rating for any program feature. All seven respondents rated it a 4.0 or 5.0.

Program staff believed their technical support is the strongest feature of the program. The interviewee explained how its focus is to encourage upgrades that bring participants higher than code and listed the activities that the program conducts to that end:

- In some case, the program performs on-site metering to inform customers about their consumption and guide their next steps. The interviewee believed this approach has been impactful.
- Program representatives conduct building walk-throughs and provide recommendations for improvements.

[8] It is unclear how to exactly interpret the second respondent's response: "It could have been smoother as far as identification of equipment."

- They share high-level knowledge of the market and describe other organizations' projects and the savings they have achieved.
- The interviewee found that the program's fostering of peer-to-peer connections – such as roundtable discussions – has been a useful resource for participants and likely would not occur without the program.

2.3.3.6 Incentives

Program staff reported that the Market Opportunities program incentives are low relative to the typical project costs. Staff expressed concerns that once the "low-hanging fruit" projects are completed, customers with larger projects will not be motivated to participate if incentives remain similar. Additionally, program staff acknowledged that the incentive levels do not account for additional costs associated with program upgrades (e.g., space redesign needed to accommodate new measures).

Participants rated their satisfaction with the program's incentive levels at 4.3, on average. At different points in the survey, a few respondents either rated their satisfaction with the rebate amounts poorly and/or directly recommended that incentive amounts increase. When prompted for more details, one said that there should be a "better rate of return" and another said that the amount should be more closely associated with "real-world" savings.

2.3.3.7 Program Measures

The program launched a refrigeration campaign in late FY2018 to address gaps in other custom commercial programs that did not focus on refrigeration measures for grocery stores and large kitchens. Program staff hope to continue expanding refrigeration measure offerings in the future.

Participants are very satisfied with the types of measures that the Market Opportunities program supports, rating it a 4.8, on average. In fact, participants did not provide any suggested measures to add to this program. Participants are also highly satisfied with the performance of the measure installed through the program (4.8, on average).

2.3.3.8 Drivers and Barriers to Participation

All 12 participants reported that they were driven to participate in the program to save money and advance long-term strategic energy goals. In fact, most respondents reported that they realized maintenance and operation savings (11 of 12 respondents), energy savings (10), and equipment savings (9).

Program staff expressed concerns that some customers may be deterred by the effort and documentation required to participate, yet responses indicate that participation will be sustained:

- When asked what assistance DCSEU can provide participants going forward to help meet their energy needs, participants simply requested that the program continue offering rebates and the services it already does.
- Nearly one-half of the participants (5 of 12) have plans for energy-efficient or renewable energy improvements in the next two years, and all of them will consider involving DCSEU in their future plans.

- Nearly all participants (11 of 12) said that they faced no hurdles when deciding to implement the primary measure. One participant did recall challenges with "calculations," but that person was highly satisfied with the program application and technical assistance that they received and did not specify what calculations were problematic.

2.3.4 Recommendations

Based on the findings of our analysis, we offer the following recommendations for the Market Opportunities program:

- Request additional information from customers on the rationale behind control changes that lead to significant energy savings. Ensure that the control changes will satisfy the facility's operational requirements to reduce the likelihood of control strategies being rolled back in the future, leading to reduced savings.
- Ensure that the SEU tracker includes sufficient documentation on both standard and nonstandard inputs required to reproduce the saving calculations.
- Consider collecting more details during post inspections. The post inspection can be used not only to verify the installation of rebated equipment, but also to confirm operational information such as equipment schedules or setpoints.
- Consider establishing guidelines for post inspection timing. For controls changes and other building commissioning measures, completing the post inspection several months after project completion may allow the DCSEU to identify situations where the customers anticipated actions were not fully implemented.
- Consider establishing a pool of approved vendors to strengthen program relationships. Increasing engagement among vendors should encourage them to prioritize the program in their sales discussions. Offer these companies training. Also, list their contact information and highlight their specialties on the program website. Monitor their participation levels and connect with less active vendors to identify barriers to participation.

2.4 CI RX - Equipment Replacement (7511CIRX)

The C&I RX Equipment Replacement program, also known as Business Energy Rebates (BER), provides rebates to small-to-medium sized businesses and institutions. The program offers prescriptive incentives for lighting, HVAC, compressed air, refrigeration, food service, and vending equipment. Rebates require written pre-approval and are provided for facility improvements that result in a permanent reduction in electric and/or natural gas energy usage (persisting for a minimum of five years). The DCSEU provides per-unit rebates of up to $5 per bulb for screw-in LEDs, $40 per fixture for more advanced interior lighting, $60 per fixture for exterior lighting, $10-$20 per sensor for lighting controls, $350 for an efficient reach-in refrigerated case, and $750 for qualified commercial kitchen equipment. Other measures are rebated based on the size and efficiency of the equipment, with all rebates capped at 100% of the participant cost. Updates to the program offerings and incentive amounts are made on a quarterly basis to better address demand and to highlight specific measures for customers.

Savings were accrued and incentives were provided for 153 unique projects in FY2019. Table 47 shows the measure type contributing savings to the program during FY2019. The FY2019 program year saw 96.2% of all energy savings from lighting; 0.4% from variable frequency drives (VFDs); 0.1% from commercial equipment, including refrigerators, freezers and hot food holding cabinets; 0.9% from boilers and natural gas measures; and 2.4% from Building Operator Certification.

Table 47: Standard CIRX Equipment Replacement Program Savings Contributions

Measure Type	Percent of FY2019 Combined Energy Savings (MMBtu)	Percent of FY2019 Electric Savings (MWh)	Percent of FY2019 Gas Savings (MMBtu)	Percent of FY2019 Peak Demand Savings (MW)
Lighting	96.2%	97.6%	113.4%	99.4%
Variable Speed Drive	0.4%	0.4%	-	0.3%
Commercial Kitchen Equipment	0.1%	0.1%	-	0.3%
Replace Boiler, Natural Gas	0.9%	-	-10.6%	-
Building Operator Certificate	2.4%	1.9%	-2.8%	-

In FY2019, DCSEU began claiming energy savings for documented activities related to the delivery of training courses and other support launched in 2017 for the purpose of increasing energy code compliance of new commercial and multifamily buildings.

For the FY2019 CI RX Equipment Replacement program, we completed the following evaluation activity:

- Gross Savings Verification

2.4.1 Gross Savings Verification

Table 48 displays the tracked savings, realization rate, and evaluated savings for the CIRX Equipment Replacement program for each of its two initiatives in FY2019. For the standard CIRX initiative, the electric savings realization rate equals 106%, the peak demand realization rate equals 116%, and the natural gas savings realization rate equals 82%. For the Code Compliance Support Attribution initiative, the realization rate for all three types of savings equals 100%.

Table 48: CIRX Equipment Replacement Savings and Realization Rates by Initiative

Savings Type	Standard CIRX			Code Compliance Attribution		
	Tracked Savings	Realization Rate	Evaluated Savings	Tracked Savings	Realization Rate	Evaluated Savings
FY2019 Electric Savings (MWh)	9,592	106.4%	10,205	10,659	100.0%	10,659
FY2019 Peak Demand Savings (MW)	1.47	115.8%	1.70	1.22	100.0%	1.22
FY2019 Gas Savings (MMBtu)	-2,634	81.8%	-2,155	4,714	100.0%	4,714

Table 49 displays the tracked savings, realization rate, and evaluated savings for the overall CIRX Equipment Replacement program. The electric savings realization rate equals 103%, the peak demand realization rate equals 109%, and the natural gas savings realization rate equals 123%.

Table 49: Overall CIRX Equipment Replacement Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2019 Electric Savings (MWh)	20,251	103.0%	20,864
FY2019 Peak Demand Savings (MW)	2.7	108.5%	2.9
FY2019 Gas Savings (MMBtu)	2,080	123.1%	2,559

2.4.1.1 Standard CIRX Initiative

In this section, we describe the evaluation of the standard CIRX initiative.

2.4.1.1.1 Sampling

Given the homogenous makeup of the program, we assumed a coefficient of variation (C_v) of 0.5 for our initial sample design. With a precision target of ±20% at 80% confidence, this required a selection of 11 unique sample sites. We employed stratified random sampling with ratio estimation for the prescriptive project selection.

We allocated the number of sample points across two strata (large and small probability projects) based on each stratum's contribution to the program savings. The NMR team categorized projects with over 1,000 MMBtu of energy savings as large probability, while we categorized projects with under 1,000 MMBtu savings as small probability. Randomly sampling from the two groups enabled us to balance between capturing projects with a larger contribution to the program savings while still allowing space for smaller projects. Table 50 presents the final sample for the CIRX Equipment Replacement Program.

Table 50: CIRX Equipment Replacement Sampling Plan

Substratum	Energy Savings (MMBtu)	Percent of Energy Savings	FY2019 Participation (Projects)	Number of Sampled Projects
Large Probability	11,360	38%	7	5
Small Probability	18,732	62%	146	6

The selected sample included nine lighting projects, one VFD project, and one convection oven project. These 11 projects encompassed 9,046 MMbtu, or 30% of the total tracked energy savings from the CIRX Equipment Replacement program. For our selected sample, lighting measures provided about 99% of the total energy savings, variable speed drives provided 1%, and a commercial kitchen convection oven provided 0.1%.

2.4.1.1.2 Methodology

The NMR team conducted a desk review for each of the sampled projects to determine the evaluated savings. The NMR team did not review any custom analyses for this program as all the projects were prescriptive. The desk reviews relied on algorithms and assumptions presented in the TRM. When project files provided more accurate site-specific information, the NMR team overwrote TRM assumptions with site-specific data.

To facilitate the prescriptive lighting savings calculations, the NMR team constructed our own lighting savings calculator. The calculator used SEU's reported savings database to look up project-specific inputs, such as basic customer information, facility type, location of installed lighting, and installed fixture details and quantities. Heating fuel type, air conditioning, and schedule designation for each space was based on the TRM, with minor deviations subject to engineering judgment based on available project documentation. For example, the TRM assumes 68% of buildings utilize fossil fuel space heating. However, space heating type differs depending on the building and location of installations. The NMR team adjusted this assumption to reflect the heating fuel type when known and to show no heat in the case of exterior or parking garage fixtures. The NMR team also removed interactive effects for underground parking garages as they are assumed to not be heated. Additionally, one project was found to be a new construction project that included occupancy sensors. The NMR team reviewed the relevant energy code and adjusted the energy savings to reflect the sensors being required by code. We then used the calculator to map site-specific inputs to the appropriate TRM baseline and installed wattages, CFs, waste heat factors, and controls savings factors.

Each project utilized its own calculator file, and an engineer reviewed the automatically loaded data for accuracy and completeness. Then we reviewed project files and adjusted the deemed values if site-specific information was supported by sufficient project documentation, such as invoices, specifications, or email correspondence. These adjustments often included changes to installed fixture and/or lamp wattage values, which we checked against the provided product cut-sheets.

In addition to the nine lighting projects reviewed, the NMR team reviewed one VFD project and one food service product installation. Similar to the methodology for the lighting projects, the evaluation team used a custom calculator to evaluate the savings for this VFD project. The

calculator auto-populated the reported savings values, and then the NMR team used the TRM VFD equations and assumptions to verify reported savings. The NMR team reviewed project documentation to make changes where values differed from the TRM assumptions.

The final CIRX project included an Energy Star food service equipment convection oven. The calculator pulled in reported savings values, and the commercial convections page of the Mid Atlantic TRM was used to calculate electric savings and demand savings as a DCSEU TRM protocol does not exist for this measure. The NMR team took all of the values from either project-specific documentation and spec sheets or from the Mid Atlantic TRM default values.

2.4.1.1.3 Results

The program-wide impact results of the CIRX Equipment Replacement Program are shown in Table 51. The findings that contribute to the realization rates are discussed in the text that follows.

Table 51: CIRX Equipment Replacement Impact Results

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2019 Electric Savings (MWh)	9,592	106.4%	10,205	±4.5% @ 80%
FY2019 Peak Demand Savings (MW)	1.47	115.8%	1.70	±12.1% @ 80%
FY2019 Gas Savings (MMBtu)	-2,634	81.8%	-2,155	±42.8% @ 80%

The program-level electric savings realization rate is 106%, while the sampled project-specific realization rates ranged from 68% to 142%. The program-level demand savings realization rate is 115%, while the sampled project-specific demand realization rates ranged from 89% to 196%. The program-level gas savings realization rate is 82%, while the sampled project-specific realization rates ranged from 0% to 185%. The selected sample ultimately achieved a ±4.5% precision at the 80% confidence level for electric savings.

The largest contributor to the sampled project-specific electric savings realization rates exceeding 100% was adjustments to the efficient lighting wattage. The efficient case wattages used by DCSEU in the ex ante analyses relied on TRM assumptions instead of actual wattages. The new calculations done by the NMR team used project-specific bulb specification sheets for energy-efficient wattages. These energy-efficient wattages differed from the TRM prescriptive wattages.

The peak demand realization rate was affected by the updated project-specific wattage values and waste heat demand factors. The evaluation team updated the waste heat factors to reflect when fixtures installed were exterior fixtures or located in unconditioned spaces. Two projects utilized site-specific HOU for lights that ran continuously at 8,760 but the CF was left as the default 57.82% instead of 100% for continuous operation. This adjustment increased the demand savings.

The largest contributor to the natural gas savings realization rate was removing the interactive effects for light fixtures that are not located in conditioned space, thereby reducing both the heating penalty and realization rate. This was offset by the increased heating penalty associated with higher electric savings for the lighting projects located in conditioned space, as the two values are related. The higher the electric savings are for a lighting project, the larger the associated gas penalty will be as the heating system must produce more heat to compensate for the lack of heat

dissipating from more efficient lights. The evaluated savings are based on zero gas penalties for lighting measures installed in exterior or unconditioned spaces.

The VFD project yielded a realization rate just under 100% due to the original calculations using an incorrect or rounded horsepower value. When the NMR team calculated the evaluated savings, the horsepower provided on the drive specification sheet was used to provide a more accurate calculation of savings, resulting in a small downward adjustment.

DCSEU calculated the reported savings from the ENERGY STAR Convection Oven project using the ENERGY STAR Commercial Kitchen Equipment Calculator, last updated February 2015. The NMR team calculated evaluated savings using the Mid Atlantic TRM, resulting in energy and demand savings of 145% and 109%, respectively.

2.4.2 Code Compliance Support Initiative

The methodology for calculating energy savings for the Code Compliance Support Initiative is outlined in its Program Implementation Procedure (PIP) document. The evaluation team reviewed and approved the final calculation methodology and verified that the savings in the tracking database are consistent with the PIP approach. Therefore, we assign 100% realization rates to the energy savings from the Code Compliance Support Initiative.

2.4.3 Recommendations

Based on the findings of our evaluation, we offer the following recommendations for the CI RX program:

- Use site-specific information where available to improve the accuracy of savings calculations, including efficient case wattages and equipment efficiencies. Instead of relying on the assumptions generated by the detailed measure names (LED-101, LED-102, LED-103, etc.) for the efficient lamp wattage, use the recorded site-specific efficient case lamp wattage to calculate the wattage difference. In addition, apply fuel heating type and waste heat factors based on site specific information, instead of default TRM values, when available.
- When site-specific HOU values are input, an associated CF should be calculated to ensure that peak demand savings are not understated due to an incongruence in energy and demand load shapes. It is not recommended to use a standard CF value with a variable HOU value. The bulk of savings discrepancies stem from the blended CF being used for lighting that operates 24/7. At a minimum, we recommend using a flag to assign a CF of 100% to any 24/7 lighting.
- The TRM assigns a 3.7% summer CF for exterior lighting. However, an analysis of historical sunrise and sunset times shows that fixtures controlled by photocells will not have any summer coincidence. We recommend changing the TRM value to 0% as most exterior LEDs come standard with integral photocells. Additionally, customers who utilize timers most likely adjust them seasonally for safety and thus will still be avoiding summer peak hours. However, exceptions should be made for 8,760-hour lighting, where the summer CF would be 100%. The evaluation team did not make this adjustment to the verified projects.

- Apply the nominal horsepower on the controlled motor without rounding to accurately calculate the energy and demand savings for VFDs.
- Ensure that all projects in the CIRX program are replacing existing equipment and are not new construction, which require the baseline to consider the current building energy code.

2.5 UPSTREAM LIGHTING (7513UPLT)

The Upstream Lighting program provides instant rebates (i.e., discounts) to customers purchasing lighting equipment through qualified distributors. Through this program, customers can purchase light bulbs from any one of nine participating distributors for a discounted rate. As it has matured, the program has adjusted discounts to align with market conditions. Available lamp types include Energy Star 2.0 certified LED directional, omnidirectional, and decorative bulbs, as well as DLC certified linear LED tubes.

These Instant Business Rebates support DCSEU's midstream work in the commercial sector. By drawing on the motivation for higher yields in the distribution channels, the program drives increased numbers of efficient products to showroom floors. The structure of this program allows for closer and more efficient tracking of product purchases. The distributors provide information on sales directly to the DCSEU, enabling a higher level of quality control. This allows the DCSEU to adjust the incentives more frequently to match the conditions of the changing market.

For the FY2019 Upstream Lighting program, we completed the following evaluation activities:

- Gross Savings Verification
- Net Savings Estimation
- Process Evaluation

2.5.1 Gross Savings Verification

Table 52 shows the tracked savings, realization rate, and evaluated savings for the Upstream Lighting program. Overall, the evaluation found the tracked savings to be calculated with a high degree of accuracy. The electric savings realization rate was 102%, the demand savings realization rate was 102%, and the gas savings realization rate was 101%.

Table 52: Upstream Lighting Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2019 Electric Savings (MWh)	16,688	101.6%	16,950
FY2019 Peak Demand Savings (MW)	2.37	101.6%	2.41
FY2019 Gas Savings (MMBtu)	-5445	100.7%	-5,484

2.5.1.1 Sampling

Given the homogenous makeup of the program, the NMR team assumed a coefficient of variation (C_v) of 0.5 for our initial sample design. With a precision target of ±20% at 80% confidence, this required a selection of 11 unique sample sites. We employed stratified random sampling with ratio estimation for the prescriptive project selection.

We allocated the number of sample points across three substrata (certainty, large probability, and small probability projects) based on each substratum's contribution to the program savings. The certainty strata cut off was set at 3,000 MMBtu. Projects that had total energy savings above 3,000 MMBtu were automatically selected into the sample, while projects below that threshold were randomly sampled. The 750 MMBtu value reflected a good balance point between capturing projects with a large singular contribution to the program savings while still allowing space in the sample for randomly selected projects so that the sample was not entirely composed of certainty projects. Table 53 presents the final sample for the UPLT Program.

Table 53: Upstream Lighting Sampling Plan

Stratum	Percent of Program Energy Savings	FY2019 Participation	Number of Sampled Sites
Certainty	6%	1	1
Large Probability	26%	13	5
Small Probability	67%	116	5

2.5.1.2 Methodology

The NMR team conducted a desk review for 11 of the 130 total projects to calculate the evaluated savings. These calculations relied on algorithms and assumptions presented in the TRM. When information in the project files deviated from the TRM, the NMR team overwrote these assumptions with site-specific data.

To calculate the prescriptive lighting savings, we employed our own lighting savings calculator. The calculator utilized DCSEU's reported savings database to look up project-specific inputs, such as basic customer information, facility type, location of installed lighting, and installed bulb/fixture numbers and quantities, which our engineers reviewed for correctness and completeness. Assumed values from the TRM included hours of operation, prescriptive wattages, waste heat factors, in-service rate, percent of lighting in heated spaces, and fossil fuel and electric waste heat factors. The NMR team applied values from the TRM based on the type of bulb or fixture and the installation location (indoor versus outdoor). Hours of operation were based on the LED category of the bulb or fixture.

The NMR team then reviewed supporting project documentation such as invoices, spec sheets, or email correspondence and adjusted the deemed values if site-specific information was provided.

2.5.1.3 Results

The program-wide impact evaluation results for the Upstream Lighting Program are shown in Table 54. The findings that contributed to the realization rates are described in the text that follows.

Table 54: Upstream Lighting Program Impact Results

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2019 Electric Savings (MWh)	16,688	101.6%	16,950	±2.9% @ 80%
FY2019 Peak Demand Savings (MW)	2.37	101.6%	2.41	±2.4% @ 80%
FY2019 Gas Savings (MMBtu)	-5,445	100.7%	-5,484	±2.9% @ 80%

The program-level electric and demand savings realization rates are 102%. The largest contributor to the sampled project-specific electric realization rates exceeding 100% was adjustments to the efficient lighting wattage. The efficient case wattages used by DCSEU in the ex ante analyses relied on TRM assumptions instead of actual fixture wattages. The calculations done by the NMR team used project-specific bulb specification sheets for energy-efficient wattages.

The natural gas realization rate equaled 101%. The largest contributor to this realization rate was the increased heating penalty associated with higher electrical savings, as the two values are related. The higher the electric savings are for a lighting project, the larger the associated gas penalty will be as the heating system must produce more heat to compensate for the lack of heat dissipating from more efficient lights.

2.5.2 Net Savings Estimation

The NMR team calculated the NTG ratio for the Upstream Lighting program. Composed of free-ridership and participant spillover, the NTG ratio is based on IDIs with seven participating distributors and surveys with 48 participating end users.

Chapter 21 of the *Uniform Methods Project (UMP): Methods for Determining Energy Efficiency Savings for Specific Measures* addresses methods for estimating net savings for upstream program. It explains that in these scenarios, surveys with trade allies, such as distributors, are a more reliable source than surveys with end users:

> *"Although consumers ultimately decide what they will purchase, they may not be aware of the influence of the interventions for upstream programs where trade ally decisions are driving change."*[9]

The UMP characterizes end-user surveys as a complement to trade ally surveys in the upstream program NTG context. Therefore, we approached the distributor responses as the primary method

[9] National Renewable Energy Laboratory. *Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* Chapter 21. Estimating Net Savings – Common Practices. October 2017. https://www.nrel.gov/docs/fy17osti/68578.pdf

and end-user responses as the secondary method for estimating free-ridership. We used participant spillover among end users as an adder.

2.5.2.1 Distributor Free-ridership

Free-ridership from distributors is based on interviewees' estimates of how their sales would have changed if the Upstream Lighting program discounts had not been available. All seven distributors believed that their FY2019 sales of program-eligible LEDs would have been lower in the absence of the program. On average, they estimated that those sales would have been 42% lower if the program had not been available. Weighting by the program savings associated with interviewees' companies increases that estimate slightly, to 45%. Therefore, as shown in Table 55, free-ridership among Upstream Lighting program distributors is 55% (100% minus 45%).

Table 55: Free-ridership for Upstream Lighting Program among Distributors

Interviewee	Percent of FY2019 Program Savings (n=7)	Interviewee Retrospective Estimate of Change in Sales without Program	Free-ridership
1	1%	−50%	50%
2	14%	−50%	50%
3	20%	−50%	50%
4	29%	−50%	50%
5	13%	−42%	59%
6	18%	−35%	65%
7	4%	−18%	83%
Average (unweighted)		−42%	58%
Average (savings-weighted)		**−45%**	**55%**

2.5.2.2 End-user Free-ridership

We estimated free-ridership among end users based on the following two factors:

- Intention or the expected behavior in the absence of the program; and
- The influence of various program elements on the decision to participate in the program.

Intention

As shown in Table 56, the 48 Upstream Lighting participating end users received the following scores:

- Nearly one-fifth of participating end users reported they would have delayed the purchase of the LEDs by at least one year (17%) or canceled the purchase altogether in the absence of the program (2%). We assigned a low free-ridership intention score (0%).
- About one-quarter of participating end users (27%) said they would have purchased the LEDs but purchased a smaller quantity in the absence of the program. We assigned a moderate free-ridership intention score (25%).
- The remaining participating end users said they would have purchased the same quantity of LEDs in the absence of the program.

- Fifteen percent of respondents said they might have had the funds available, so we assigned a moderate-high free-ridership intention score (37.5%).
- Forty percent of the 48 respondents indicated they definitely would have had the funds to cover the full cost of the LEDs, so we assigned a high free-ridership intention score (50%).

The overall free-ridership intention score across all 48 participating end users is 32%.

Table 56: Free-ridership Intention Scoring for Upstream Lighting Program among End Users

Intention in the Absence of the Program	Funds Available to Cover the Entire Cost	Assigned Free-ridership Intention Score (%)	Percent of Respondents[1]
• Delayed the purchase of LEDs for at least one year OR • Cancelled the purchase of the LEDs altogether	• Not Asked	0%	19%
• Purchased the LEDs but scaled back the quantity OR • Don't know OR • I'd rather not answer	• Not Asked	25%	27%
• Purchased the same quantity of LEDs	• Definitely would not have had the funds OR • Don't know OR • I'd rather not answer	25%	-
	• Might have had the funds	37.5%	15%
	• Definitely would have had the funds	50%	40%
Total		**32%**	**48**

[1] Percentages do not sum to 100% due to rounding.

Influence

Table 57 displays the influence rating of various program features on participants' decision to install the measure, using a 1 to 5 scale, where 1 means it "played no role at all" and 5 means it "played a great role." The Upstream Lighting program features with the highest average ratings among participating end users include information or recommendations from contractors or distributors associated with the program (4.4, on average), prior experience with a DCSEU program (4.3), and the discount for the LEDs (4.3).

Table 57: Influence of DCSEU Program Features for Upstream Lighting Program Among End Users

Features	n[1]	1 Played no role at all	2	3	4	5 Played a great role	Average Rating
Information or recommendation from contractors or distributors associated with the program	46	2%	2%	11%	26%	59%	4.4
Previous experience with a DCSEU program	41	10%	2%	7%	10%	71%	4.3
The discount for the LEDs[2]	47	4%	6%	6%	23%	60%	4.3
Information or recommendation provided by a DCSEU representative	35	17%	3%	11%	26%	43%	3.7
DCSEU program marketing materials about the program	41	22%	20%	17%	20%	22%	3.0

[1] Sample sizes exclude those who said, "Not applicable" or "I'm not sure."

The NMR team assigned each Upstream Lighting participating end user a free-ridership influence score based on the highest rating they provided for any of the above program features (Table 58):

- Most Upstream Lighting participating end users (92%) indicated that at least one program feature played a great role in their decision, so we assigned them a free-ridership influence score of 0%.
- Six percent of participating end users provided a maximum rating of 4.0, so we assigned them a free-ridership influence score of 12.5%.
- Just one participating end user (2%) gave a maximum rating of 3.0. We assigned them 25% for the free-ridership influence score.

The overall free-ridership influence score across all 48 participating end users is 1%.

Table 58: Free-ridership Influence Scoring for Upstream Lighting Program Among End Users

Maximum Influence Rating	Assigned Free-ridership Influence Score (%)	Percent of Respondents
5 - program feature played a great role	0%	92%
4	12.5%	6%
3	25%	2%
2	37.5%	-
1 - program feature played no role OR Not Applicable	50%	-
Don't know OR Refused	25%	-
Total	**1%**	**48**

For each participating end user, we summed the free-ridership intention score and the free-ridership influence score to yield a cumulative free-ridership rate for participating end users. We calculated both unweighted and savings-weighted free-ridership values, where we applied a weight based on the measure with the most tracked total energy savings associated with their project. The average unweighted free-ridership rate among Upstream Lighting program participating end users was 33% and the average weighted rate was 30% (Table 59).

Table 59: Free-ridership Rate for Upstream Lighting Program Among End Users

	Average	Minimum	Maximum
Free-ridership (unweighted)	33%	0%	75%
Free-ridership (savings-weighted)	30%	0%	75%

2.5.2.3 Participant Spillover

Four participating end users reported installing energy-efficient or renewable energy equipment – which did not receive an incentive – at a DC location after their Upstream Lighting project (Table 60). On a 1 to 5 scale, where 1 means "no influence at all" and 5 means "great influence," three of the five end users rated the Upstream Lighting program's influence on those installations a 1.0, so we do not consider them spillover measures. The fourth respondent reported installing 300 LED fixtures and motion sensors and rated the program influence a 5.0, so we assigned them a spillover influence score of 100%. This respondent represents a large property management firm that oversees multiple locations in DC, some of which received LEDs through DCSEU programs in FY2020.

Table 60: Spillover Influence Scores for Upstream Lighting Program among End Users

Influence Rating	Assigned Influence Score (%)	Spillover Measures	Count of Respondents
Rating of 2 (some influence)	25%	-	-
Rating of 3	50%	-	-
Rating of 4	75%	-	-
Rating of 5 (great influence)	100%	LED light fixtures and motion sensors	1
Respondent does not know how much influence	50%	-	-

We estimated the savings associated with these measures and applied the spillover influence score (100%) to estimate the total spillover savings among participating end users. We then divided that estimate by the cumulative tracked savings across all 48 survey respondents to calculate the spillover rate for the program. This calculation resulted in a spillover rate of 10% among participating end users for the Upstream Lighting program. However, the spillover respondents organization manages multiple participating properties; therefore, it is not known where the spillover LEDs were installed and whether the LEDs did in fact receive a DCSEU rebate through the Commercial Upstream Lighting program (which does not track installation locations) or another DCSEU program in FY2020 (Table 61). Given the incomplete information, we reduce the spillover rate by one-half (from 10% to 5%) to reflect this uncertainty.

Table 61: Participant Spillover Rate for Upstream Lighting Program

	Average	Minimum	Maximum
Spillover Rate	5%	0%	310%

2.5.2.4 Combined NTG Ratio

The free-ridership rate among distributors (55%) was much higher than that of end users (30%). There are several factors to consider in determining how to move forward:

- As mentioned, it is a best practice to prioritize the responses of trade allies, such as distributors, in estimating NTG ratios for upstream programs. In this case, participating end users rated the influence of the recommendation of the distributor or contractor on their decision making the most highly (4.4, on average).
- That said, participating end users also rated the program discount nearly as highly (4.3, on average), so we should not dismiss the importance of the program on sales. Distributors acknowledged the value of the incentives; in the words of one distributor,

  > *"These are products that are being sold proactively by our sales team, and they're selling it based on the incentive levels [on which] we're able to sell them. For example, to be able to sell an A19 [LED bulb] that's advertised as $0.95, when in reality without the program it's probably closer to $3 or $4 apiece, the [ability] to sell that goes down drastically."*

- Moreover, our benchmarking effort revealed free-ridership rates more in line with that of DCSEU end users – in Pennsylvania, free-ridership rates for upstream lighting programs range from 15% to 33% (Section 4.2). Pennsylvania evaluators relied entirely on end-user surveys.
- Yet, distributors and program staff indicated that DCSEU's upstream lighting incentives are significantly lower than neighboring states, and with low incentive amounts, often comes high free-ridership.

Therefore, there is convincing evidence to value both perspectives and use a mid-point value between the two free-ridership estimates and assume a free-ridership rate of 43% for the Upstream Lighting program. After adding the participant spillover rate (5%), the NTG for the Upstream Lighting program is 62% (Table 62).

Table 62: Combined NTG Ratio for Upstream Lighting Program

Participants	Free-ridership	Participant Spillover	NTG (1 – FR + PSO)
Distributors	55%	n/a	45%
End users	30%	5%	75%
Recommended	**43%**	**5%**	**62%**

2.5.3 Process Evaluation

For the process evaluation of the Upstream Lighting program, the NMR team completed IDIs with program staff and program partners (distributors), as well as telephone surveys with program participants (Table 63). The results from these evaluation activities are presented below.

Table 63: Upstream Lighting Process Evaluation Activities

Stakeholder	Completed
Program staff interviews	1
Program distributor interviews	7
Participating end user surveys	48

2.5.3.1 Key Findings

These were the key findings from the process evaluation of the Commercial Upstream Lighting program:

- Satisfaction is high among participating end users and distributors. On a scale from 1 to 5, where 1 is "not at all satisfied" and 5 is "very satisfied," both distributors and end users rated their satisfaction with the program overall a 4.6, on average.
- The NPS[10] for the Commercial Upstream Lighting program was 83.
- Program staff hope to include HVAC and gas measures in the program soon. Nearly one-third of commercial program participant respondents (30%) suggested that the program support HVAC equipment upstream, too. Commercial Upstream Lighting program distributors and end-user participants approved of the range of eligible lighting products, as well as their performance and energy savings; however, there is strong interest in expanding beyond lighting.
- Distributors reported promoting the program to their customers, and more than three-quarters of participants (77%) heard about the program from their distributor at some point. The program actively supports participating distributors and monitors their progress to help increase sales.
- Program staff and distributors agreed that the program is effectively streamlined. While participating distributors confirmed that they have all of the resources needed to participate, software needs can deter smaller independent distributors from participating.
- While they considered incentives *sufficient* enough to encourage participation, program staff and distributors explained that their incentives are significantly lower than neighboring programs. However, participating end users were satisfied with the discount amounts (rating them a 4.5, on average).

[10] The NPS is a well-established measure of customer loyalty. Using a scale of 0 to 10, where 0 is "extremely unlikely" and 10 is "extremely likely," respondents are asked how likely they are to recommend the program to someone else. Respondents are then grouped as promoters (score 9-10), passives (7-8), and detractors (0-6). The NPS is calculated by subtracting the percentage of detractors from the percentage of promoters and is presented as a whole number.

- Some of the distributors reported that the program has increased their stocking of energy-efficient lighting, as well as the size of their workforce.
- Signs pointed to sustained participation in the near term. For example, most distributors (6 of 7) expected their involvement with the Commercial Upstream Lighting program to increase in the next year.

2.5.3.2 Program Satisfaction

Program satisfaction is high:

- On a scale from 1 to 5, where 1 is "not at all satisfied" and 5 is "very satisfied," distributors rated their satisfaction with the program overall a 4.6, on average. All seven distributors reported that participation in the Commercial Upstream Lighting program has increased their sales and their value to their customers
- Participating end users rated their satisfaction with the program overall a 4.8, on average. Table 64 shows their satisfaction ratings in detail.
- On a scale from 0 to 10, where 0 is "extremely unlikely" and 10 is "extremely likely," participants rated their likelihood to recommend the program to someone else a 9.5, on average. The NPS for the program among participating end users was 83. Overall, 88% of respondents were *promoters* – that is, these participating end users may actively promote the program to other potential participants by word of mouth.

Table 64: Participant Experience with the Upstream Lighting Program

Feature	n[1]	1 Not at all satisfied	2	3	4	5 Very Satisfied	Average Rating
Your experience overall	**47**	**-**	**-**	**2%**	**13%**	**85%**	**4.8**
The performance of the new equipment	46	-	-	-	13%	87%	4.9
Assistance from the distributor	44	-	-	7%	2%	91%	4.8
Assistance from the installation contractor	26	-	-	8%	15%	77%	4.7
Information about DCSEU offerings	46	-	2%	4%	20%	74%	4.7
The type of eligible equipment	43	-	2%	5%	16%	77%	4.7
Energy savings from new equipment	45	-	2%	7%	22%	70%	4.6
The discount amount	44	-	-	9%	27%	64%	4.5

[1] Sample size varies because results exclude those who said, "Not applicable" or "I'm not sure."

2.5.3.3 Marketing and Outreach

Over three-quarters of the 48 participating end users (77%) heard about the Commercial Upstream Lighting program from a distributor at some point, and more than two-fifths (44%) had *first* learned about it from the distributor. Most of the distributors interviewed (5 of 7) reported that they actively market the program. They described featuring it on their websites, mentioning it in emails or newsletters to customers, and discussing it directly with customers.

Most of the participating distributors interviewed came to the program after having been involved in or participating in other DCSEU programs. Five of the seven recalled having been contacted by DCSEU program staff about the Commercial Upstream Lighting program.

Program staff are tuned into distributors' outreach efforts. Program staff reported how they compare participating distributors' program sales to budgets, and if they identify lagging sales, program staff reach out to those distributors to assist with marketing. DCSEU features the distributors on its website and offers co-branding where a distributor's logo can be placed on program pamphlets.

Despite the program being upstream, most participating end user respondents (90%) knew that DCSEU had discounted the LEDs they installed.

2.5.3.4 Program Administration

According to program staff, the Commercial Upstream Lighting program is streamlined such that the documentation and review process are more automated than other programs. However, program staff also recognize that these features make it difficult to verify installation or collect information on facility characteristics and energy usage.

Based on participating end user and distributor responses, it appears that program administration is going well:

- When asked which aspects of the Commercial Upstream Lighting program they would change, participating end users most frequently replied that they would not change anything (71%).
- All seven distributors confirmed that they have participated in energy-efficiency programs operated by other organizations. In comparison, they found that DCSEU's program was particularly streamlined.
- Six of seven distributors reported that the program's administrative requirements are not difficult to fulfill, yet one found it time-intensive given the amount of manual data input needed.
- All seven distributors considered themselves knowledgeable about the program and had all of the information, tools, and training that they needed to participate.

2.5.3.5 Incentives

Distributors confirmed that the Commercial Upstream Lighting program successfully encourages customers to purchase energy-efficient equipment. Five of the seven distributors indicated that the influence of the incentives differs depending on the type of product – mostly, they perceived that program incentives influence sales of the most common/popular LEDs (e.g., MR16 bulbs and linear tubes).

While distributors generally agreed that incentive levels are *sufficient* to encourage participation, their reactions were mixed, with most speculating or implying that participation could be increased if discounts were higher. Additional findings related to incentive amounts include the following:

- Two distributors said that the incentive levels are significantly lower than comparable neighboring programs, making it a tougher "sell." Program staff acknowledged this difference and explained that their budget necessitates lower incentive amounts to achieve savings goals.
- The program caps the number of LEDs per facility that it will discount per fiscal year. One distributor explained that this can be troublesome with larger facilities that order incrementally, causing tracking difficulties for the distributor. The interviewee was unclear on how to apply these requirements to larger organizations with multiple buildings, such as a university. Program staff indicated that this requirement, along with additional verification processes on customers that purchase more than 1,000 bulbs, helps curtail the possibility that program-discounted lighting also receives rebates via a DCSEU downstream program.
- Just 17% of the 48 participating end users requested that the discounts increase when asked what DCSEU can do to assist them in their future energy needs. Participating end users were pleased with DCSEU's discount amounts, rating their satisfaction a 4.5, on average.

2.5.3.6 Program Measures

Distributors generally approved of the range of Commercial Upstream Lighting program's eligible measures, with a couple caveats in relation to program's offered by other organizations:

- While one distributor praised the program as having the best product eligibility in comparison to other regional rebate programs, the interviewee suggested adding more fixture options to the program. Program staff indicated that they added exterior fixtures and additional bulbs in the last fiscal year, nearly doubling the number of measures offered.
- One distributor observed room for growth. In the distributor's words,

> *"I think it is a good mix of products that covers most checked boxes for our customers, but some of the other programs in the area maybe have a more robust amount of categories that are offered for incentives, which do cover a lot more of the entire lighting catalogue than just specific categories."*

Commercial Upstream Lighting program end users have had positive experiences with program measures:

- Their highest satisfaction ratings were with the performance of the LEDs, rating them a 4.9, on average.
- They rated their satisfaction with the energy savings from the LEDs a 4.6, on average. In fact, when asked what benefits their company realized since participating, end users most often reported that their company has saved money on energy costs by installing LEDs through the program (98%).
- They rated their satisfaction with the range of eligible measures a 4.7, on average. Only two suggested that the program add other types of lighting, but they did not provide specific details.[11]

Program staff seek to expand beyond lighting measures by adding options such as gas measures and circulator pumps for HVAC systems. They anticipate that a combination of upstream discounts and distributor education would facilitate the adoption of efficient HVAC systems because they have seen customers struggle to identify which HVAC systems are eligible, especially in a replace on failure situation.

The NMR team asked program partners interviewed in connection with programs other than Commercial Upstream Lighting whether it would be effective to provide incentives to HVAC distributors to sell energy-efficient HVAC equipment. All three partners responded in support of this initiative:

- According to the P4P program partner, building owners often bypass consultants and work directly with distributors, who may not recommend the energy-efficient option due to lack of awareness or concerns about the cost.
- The program partner interviewed in connection with the Low-Income Multifamily Comprehensive (LICP) program was enthusiastic about the plan.
- A lighting distributor that participates in the Low-Income Prescriptive Rebate program observed that this strategy has been effective in Maryland, noting that the success depends on setting the incentives sufficiently high enough to influence customer behavior.

During the participant survey, we asked all respondents (including the Market Opportunities – Custom, Commercial Custom Retrofit, and Solar PV Market Rate participants) what non-lighting energy-efficiency measures DCSEU should offer with an instant discount through distributors. In line with program staff's vision, they most often suggested HVAC equipment (30%) and VFDs (11%). Table 65 shows their responses in full.

[11] When asked how they would change the program, one participant requested that it include bulbs from more manufacturers, but it is unclear if this is a matter of the distributor's offerings or program requirements.

Table 65: Participant Recommendations for Non-Lighting Upstream Measures

Measure	Percent of Respondents (n=73)[1]
HVAC equipment	30%
VFDs	11%
Kitchen and refrigeration equipment	7%
Water conservation measures	5%
Appliances	5%
Building shell measures	4%
Other	12%
None	36%
Don't know/Refused	16%

[1] Percentages sum to greater than 100% because some respondents provided more than one recommendation. Sample also includes participants from other commercial programs.

2.5.3.7 Drivers and Barriers to Participation

Participating end users indicated that they installed LED lighting to save money on energy costs and/or operating costs (100%). They also commonly participated out of a need for more reliable equipment (81%) to contribute towards their organization's long-term strategic energy management plan.

While most participants (85%) reported that they did not face hurdles to participation, some interviewees/respondents pointed to a few hurdles for end users:

- A few participants mentioned issues with installation, such as lag times related to internal approvals, multiple demands on property managers' time, and difficulty in finding compatible fixtures or matching the color of the new LED bulbs to the existing LEDs.
- One distributor stated that some customers are not motivated by program discounts because operating costs (i.e., electricity bills) and costs of goods (e.g., LEDs) come from different pools of money, likely meaning that returns on investment are not always a driver to participation and any unnecessary up-front costs for upgrades are not directly justified.

There can also be obstacles for distributors to participate. For example, one distributor explained that it is time intensive to participate given the amount of manual data input needed. In fact, program staff recalled that "mom and pop" distributors stopped participating in the program or were deterred from the start because they do not have the software or staff to effectively track measures and "bake" rebates into sales prices. While program staff expressed a desire to help these partners, they acknowledged that they do not have the resources to upgrade the distributors' sales software.

The program has had positive impacts on distributors:

- Six of seven distributors confirmed that they have increased their stocking of high efficiency LEDs since becoming involved with the program. They attributed that change to DCSEU and other regional utilities, as well as evolving market forces, rating the program's impact 3.9 on a scale of 1 to 5, where 1 is "very little impact" and 5 is "a great deal of impact."

- Three distributors needed to increase their workforce to meet customer demand for program-related products.

Distributors and end users answered questions about their future plans:

- Most distributors (6 of 7) expect their involvement with the Commercial Upstream Lighting program to increase in the next year. The seventh expressed uncertainty given the high level of market penetration already achieved by that respondent's company.
- Eighty-one percent of participating end users reported that they had plans for energy-efficient or renewable energy improvements in the next two years, and nearly all of them (96%) will consider involving DCSEU in their future plans.

2.5.4 Recommendations

Based on the findings of our evaluation, we offer the following recommendations for the Commercial Upstream Lighting program:

- Apply site-specific information where available, including efficient case bulb/fixture wattage included in the equipment specification sheets instead of relying on the assumptions generated by the detailed measure names (LED-101, LED-102, LED-103, etc.) for the efficient lamp wattage.
- Commercial Upstream Lighting program processes are working well and are streamlined; program staff should applaud their successful execution of the program. While the program is not in the position to provide new software for independent distributors, it may be worthwhile to offer troubleshooting or training to help them overcome basic technical data tracking issues that may support their participation.
- Support non-lighting measures as planned, particularly HVAC measures.
    - Explore the impacts of discounting other measures, such as VFDs.
    - When shifting to a new sector of distributors, ensure there is a strong system in place to track installation locations.
    - If new measures are added, consider changing or shortening the name of the program so it is no longer lighting specific (e.g., Commercial Upstream program) to prevent confusion among non-lighting distributors as they consider joining the program.

2.6 Pay for Performance (7520P4PX)

The P4P track focuses on C&I existing buildings that are undergoing complex, multi-measure efficiency projects, including those with behavioral or operational changes. Projects with these types of measures are challenging to analyze with traditional prescriptive or spreadsheet savings calculations.

Incentives are paid based on pre- and post-project metered data, where actual energy saved is determined using multivariate linear regression of AMI (electric) or monthly (natural gas) meter data. The program utilizes the Temperature and Time of Week (TTOW) algorithm developed by

Lawrence Berkeley National Laboratory (LBNL).[12] The TTOW model produces a piecewise estimate of hourly or sub-hourly interval meter data based on energy usage, outdoor air temperature, an occupancy indicator variable, and 167 hours of the week indicator variables. The baseline period usage data is fit with a baseline model. The baseline model is then compared to the actual customer usage during the evaluation period to determine the savings.

In FY2019, the program provided incentives for three projects. Table 66 presents the breakdown of tracked savings for each project in FY2019. The majority of the savings for the program during FY2019 originated from scheduling, equipment control updates, and commissioning measures.

Table 66: P4P Program Tracked Savings by Project

Project ID	Electric Energy Savings (MWh)	Peak Demand Savings (MW)	Gas Savings (MMBTU)
16700	64.9	0	0
16835	406.1	0	0
17650	184.1	0.021	879
Total	**655.1**	**0.021**	**879**

For the FY2019 P4P program, we completed the following evaluation activities:

- Gross Savings Verification
- Process Evaluation

2.6.1 Gross Savings Verification

Table 67 shows the tracked savings, realization rate, and evaluated savings for the P4P program. The electric savings realization rate was 100%, the demand savings realization rate was 100%, and the natural gas savings realization rate was 101%.

Table 67: P4P Program Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2019 Electric Savings (MWh)	655.1	100%	655.1
FY2019 Peak Demand Savings (MW)	0.021	100%	0.021
FY2019 Gas Savings (MMBtu)	879	101%	888.6

2.6.1.1 Sampling

Due to the small number of participants in the P4P program during FY2019, the evaluation team verified a census of the projects. If participation in the P4P program increases, a sampling strategy may be used in future years.

[12] Price, P. et al. *Using Whole-Building Electric Load Data in Continuous or Retro-Commissioning*. Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division. July, 2011.

2.6.1.2 Methodology

The NMR team conducted a desk review for each project, through which we calculated the evaluated savings. The goal of the desk reviews was to confirm the inputs used to model the customer energy usage and to validate the modeled savings estimates independently. The NMR team analyzed each project by following the process outlined below:

- The evaluation team reviewed the source code of the model for each project to ensure that the data supplied was appropriately pulled and analyzed. The NMR team also examined the model outputs to ensure they were consistent with expectations and were consistent with the summary values included in the project documentation.
- The NMR team ran parallel independent models using the same TTOW model algorithm. The independent model was used to validate that the modeled energy usage was accurate and consistent with the prescribed modeling methodology.

2.6.1.3 Results

The program-wide impact evaluation results for the program are shown in Table 68. The findings that contributed to deviations in the realization rates are described in the text that follows. The evaluation team utilized a census approach for the P4P program.

Table 68: P4P Program Impact Results

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2019 Electric Savings (MWh)	655.1	100%	655.1	n/a - census
FY2019 Peak Demand Savings (MW)	0.021	100%	0.021	n/a - census
FY2019 Gas Savings (MMBtu)	879.6	101%	888.6	n/a - census

The program-level realization rates are 100% for electric savings, 100% for demand savings, and 101% for natural gas savings. The evaluation team concluded that the SEU developed and implemented the modeling and savings calculations correctly. The model developed by the SEU is robust, includes several valuable control checks, and has some built-in flexibility to handle varying customer data intervals.

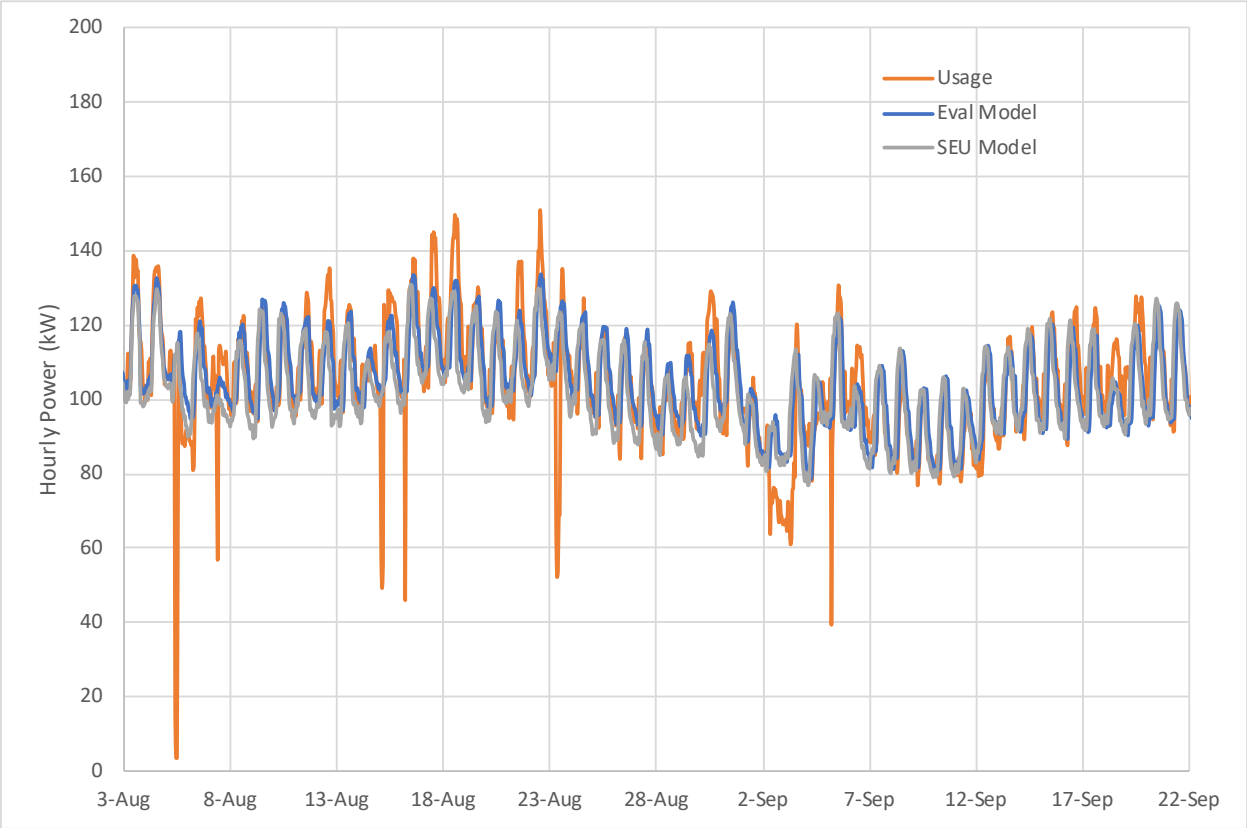
The evaluation team reviewed the model source code developed by the SEU. The model code uses an open-source programming language (python) and transparent packages, such as pandas.[13] The modeling code does use proprietary modules and files, such as weather data, which could not be used by the evaluation team since the files reside on internal SEU servers. The evaluation team expected this type of coding because it is necessary to deploy code broadly across an organization, and it did not impede the evaluation team's review. The evaluation team independently gathered weather data and confirmed that SEU collects and uses it properly.

After the NMR team reviewed the model code, we developed independent models of the energy savings. The evaluation team also utilized the TTOW algorithm. The evaluation team developed independent estimates to confirm and validate that the ex ante savings estimates were

[13] Pandas is the data analytics library for the python computing language. It contains many routines and modules for large scale data manipulation. https://pandas.pydata.org/

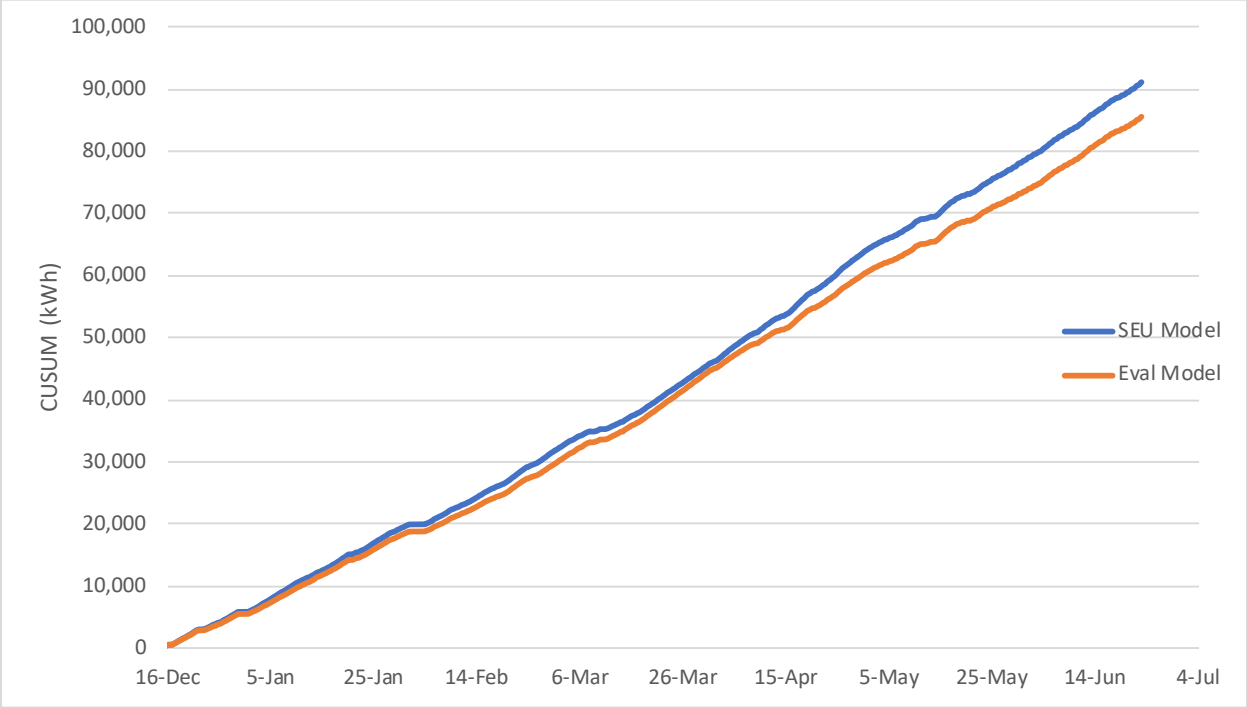
reasonable. Figure 3 shows a snapshot for one of the reviewed projects containing the customer's actual hourly usage, the evaluation team's baseline model, and the SEU's model used in the ex ante savings. The evaluation team and SEU models both match customer usage well and are nearly identical. The large spikes and dips in customer usage are indications of non-routine events, which TTOW do not explain. Future work on modeling can focus on including independent variables that help identify and explain non-routine events.

Figure 3: SEU and Evaluation Team Baseline Models with Customer Usage for Project 17650



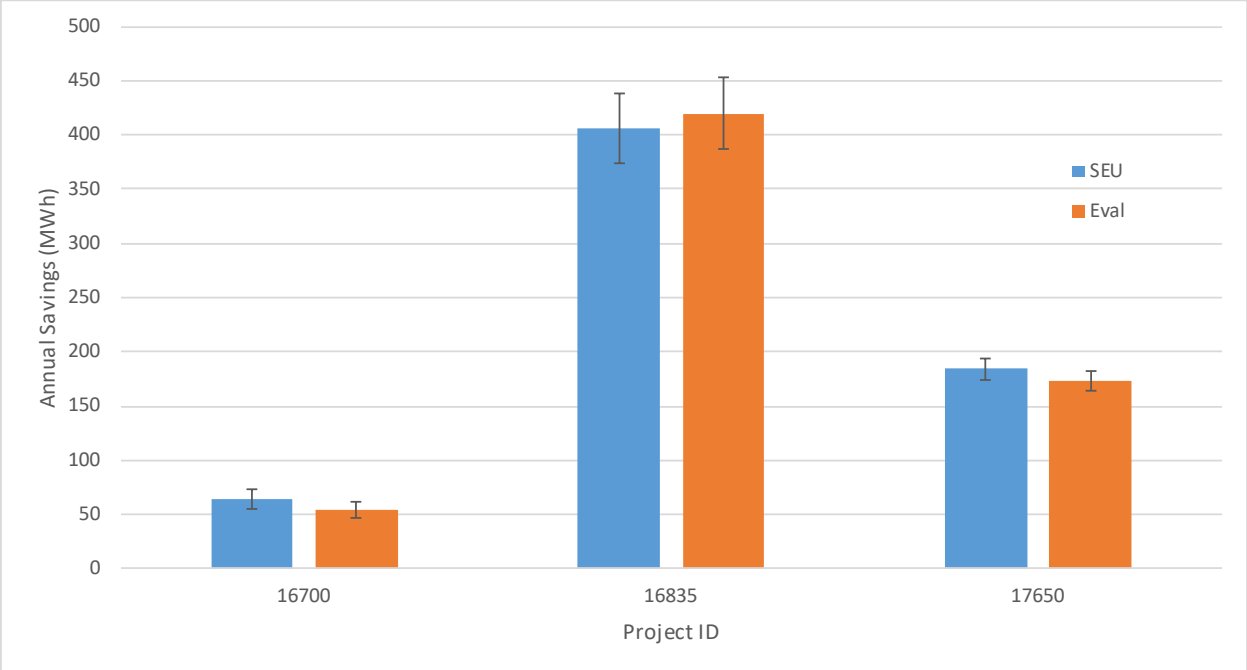
Once the baseline model was developed, the evaluation team then calculated the savings for each project by comparing the modeled baseline usage to the customer's actual usage during the evaluation periods. As would be expected, the ex ante and evaluation team cumulative savings estimates were consistent. Figure 4 shows the SEU and evaluation team cumulative summation (CUSUM) savings estimates for Project 17650. The calculations follow the same pattern and are very similar throughout the evaluation period for this project. The other two reviewed projects showed similar results.

Figure 4: CUSUM Electric Savings for Project 17650



The evaluation team completed the above review steps for each of the three projects in the program during FY2019. Savings estimates calculated by the evaluation team were within the fractional savings uncertainty bounds at the 90% confidence level of the ex ante savings estimates, indicating statistically similar results for electric savings (Figure 5).

Figure 5: SEU and Evaluation Team Electric Savings by Project



The evaluation team also verified the peak demand savings claimed by the SEU and found them to be accurate. One project, Project ID 17650, also claimed natural gas savings. Because interval natural gas data was not available, the SEU utilized monthly billing records. The evaluation team verified that the monthly regression model was calculated correctly for this project. However, the SEU annualized the electric savings for this project since only six months of post-implementation electric data was available. The ex ante calculation of natural gas savings used the same months for baseline and post-implementation as the electric savings analysis; however, the SEU did not annualize the savings. Therefore, the evaluation team annualized the natural gas savings estimates by adding in an estimate for heating degree days (HDD) for October. This change increased the verified gas savings for this project slightly and led to a higher than 100% realization rate for gas savings.

2.6.2 Process Evaluation

For the process evaluation of the P4P program, the NMR team conducted IDIs with program staff and one program partner (Table 69).

Table 69: P4P Program Evaluation Activities

Stakeholder	Completed
Program staff interview	1
Program partner interview	1

2.6.2.1 Key Findings

These were the key findings from the process evaluation of the P4P program:

- The program partner interviewee was satisfied with their participation. On a scale from 1 to 5, where 1 is “very dissatisfied” and 5 is “very satisfied,” the program partner, an energy services company, rated their satisfaction with the program a 4.0. The interviewee reported having no difficulties participating in the program.
- DCSEU is actively growing to meet the needs of this emerging program. Despite the fact that the program recently launched, program administration is smooth according to the program partner.
- On a scale from 1 to 5, where 1 is “very difficult” and 5 is “not at all difficult”, the program partner rated the administrative requirements of the program a 4.0. Further, the fact that information requests are incremental (versus all at once) makes the process manageable. The program partner recommended that the program be conservative in its metering requirements.
- The program’s information sharing approach should be refined as it develops. The program partner offered some suggestions for creating a more transparent participation process by sharing more information about the modeling process, incentive structures, savings estimates, realized-savings summaries, etc.
- DCSEU incentives are reportedly quite low compared to a neighboring P4P program. Nonetheless, interviewees expected participation in the DCSEU P4P program to increase, especially with a building technology market that has progressively advanced.

2.6.2.2 Program Satisfaction

On a scale from 1 to 5, where 1 is "very dissatisfied" and 5 is "very satisfied," the program partner rated their satisfaction with the program a 4.0. The program partner views the P4P program enthusiastically, saying, "It will mean more business for us, so it is a very exciting program that we're happy to be a part of."

2.6.2.3 Marketing and Outreach

Program staff explained that the marketing and outreach for the P4P program operates similarly to the other DCSEU custom programs. DCSEU staff attend trade shows, conferences, and events to promote the program. DCSEU account managers leverage their existing relationships with customers to recruit potential participants.

The program partner reported that they advertise the program in email marketing campaigns and meet with their customers to educate them about the program. According to program staff, program partner efforts and word of mouth through existing participants have helped grow participation.

2.6.2.4 Program Administration

Program staff are in the process of training engineers to process the additional workload created by the program expansion. Their efforts so far have met the program partner interviewee's needs, saying they had no difficulties engaging with the program and offering the following feedback:

- The turnaround time to process incentives was reasonable.
- DCSEU staff had satisfactorily addressed all of the interviewee's requests and needs.
- The program partner had no difficulties engaging with the program.

2.6.2.5 Program Requirements

Program requirements appear to be reasonable:

- On a scale from 1 to 5, where 1 is "very difficult" and 5 is "not at all difficult," the program partner rated the administrative requirements of the program a 4.0.
- The program partner noted that DCSEU requests a substantial amount of information, but the interviewee believed that the requirements are reasonable and manageable, especially when compared to similar programs offered by other organizations that the program partner has participated in. The interviewee found that DCSEU's approach where requirements are "spread out" is particularly helpful in creating an easy participation process.

Program staff reported that they are developing guidelines to identify which types of projects require metered data in response to high levels of interest among potential participants. The program partner offered their perspective on the topic of metering:

> *"…because we do all of our calculations and check that against expected savings, so if you have robust calculations along with some building operational data, I think that's good enough. I don't think you really need to install meters to track any specific projects, personally."*

2.6.2.6 Information Sharing

Program staff described how they seek to streamline the information exchange between DCSEU and the customer. The program needs to adequately share information to ensure its long-term success:

- The program partner believed that they had a high-level understanding of the program, but thought the program had not shared enough information on their modeling methodology.
- The program partner also expressed concern and confusion around the program's rules about installing other energy-efficiency measures during the participation period.

The program partner identified some effective strategies to enhance communication and increase participation:

- Speak directly with customers.
- Clarify the relationship between savings and incentives amounts.
- Share more savings forecasts with participants after actual measure installation.
- Share summaries of energy usage before and after the performance period.

2.6.2.7 Incentives

The program partner would like for incentive levels to increase. The interviewee estimated that the DCSEU P4P program incentives are about one-third the size (in terms of dollar per kWh) of those for a similar regional program.

As implied above, the program partner expressed a need for greater transparency in incentive estimates.

2.6.2.8 Drivers of and Barriers to Participation

The program partner expected program participation to increase in the coming years given an uptick in large commercial buildings implementing centralized systems and connected equipment. Program staff echoed this assessment, pointing to major changes in the industry that have made energy monitoring technologies more affordable and accessible.

Though, program staff pointed out that the substantial cost ("tens of thousands of dollars") of converting older, legacy proprietary systems to more open protocols presents the biggest challenge. On that note, the program partner asserted that some customers are deterred from installing energy-efficiency measures because of up-front costs.

2.6.3 Recommendations

Based on the findings of our evaluation, we offer the following recommendations for the P4P program:

- The evaluation team recommends that the SEU continue to utilize the TTOW modeling algorithm whenever possible. The TTOW model is well supported by the literature and has been found to be a very accurate energy predictor when weather data is the only available independent variable.

- The electric savings for projects in the P4P program are calculated on an annualized basis. The natural gas savings for one project were not annualized in the same fashion. The evaluation team recommends that the SEU normalize energy and natural gas savings for each project included in the P4P program.
- FY2019 was the first year that the P4P program claimed savings. All three of the participants are expected to continue participating and claiming savings in FY2020. The evaluation team recommends that the SEU be diligent in ensuring that the evaluation periods for FY2020 savings begin immediately after the verification period for FY2019 ended. For example, if the post-implementation period for FY2019 savings ended June 30, 2019, the post-implementation period for FY2020 should begin July 1, 2019. This ensures that the persistence of savings is properly accounted for as the program cycle continues.
- The electric savings for one project were annualized due to less than one year of post-implementation data being available. The evaluation team supports annualizing savings estimates. However, it is essential that the savings for any projects that are annualized be re-evaluated (trued-up) once enough data is available. Based on conversations with the SEU staff, true-up will occur during the second year of participation for these customers. The evaluation team supports this process and recommends that the SEU ensure that the second year savings analysis include data starting immediately after the FY2019 post-implementation period.
- Given the nature of the P4P program, it is likely that some customers may not be in the program for more than one year. If customers leave the program, but less than one year of post-implementation data was available to estimate savings, a true-up of the full-year savings should occur. The evaluation team recommends that savings true-ups be completed for customers who leave the program without a full year of post-implementation data being available.
- The current COVID-19 outbreak is likely to impact the post-verification energy savings for projects that will be claimed in FY2020. The evaluation team recommends that the SEU work with the evaluation team to develop a methodology to account for the effects of COVID-19 when modeling the P4P program savings. The evaluation team is willing to assist, review, and analyze projects prior to closing FY2020 to ensure a collaborative and transparent process.
- Continue *staging* application materials – which has been positively perceived – to avoid burdening customers and thus sustain participation.
- To further improve program delivery, take steps to improve transparency.
    - Use more comprehensive descriptions of modeling algorithms in program applications or participant-facing materials. Possibly devote a webinar with vendors to answer their questions.
    - Clarify program rules about installing other energy-efficiency measures during the participation period in program documents and discuss these rules in meetings with vendors and customers or during vendor webinars.

  - In program discussions with participants, ensure they understand the estimated savings and incentives for their projects.
  - Create a strong feedback loop about consumption during (and after) the performance period that leverage tables and graphs to illustrate changes in usage.
- Be sure to directly address up-front costs in the initial conversations with potential participants. Understanding a potential participant's financing hurdles will foster a stronger relationship. It may also offer program staff the opportunity to share information on non-program financing opportunities.
- Explore the impact of increasing incentive rates on the cost of energy savings.

2.7 SOLAR PV MARKET RATE (7101PVMR)

The Solar Photovoltaic Market Rate (PVMR) Program provides incentives to buildings that install solar panels that produce local electricity to reduce their consumption from the electric grid. This program was established to help DC meet its Renewable Portfolio Standard renewable energy capacity goals. At its inception, the program's goal was to meet a capacity benchmark of five MW by providing rebates for solar projects in the District of Columbia. Moving forward, the program is aiming to achieve the DCSEU performance benchmark and address the needs of the solar market by serving as a low or no cost technical assistance center for solar installations. This effort will supplement the Solar for All program, which provides assistance for solar projects in low-income single-family homes and community solar projects.

The District of Columbia has a strong demand for solar projects. The project pipeline builds up well in advance and DCSEU will sometimes defer projects to the next fiscal year because they exhaust funding in the current fiscal year. However, DCSEU will still work to promote solar installations even without funding to award.

Due to budget constraints, DCSEU did not set up the solar program as an independent program. The program falls under the custom and new construction tracks, and projects are diverted to the solar track to facilitate renewable capacity tracking. If customers were planning to implement solar or PV installations or exhibited an interest, account managers would raise this incentive option and DCSEU would pay a custom incentive as part of the project. The DCSEU also worked with contractors to identify potential projects.

At the start of a project, the contractor submits project information to Pepco and DCSEU. DCSEU sets a price per watt capacity as a starting point. If necessary, this amount can be tweaked to make the project more financially appealing. However, solar incentive amounts are more defined than for other custom measures.

Both Pepco and DCSEU must sign off on submitted projects before they may be installed or funded. Pepco vets the project for interconnection compatibility and DCSEU reviews the scope of work, spec sheets, and other documentation. DCSEU analyzes projects using NREL's PV Watts tool and a custom load shape is created for each project. Once both organizations approve the project, DCSEU inspects the installation and Pepco provides proof of interconnection before a rebate is issued.

Marketing efforts are limited due to budget constraints. Typically, the DCSEU engages existing customers who are interested in pursuing solar and the customers then involve their installers. Sometimes DCSEU works directly with developers who pitch projects. DCSEU also held a series of webinars on the cost benefit analysis for solar installations to create awareness of the benefits of solar energy projects.

In FY2019, the program provided incentives for 15 projects and claimed 10,365 MWh of electric savings and 2.32 MW of peak demand reduction. For the FY2019 Solar PV Market Rate program, we completed the following evaluation activities:

- Gross Savings Verification
- Net Savings Estimation
- Process Evaluation

2.7.1 Gross Savings Verification

Table 70 shows the tracked savings, realization rate, and evaluated savings for the program. No gas savings are claimed for this program as it is entirely comprised of solar panel installations, and no interactive effects are present. The electric savings realization rate was found to equal 102%, while the demand savings realization rate equals 103%.

Table 70: PV Market Rate Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2019 Electric Savings (MWh)	10,365	102.1%	10,577
FY2019 Peak Demand Savings (MW)	2.32	103.1%	2.39

2.7.1.1 Sampling

Due to the heterogeneous makeup of the program, the PVMR program sample design employed stratified random sampling. The NMR team created a certainty stratum, which ensured that we reviewed the largest project from the program. The NMR team assigned projects with more than 1,000 MMBtu of total energy savings to the certainty stratum. There was a single certainty stratum project that represented 86% of the program savings. The NMR team assigned the remaining

projects to the probability stratum, from which we drew a random sample (Table 71). We selected seven of the 15 projects for review in the FY2019 evaluation.

Table 71: PV Market Rate Sampling Plan

Stratum	Percent of Program Energy Savings	FY2019 Participation	Number of Sampled Sites
Certainty	86%	1	1
Probability	14%	14	6

2.7.1.2 Methodology

The NMR team conducted desk reviews for the seven sampled projects, through which we calculated the evaluated savings. Two desk reviews used additional information gathered from onsite verifications. One onsite was for a certainty stratum project and the other was for a probability stratum project. While onsite, the NMR evaluation team completed the following tasks:

- Verified the installation of the solar array
- Confirmed the specifications of the array, such as module type, array tilt, and invertor efficiency
- Confirmed the installation date of the solar panels

The National Renewable Energy Laboratory (NREL) PV Watts Calculator[14] was used to calculate the energy savings. The PV Watts tool relies on several key inputs, including the following:

1. **Site Address –** The location (address or latitude/longitude) of the solar PV installation
2. **DC System Size** – The direct current (DC) power output of the system
3. **Module Type** – The type of solar panels. Either standard, premium, or thin film
4. **Array Type** – Fixed, one-axis tracking, or two-axis tracking
5. **System Losses** – Estimate of real-world system losses
6. **Tilt** – Roof angle where the panels are installed
7. **Azimuth** – Direction panels face away from true north
8. **DC to AC Size Ratio** – Inverter AC output compared to solar array DC output
9. **Inverter Efficiency** – DC to AC conversion efficiency
10. **Ground Coverage Ratio** – How close together the panels are placed

During the desk review process, our engineers reviewed all available project documentation for consistency. Project drawings, spec sheets, and invoices often supplied more accurate project information, including specific inverter efficiency values, exact site addresses, installation locations (such as rooftop), or a DC to AC Size Ratio. Regardless, for each project, the NMR team created an updated PV Watts model utilizing project documentation to verify the reported savings or provide more accurate savings calculations.

During the site visits, field engineers visually confirmed the key inputs to the PV Watts calculation. Additionally, the NMR team interviewed the customer regarding planned maintenance or other scheduled periods where the array would be disabled. After completing the onsite visit, engineers

[14] https://pvwatts.nrel.gov/

verified that the information used in the calculations of the desk reviews was accurate and updated the desk reviews with any additional information obtained onsite.

2.7.1.3 Results

The program-wide impact evaluation results for the PVMR program are shown in Table 72. The findings that contributed to the realization rates are detailed in the text that follows.

Table 72: PV Market Rate Program Impact Results

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2019 Electric Savings (MWh)	10,365	102.1%	10,577	±0.1% @ 80%
FY2019 Peak Demand Savings (MW)	2.32	103.1%	2.39	±0.1% @ 80%

The program-level realization rates are 102% for electric savings and 103% for demand savings. The selected sample ultimately achieved a ±0.1% precision at 80% confidence for electric savings and ±0.1% precision for demand savings.

The NMR team found that some of the projects evaluated did not use the correct installation address for the panels in PV Watts (the general city of Washington D.C. versus actual installation address). Updating the address using the application led to a slight increase in energy and peak demand savings as PV Watts obtains weather data based on the address input by the user. The savings also saw a slight increase due to site specific inverter efficiencies being input in PV Watts software instead of an assumed value of 96% (which is the PV Watts default inverter efficiency).

The evaluation team has leveraged the PV Watts solar calculator for evaluations in other jurisdictions and vetted its accuracy and reliability. The tool also projects estimated energy production relative to typical meteorological year (TMY3) data,[15] providing the DCSEU with a weather normalized generation estimate.

2.7.2 Net Savings Estimation

The NMR team calculated the NTG ratio, which is composed of free-ridership and participant spillover. We estimated free-ridership and participant spillover based on question responses from five telephone surveys completed with participating Solar PV Market Rate customers.

2.7.2.1 Free-ridership

We estimated free-ridership based on the following two factors:

- Intention or the expected behavior in the absence of the program; and
- The influence of various program elements on the decision to participate in the program.

Intention

As shown in Table 73, the five Solar PV Market Rate program participants received the following scores:

[15] https://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/

- One participant reported they would have delayed the measure installation by at least one year. We assigned this respondent a low free-ridership intention score (0%).
- Two other participants said they would have installed the measure but scaled back the scope or efficiency in the absence of the program. We assigned these respondents a moderate free-ridership intention score (25%).
- The other two respondents reported they would have installed the measure with the exact same scope and efficiency in the absence of the program and they would have had the funds to cover the entire cost of the measure, so we assigned them a high free-ridership intention score (50%).

The overall free-ridership intention score across all five respondents is 30%.

Table 73: Free-ridership Intention Scoring for Solar PV Market Rate Program

Intention in the Absence of the Program	Funds Available to Cover the Entire Cost	Assigned Free-ridership Intention Score (%)	Count of Respondents
• Delayed the installation of the measure for at least one year OR • Cancelled the installation of the measure altogether	• Not Asked	0%	1
• Installed the measure but scaled back the scope or efficiency OR • Don't know OR • I'd rather not answer	• Not Asked	25%	2
• Installed the measure with the exact same scope and efficiency	• Definitely would not have had the funds OR • Don't know OR • I'd rather not answer	25%	-
	• Might have had the funds	37.5%	-
	• Definitely would have had the funds	50%	2
Total		**30%**	**5**

Influence

Table 74 displays the influence rating of various program features on participants' decision to install the measure, using a 1 to 5 scale, where 1 means it "played no role at all" and 5 means it "played a great role." The Solar PV Market Rate program features with the highest average ratings include the rebate (4.4, on average) and prior program experience (4.2).

Table 74: Influence of DCSEU Program Features for Solar PV Market Rate Program

Features	n	1 Played no role at all	2	3	4	5 Played a great role	Average Rating
The financial incentive/rebate	5	-	1	-	-	4	4.4
Previous experience with a DCSEU program	5	-	-	2	-	3	4.2
Information provided by a DCSEU representative	5	1	1	-	2	1	3.2
Results of DCSEU audits or technical studies	5	1	2	1	1	-	2.4
Information or recommendation from contractors or suppliers associated with the program	5	2	2	1	-	1	2.4
DCSEU program marketing materials about the program	5	1	2	1	1	-	2.4

The NMR team assigned each respondent a free-ridership influence score based on the highest rating they provided for any of the above program features. Nearly all Solar PV Market Rate program respondents (4 of 5) indicated that at least one program feature played a great role in their decision, so we assigned them a free-ridership influence score of 0% (Table 75). A single respondent provided a maximum rating of 3.0, so we assigned them a free-ridership influence score of 25%.

The overall free-ridership influence score across all five respondents is 5%.

Table 75: Free-ridership Influence Scoring for Solar PV Market Rate Program

Maximum Influence Rating	Assigned Free-ridership Influence Score (%)	Count of Respondents
5 - program feature played a great role	0%	4
4	12.5%	-
3	25%	1
2	37.5%	-
1 - program feature played no role OR Not Applicable	50%	-
Don't know OR Refused	25%	-
Total	**5%**	**5**

For each respondent, we summed the free-ridership intention score and the free-ridership influence score to yield a cumulative free-ridership rate. We calculated both unweighted and savings-weighted free-ridership values, where we applied a weight based on the measure with the most tracked total energy savings associated with the project. The average unweighted free-ridership rate was 35%, and the average weighted free-ridership rate for the Solar PV Market Rate program was 49% (Table 76).

Table 76: FY2019 Free-ridership Rate for Solar PV Market Rate Program

	Average	Minimum	Maximum
Free-ridership (unweighted)	35%	0%	75%
Free-ridership (savings-weighted)	49%	0%	75%

The FY2018 free-ridership rate for the Solar PV Market Rate program was 0%. Given the small sample sizes for both years, we recommend combining the results from both years through a savings-weighted approach. This approach produces a free-ridership rate of 44% (Table 77).

Table 77: FY2018-FY2019 Free-ridership Rate for Solar PV Market Rate Program

	Sample Size	Percent of Sampled Energy Savings	Free-ridership Rate
FY2018	2	11%	0%
FY2019	5	89%	49%
Weighted Average			**44%**

2.7.2.2 Participant Spillover

None of the participants reported installing energy-efficient or renewable energy equipment at a DC location that did not receive an incentive from any program after their Solar PV Market Rate project. Therefore, the spillover rate is 0% (Table 78). In FY2018, the spillover rate was also 0%, so there is no need to adjust the FY2019 result.

Table 78: FY2019 Spillover Rate for Solar PV Market Rate Program

	Average	Minimum	Maximum
Spillover Rate	0%	0%	0%

2.7.2.3 NTG Ratio

The savings-weighted NTG ratio for the Solar PV Market Rate program equals 56% (Table 79).

Table 79: FY2018-FY2019 NTG Ratio for Solar PV Market Rate Program

	Free-ridership	Participant Spillover	NTG (1 – FR + PSO)
Net-to-Gross Ratio	44%	0%	56%

2.7.3 Process Evaluation

For the process evaluation of the Solar PV Market Rate program, the NMR team surveyed five participants via a telephone survey.

Table 80: Solar PV Market Rate Program Evaluation Activities

Stakeholder	Completed
Participant surveys	5

2.7.3.1 Key Findings

These were the key findings from the process evaluation of the Solar PV Market Rate program:

- Program satisfaction is high. On a scale from 1 to 5, where 1 is "not at all satisfied" and 5 is "very satisfied," the five participants rated the program a 4.8, on average. In particular, they were satisfied with the types of eligible equipment, preapproval process, and technical assistance they received from DCSEU.
- The NPS[16] for the Solar PV Market Rate program was 80, with four of the five respondents providing *promoter* ratings.
- In addition to being fully satisfied with the preapproval process, respondents had a relatively positive experience with the application itself. It appears that the support that DCSEU and contractors provide during the application process is critical to ensure a positive customer experience.
- To improve program administration, participants recommended processing rebates more quickly, adjusting project milestone deadlines so they better align with construction cycles, and improving communication between program staff and installation contractors.
- Participants are mostly satisfied with the program's incentive levels, with only one of the five respondents rating their satisfaction at less than 5.0. While two respondents suggested increasing rebate levels, they did not position it as a major concern.

2.7.3.2 Program Satisfaction

Program satisfaction is high:

- On a scale from 1 to 5, where 1 is "not at all satisfied" and 5 is "very satisfied," participants rated the program a 4.8, on average. Table 81 shows their satisfaction ratings in detail.
- Where applicable, all five participants gave satisfaction ratings of 5.0 for the types of eligible equipment, preapproval process, and technical assistance they received from DCSEU.
- On a scale from 0 to 10, where 0 is "extremely unlikely" and 10 is "extremely likely," participants rated their likelihood to recommend the program to someone else a 9.6, on average. The NPS for the program among participating end users was 80. Overall, four of the five respondents were *promoters* – that is, these participants may actively promote the program to other potential participants by word of mouth. The fifth respondent was *passive*, rating their likelihood to recommend the program to someone else an 8.0.

[16] The NPS is a well-established measure of customer loyalty. Using a scale of 0 to 10, where 0 is "extremely unlikely" and 10 is "extremely likely," respondents are asked how likely they are to recommend the program to someone else. Respondents are then grouped as promoters (score 9-10), passives (7-8), and detractors (0-6). The NPS is calculated by subtracting the percentage of detractors from the percentage of promoters and is presented as a whole number.

Table 81: Participant Satisfaction with the Solar PV Market Rate Program

Feature	n[1]	1 Not at all satisfied	2	3	4	5 Very Satisfied	Average Rating
Your experience overall	**5**	**-**	**-**	**-**	**1**	**4**	**4.8**
The type of eligible equipment	5	-	-	-	-	5	5.0
The preapproval process	4	-	-	-	-	4	5.0
Technical assistance from DCSEU	3	-	-	-	-	3	5.0
Time to receive the rebate or incentive	5	-	-	-	1	4	4.8
Performance of the new equipment	5	-	-	-	1	4	4.8
Energy savings from new equipment	4	-	-	-	1	3	4.8
The rebate or incentive amount	5	-	-	1	-	4	4.6
The application process	4	-	-	1		3	4.5
Assistance from the installation contractor	4	-	-	1	-	3	4.5
Information about DCSEU offerings	5	-	-	1	2	2	4.2

[1] Sample size varies because results exclude those who said, "Not applicable" or "I'm not sure."

2.7.3.3 Program Administration

Participants have a relatively positive experience with the application process. They rated their satisfaction with it a 4.5, on average. It appears that the support that DCSEU and contractors provide to complete the applications is impactful. On a scale from 1 to 5, where 1 is "very difficult" and 5 is "very easy," participants rated the ease of completing the application a 4.5, on average. Only one participant reported receiving no assistance completing the application from either DCSEU staff members or a contractor. This was the only respondent to rate the ease of completing the application a 3.0 versus a 5.0.[17]

Three participants recommended ways to improve program administration:

- One recommended extending the project milestone deadline, reasoning that the current structure does not account for the realities of construction (likely referencing the financing and permitting constraints they operate under).
- That same respondent thought that communication between construction contractors and the program staff needs to be more open and detailed.
- Another respondent suggested that the program process rebates more quickly.

The three participants who received technical assistance from DCSEU rated their satisfaction as a 5.0, showing no change from FY2018 participant survey results.

[17] Four participants rated their ease completing the application; the fifth participant declined to give a rating because their contractor filled out that organization's application.

2.7.3.4 Incentives

Participants are satisfied with the program's incentive levels. They rated their satisfaction with it a 4.6, on average – only one respondent rated it less than a 5.0. However, two of the five participants recommended increasing incentive amounts. One specified that it should increase by 25% and cover a larger share of costs but caveated that "Overall, [the incentive] was pretty good."

2.7.3.5 Drivers and Barriers to Participation

Participants reported the reasons they were motivated to participate:

- All five respondents were driven to participate to save money on energy costs and advance long-term strategic energy goals. Four of the five participants reported that they realized that goal.
- Four respondents were also driven by a goal to promote positive public relations. Three of these four respondents (plus one other) reported realizing this goal.
- Four respondents also sought to reduce operating or maintenance costs. All four reported that they reduced their operating costs.

Results show minimal hurdles that hinder the program's success:

- Two of five participants faced hurdles when deciding to participate in the program: One reported difficulties financing the project, and the other had to obtain access to a suitable roof space and waterproof it prior to participation. Both participants reported that the rebate helped overcome these barriers to participation.
- Four out of five participants did not encounter any problems with the installation or performance of their solar PV system. The fifth reported experiencing delays and complications with installation and licensing, resulting in a one-and-a-half-year project delay.
- Looking ahead, four out of five participants reported having plans for energy-efficient or renewable energy improvements in the next two years. All participants indicated that they would consider involving DCSEU in their future plans.
- When asked what assistance DCSEU can provide participants going forward to help meet their energy needs, participants most commonly requested that DCSEU continue offering programs (3 participants) and rebates (3) and to provide information on other programs (2).

2.7.4 Recommendations

Based on the findings of our analysis, we offer the following recommendations for the Solar PV Market Rate program:

- Continue to utilize the PV Watts tool for predicting solar generation data when actual production data is not available. If project-specific solar generation data is available to the DCSEU, actual generation data should be prioritized over the theoretical estimates of the PV Watts tool.
- Utilize project-specific values in the PV Watts Calculator whenever possible. For example, use the project-specific inverter efficiency rather than the default PV Watts inverter efficiency or a rounded value to improve the energy savings accuracy. Additionally, use the exact site address when provided instead of using the zip code.
- Provide documentation of project specific values for System Losses, DC to AC Size Ratio, and Ground Coverage Ratio when they differ from the default values in PV Watts. This will enable more accurate estimation of solar generation.
- Because there are so few Solar PV Market Rate participants, the program should work closely with participants and installation contractors to develop a common and flexible understanding of project timelines and financial constraints.
- Encourage contractors to contribute as much assistance as possible with the DCSEU application process as their support is important for establishing a positive customer experience.
- Assess the length of time between system installation and rebate issuance to determine if there is an opportunity to accelerate rebate processing. If delays in rebate issuance are unavoidable for a given project, ensure regular communication with participants regarding the timeline.

Section 3 Efficient Products, Multifamily, and Single-family Residential Programs

In this section, we present a brief program summary, as well as the methodology, findings, and recommendations from our evaluations of each of the five Efficient Products and Multifamily Residential programs selected for the FY2019 evaluation:

- Retail Lighting
- Nest Seasonal Savings
- Income Qualified Efficiency Fund
- Low-income Multifamily Comprehensive
- Low-income Prescriptive Rebate

3.1 Retail Lighting (7710LITE)

The Retail Lighting initiative is an upstream program that works to increase availability and sales of LED bulbs in the District of Columbia. Partnering with retailers and manufacturers, DCSEU offers rebates for these technologies installed in DC homes and businesses and provides educational materials to raise consumer awareness of these products.

This program targets lighting manufacturers and retailers to reach residents and small businesses. The manufacturers and retailers are provided incentives on a per-bulb basis. In FY2019, the Retail Lighting initiative offered rebates for qualifying ENERGY STAR LED lightbulb purchases, including screw-base LEDs, LED fixtures, and recessed LED downlights. Working with area distributors, DCSEU also offered lighting rebates to District contractors and businesses for these products at the time of purchase.

This initiative is implemented by DCSEU, and the Energy Federation Incorporated (EFI) provides support for incentive payment and data tracking. EFI is responsible for compiling and verifying manufacturer invoices and processing payments. The manufacturers work with stores to gather sales reports they submit along with the invoice requests.

For the FY2019 Retail Lighting program, we completed the following evaluation activity:

- Gross Savings Verification

3.1.1 Gross Savings Verification

Table 82 displays the tracked savings, realization rate, and evaluated savings for the Retail Lighting program. The evaluation team calculated a realization rate of 100% for electric, peak demand, and gas savings.

Table 82: Retail Lighting Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2019 Electric Savings (MWh)	19,965	100%	19,965
FY2019 Peak Demand Savings (MW)	2.3	100%	2.3
FY2019 Gas Savings (MMBtu)	-20,340	100%	-20,340

3.1.1.1 Methodology

We reviewed rebate forms, invoices, and summary files to verify that the quantities and general measure descriptions in these documents matched the quantities and descriptions listed in the tracking database. In addition, we verified that the savings algorithms from the TRM were applied correctly for all 264,933 measures that represent 100% of FY2019 program energy savings. The NMR team used deemed wattage values and prescriptive inputs to calculate electric, demand, and gas savings.

3.1.1.2 Results

The NMR team calculated a realization rate of 100% for electric, demand, and gas savings for all Retail Lighting measure types, including screw-base LEDs, LED fixtures, and recessed LED downlights (Table 83).

Table 83: Retail Efficient Lighting Savings and Realization Rates by Measure Type

	FY2019 Electric Savings Realization Rate	FY2019 Peak Demand Savings Realization Rate	FY2019 Gas Savings Realization Rate
LED Screw-Base Bulbs	100%	100%	100%
LED Lighting Fixtures	100%	100%	100%
Recessed LED Downlights	100%	100%	100%
Total	**100%**	**100%**	**100%**

3.2 SEASONAL SAVINGS (7710STAT)

The Nest Seasonal Savings program is a thermostat optimization measure offered by Nest Labs that delivers energy savings by presenting Nest owners with the opportunity to implement more conservative thermostat setpoints for a season. The program operates by making small, incremental adjustments to participant's heating or cooling schedules.

For the FY2019 Seasonal Savings program, we completed the following evaluation activity:

- Gross and Net Savings Verification

3.2.1 Gross and Net Savings Verification

The evaluation team independently estimated gross and net verified savings[18] for the winter 2018/2019 implementation period. The Nest Seasonal Savings program uses incremental adjustments to a participant's heating or cooling schedules. We evaluated the impacts for the 2018-2019 heating season using thermostat runtime data provided by Nest.

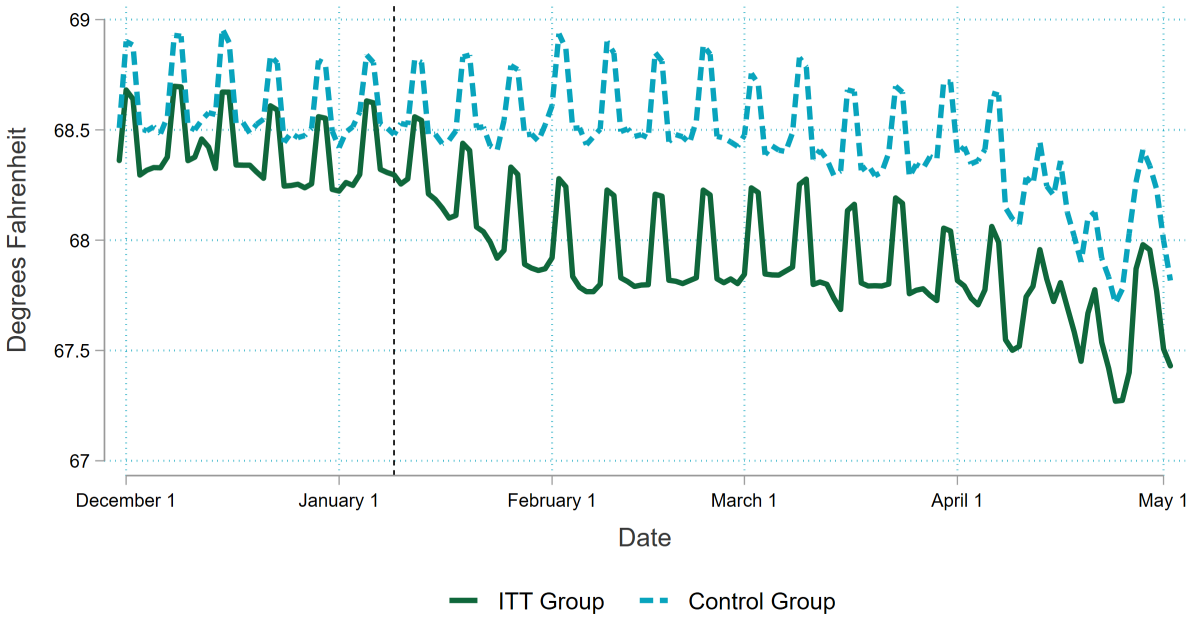
The offering was delivered as a randomized encouragement design (RED) and randomly split users into an intention-to-treat (ITT) group and a control group. This randomization allows for difference in difference (DiD) modeling to compare how changes in the ITT group compare to changes in the control group over time. Nest sent a notification to all eligible ITT thermostats, inviting them to opt-in to Seasonal Savings. Some of the eligible ITT customers that received the offer accepted it (opt-ins) and others did not accept.

The NMR team estimated per-device savings initially for the ITT group, then used the opt-in rate to scale the results and estimate the average impact per opt-in device. The NMR team then applied assumptions about heating system fuel, type, size, and efficiency to convert runtime savings into energy savings.

Figure 6 shows the average scheduled thermostat set point for both the ITT group and the control group. The black line indicates the program start date of January 9, 2019. Prior to the program start date, the average scheduled set point was slightly lower for the ITT group. Beginning January 9, 2019, the Seasonal Savings program begins the ramp up period, where the scheduled set points are slowly modified from their user settings. Following the ramp up period, the ITT Group clearly exhibits lower average scheduled set points than the control group.

[18] Because the evaluation approach used a control group to assess occupant behavior in the absence of the program, the savings reflect both gross verified and net verified savings.

Figure 6: Average Scheduled Set Point



For the winter Seasonal Savings analysis, an additional layer of complexity must be taken under consideration. Homes in DC are predominantly either heated by gas furnaces or electric air-source heat pumps. With this in mind, the evaluators assessed the Seasonal Savings impact for each system type separately.

Table 84 shows the average ITT and Average Treatment Effect on the Treated (ATT) impacts for both furnace and heat pump systems. The ITT columns show the impact estimates and the ATT column inflates these estimates by dividing by the opt-in rate specific to the system type. Effectively, the ITT results shows the average impact of being randomly selected into the ITT group and the ATT shows the average impact of opting into Seasonal Savings.

By comparing the Seasonal Savings impacts for furnaces and heat pumps, it is evident that the Seasonal Savings relative impact is larger for devices connected to heat pumps compared to devices connected to furnaces. The calculated ATT percent savings for devices connected to furnaces is 2.55%, while the calculated ATT percent savings for devices connected to heat pumps is 5.11%.

Table 84: Average Seasonal Savings Impacts per Device by System Type

System	Daily ITT Runtime Savings (minutes)	ITT (MMBTU)	ITT (kWh)	ATT (MMBTU)	ATT (kWh)	ATT Percent Savings
Furnace	2.5	0.356	2.634	0.625	4.629	2.55%
Heat Pump	5.5	N/A	32.2	N/A	61.5	5.11%

A summary of the evaluation results is provided in Table 85. It compares the reported and verified savings for the Seasonal Savings offering in winter 2018/2019.

- The electric savings realization rate is 42.2% and the natural gas savings realization rate is 43.2%. The low realization rates are largely because the baseline heating consumption assumption in the TRM measure characterization considered the heating consumption (both gas and electric) for a full year winter season rather than the mid-winter deployment of January 9. Therefore, the baseline was too high leading to higher reported savings.

Table 85: Winter 2018/2019 Seasonal Savings Results Summary

Resource Type	Reported Savings	Realization Rate	Verified Gross Savings
Electric Savings (MWh)	495.8	42.2%	209.2
Natural Gas Savings (MMBtu)	7,268	43.2%	3,138

Appendix B contains the full details of the Seasonal Savings analysis and findings.

3.2.1.1 Recommendations

Based on the findings of our analysis, we offer the following recommendations for the Seasonal Savings program:

- The reason for the differences between the reported and verified impacts is the baseline heating consumption assumption in the TRM measure characterization considered the heating consumption (both gas and electric) for a full year winter season rather than the mid-winter deployment of January 9. Heating consumption in October, November, December, and early January cannot be reduced because the offering had not been deployed. For winter 2018/2019, the evaluation team projects a natural gas baseline consumption of 24.5 MMBtu per customer in the post period, and an electric consumption baseline of 1,508.4 kWh per customer in the post period. It is recommended that the estimated baseline be adjusted to reflect the Nest mid-season deployment approach.
- Households with different heating systems should be characterized differently. A thermostat connected to a gas furnace will not also be connected to an air-source heat pump. Therefore, thermostats connected to furnaces will see inherently different resource than air-source heat pumps. The evaluation team recommends assessing electric and gas winter seasonal savings for furnaces separately from electric seasonal savings from air-source heat pumps.
- The TRM assumption used by DC SEU of 3.5% heating savings was taken from a Massachusetts evaluation of Seasonal Savings during the winter season. Based on the

evaluated findings from 2018-2019, the 3.5% assumption appears to be accurate for winter Seasonal Savings estimates, as the NMR team's estimate is 3.66% savings for the opt-in devices.

  - Although the pooled result of 3.66% was very close to the 3.5% assumption in the TRM, percent savings estimates varied by heating system type. Furnaces were estimated to have 2.55% savings, while air-source heat pumps had an estimated 5.11% savings. Despite the fact that the difference is not statistically significant, the evaluation team would recommend using the heating system type-specific percent savings results for TRM measure characterization. The baseline consumption, average equipment capacity, and fuel type needs to be considered separately, so we believe it makes sense to use the system-specific percent savings assumptions as well.

- The allocation of devices to the ITT and control groups was unbalanced (88% ITT and 12% control). The tradeoff between control group size and aggregate energy savings is important. Small control groups increase the uncertainty of the savings estimate, but any device assigned to the control group achieves no energy savings. However, control group devices are also likely to not incur any fees from Nest. The evaluation team recommends a control group size of at least 3,000 for future Seasonal Savings implementations. Considering the winter analysis is split between furnace and heat pumps, the control group is further limited to devices for each system type. The winter 2018/2019 seasonal savings program had 1,921 control group devices with runtime data. Of these devices, 1,159 were connected to furnaces and 762 were connected to air-source heat pumps.

3.3 INCOME QUALIFIED EFFICIENCY FUND (7610IQEF)

The Income Qualified Efficiency Fund (IQEF) program provides financial support to projects that increase energy efficiency in buildings, neighborhoods, and communities. This program allotted funding to DCSEU approved contractors to implement projects that resulted in significant energy savings and to pass the resulting monetary benefits on to low- or moderate-income residents in the District of Columbia. A total of 28 energy-efficiency projects were funded at DC multifamily properties, shelters, or clinics in FY2019.

Table 86 provides the breakdown of tracked savings by measure type.

Table 86: Income Qualified Efficiency Fund Program Savings Contributions

Measure Type	Percent of FY2019 Combined Energy Savings	Percent of FY2019 Electric Savings	Percent of FY2019 Peak Demand Savings	Percent of FY2019 Gas Savings
Boilers/Furnaces	28%	4%	-	60%
LED Downlights	18%	34%	39%	<-1%[19]
Water Heating	15%	-	-	35%
Outdoor LED Fixtures	10%	16%	1%	<-1%
Indoor LED Fixtures	9%	15%	10%	<-1%
Linear LEDs	7%	12%	16%	<-1%
Cooling	4%	6%	26%	2%
Screw Base LEDs	4%	7%	4%	<-1%
LED HID Replacement	2%	3%	0%	-
Thermostats	2%	<1%	-	4%
LED Pin-based CFL Replacements	1%	2%	2%	<-1%
LED Exit Signs	<1%	<1%	1%	<-1%
Occupancy Sensors	<1%	<1%	<1%	<-1%

For the FY2019 Income Qualified Efficiency Fund program, we completed the following evaluation activity:

- Gross Savings Verification

3.3.1 Gross Savings Verification

Table 87 displays the tracked savings, realization rates, evaluated savings, and sample precisions for the Income Qualified Efficiency Fund program.

Table 87: Income Qualified Efficiency Fund Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2019 Electric Savings (MWh)	1,302	100%	1,302	±0.0% @ 80%
FY2019 Peak Demand Savings (MW)	0.1	100%	0.1	±0.0% @ 80%
FY2019 Gas Savings (MMBtu)	2,610	102%	2,651	±2.7% @ 80%

3.3.1.1 Methodology

We reviewed spec sheets and other supporting documentation to verify that measure quantities, descriptions, and other key inputs matched those listed in the tracking database and utilized in

[19] Lighting gas savings are negative because of the heating penalty for efficient lighting.

savings calculations. In addition, we conducted measure reviews to verify that tracked savings are based on accurate savings parameters.

3.3.1.2 Sampling Plan

We conducted desk reviews for the nine projects with the most energy savings. For the Income Qualified Efficiency Fund program, the top nine sites represented 65% of the tracked energy savings from all 28 projects that participated in the program in FY2019.

3.3.1.3 Results

The following measure categories achieved realization rates of 100% in all applicable savings categories: boilers/furnaces, lighting, cooling, and thermostats.

Water heaters were installed at three of the sampled projects. For one of these projects, tracked water heater savings were calculated utilizing incorrect thermal efficiency and standby loss values. These incorrect values had been obtained from an out-of-date manufacturer spec sheet. We obtained the current values from a photo of the product nameplate and cross-referenced it with the ENERGY STAR qualified product list. Correcting these input values results in a gas realization rate of 105% (Table 88).

Table 88: Income Qualified Efficiency Fund Realization Rates by Measure Type

Measure Category*	FY2019 Electric Savings Realization Rate	FY2019 Peak Demand Savings Realization Rate	FY2019 Gas Savings Realization Rate
Boilers & Furnaces	100%	-	100%
Downlight LEDs	100%	100%	100%
Water Heating	-	-	105%
Outdoor LED Fixtures	100%	100%	100%
Indoor LED Fixtures	100%	100%	100%
Linear LEDs	100%	100%	100%
Cooling	100%	100%	100%
Screw Base LEDs	100%	100%	100%
LED HID Replacements	100%	100%	-
Thermostats	100%	-	100%
LED Exit Signs	100%	100%	100%
Total	**100%**	**100%**	**102%**

*Sampled measures only.

3.3.1.4 Recommendations

Based on the findings of our analysis, we offer the following recommendation for the Income Qualified Efficiency Fund program:

- Ensure that any savings inputs used in calculations match those listed on equipment nameplates.

3.4 LOW-INCOME MULTIFAMILY COMPREHENSIVE (7612LICP)

The LICP program provides custom technical services and incentives for energy-efficiency improvements to low-income multifamily projects – specifically, new construction, substantial renovation, and redevelopment housing. In FY2019, ECMs included heating and cooling systems, in-unit and common area lighting, appliances, controls, thermostats, solar PV, ventilation fans, domestic hot water systems, and low flow water fixtures.

In FY2019, the program provided incentives for 29 projects. Table 89 provides the breakdown of tracked savings by measure type. The bulk of total energy savings and total electric savings are derived from lighting and cooling measures.

Table 89: LICP Program Savings Contributions

Measure Type	Percent of FY2019 Combined Energy Savings	Percent of FY2019 Electric Savings	Percent of FY2019 Peak Demand Savings	Percent of FY2019 Gas Savings
Lighting	33%	43%	29%	<-1%[20]
Cooling	28%	28%	43%	-
VFD	7%	7%	3%	-
Heat Pumps	7%	6%	9%	5%
Water Heating	4%	-	-	37%
Appliances	4%	4%	3%	<1%
Low Flow Water Fixtures	3%	3%	-	-
Boilers/Furnaces	3%	-	-	32%
Ventilation	1%	1%	1%	-
Others	11%	9%	12%	25%

*Others include air sealing, custom HVAC motors, comprehensive building-wide savings, refrigeration controls, and pipe insulation.

[20] Lighting gas savings are negative because they are a gas penalty for efficient lighting.

For the FY2019 LICP program, we completed the following evaluation activities:

- Gross Savings Verification
- Process Evaluation

3.4.1 Gross Savings Verification

Table 90 displays the tracked savings, realization rates, evaluated savings and sample precisions for the LICP program.

Table 90: Low-income Multifamily Comprehensive Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2019 Electric Savings (MWh)	3,666	101%	3,704	±5.7% @ 80%
FY2019 Peak Demand Savings (MW)	0.6	99%	0.6	±1.9% @ 80%
FY2019 Gas Savings (MMBtu)	69	100%[21]	69	n/a

3.4.1.1 Methodology

We conducted measure reviews for nine sampled projects to verify that tracked savings are reasonable and to determine which measures merited further review. Each audit examined product documentation to identify the source of any discrepancies between tracked and evaluated savings and to assess the accuracy of the savings parameters. We reviewed specification sheets and other supporting documentation to verify that measure quantities, descriptions, and other key inputs matched those listed in the tracking database. In addition, we conducted on-site verification visits at two sampled sites.

3.4.1.2 Sampling Plan

We conducted desk reviews for the nine projects with the most energy savings. For the LICP program, the top nine sites represented 63% of the tracked energy savings from all 29 projects that participated in the program in FY2019.

3.4.1.3 Results

First, we discuss the results for lighting measures. Then, we discuss the results for other measures.

Lighting

We calculated electric, demand, and gas savings realization rates of 100% for most lighting measures; however, we found different realization rates for certain measures including recessed

[21] Across the nine sampled projects, the tracked and evaluated gas savings were both negative due to heating penalties from lighting. Because the evaluated savings are a larger negative value than the tracked savings the realization rate is >100% for the sample. However, there were positive gas savings across all program projects, indicating that the sample did not accurately reflect the program population in terms of gas savings, which represent a very small portion of overall energy savings. Therefore, we opted to apply a default realization rate of 100% for gas savings.

2X4 and other LED fixtures, pin-base LEDs, screw base LEDs, and interior lighting power density reductions.

- The electric, demand, and gas savings realization rates for direct-wired, pin-base LED replacements for CFLs all equal 101%. This is because savings from only 432 bulbs were recorded for one project, whereas 448 bulbs were installed and confirmed during the project inspection.
- Asbestos was discovered at one project after installations were underway. The complex planned to install one recessed 2x4 LED fixture in each apartment, but the discovery of asbestos resulted in a field substitution of two screw-base LEDs per apartment instead of one fixture. However, the incentive agreement and tracking database were not updated to reflect the field substitution.
- Thirty-seven LED fixtures installed in residential units at one sampled project were incorrectly recorded as common area installations. At this project, the residential units utilize heat pumps for heating, while the common areas are heated with gas. Correcting the HOU and waste heat factors for these fixtures lowered the electric and gas realization rates.
- The interior lighting power density reduction achieved realization rates above 100% due to the application of incorrect waste heat factors at two of the three sampled projects with this measure. One project had the installations incorrectly categorized as residential in-unit when the measures were installed in common areas. A second project had the installations incorrectly categorized as an in-unit installation with heat pump heating when the measures were actually installed in common areas heated with gas.
- An on-site visit at one project revealed that some, but not all, of the LEDs installed in hallways matched those reported in the tracking data. Sconces containing two 5.5-watt LEDs each were recorded in the tracking data, but a mix of these sconces and sconces containing only one 9-watt bulb were observed on site. The NMR team did not adjust savings from this project because we were not able to count exactly how many of the hundreds of sconces contained one 9-watt bulb versus two 5.5-watt bulbs, but note that savings from these LEDs at this project may have been underestimated by up to 15%.

Non-Lighting Measures

Other non-lighting measures that yielded realization rates above or below 100% for electric, demand, and/or gas savings include air sealing, clothes washers, dishwashers, refrigerators, and faucet aerators.

- Air sealing was performed at one FY2019 project. This project is heated with electric heat pumps; therefore, air sealing produced both electric and demand savings. DCSEU calculated tracked electric savings for only the heating season. We calculated electric savings for the cooling season and summed them with heating savings, resulting in an electric realization rate of 160%. Additionally, zero peak demand savings were recorded for this measure. Given the outsized impact on program peak demand savings from this sole air sealing project, we did not adjust peak demand savings.

- Energy Star clothes washers were installed at one sampled project. The electric and demand savings were calculated using the 2015 federal standard baseline Integrated Modified Energy Factor (IMEF). We updating the baseline IMEF to the 2018 federal standard[22].
- Dishwashers were installed at two sampled projects. A site visit was conducted for one of these projects and revealed that a less efficient dishwasher model was installed than the model originally planned.
- Energy Star refrigerators were installed at two sampled projects. One of these projects reported the TRM deemed savings instead of calculating the site-specific savings using the Energy Star calculator.[23]
- Faucet aerators were installed at two sampled projects and achieved an electric realization rate of 100%. Demand savings were not multiplied by the quantity of measures installed at one project; instead, demand savings for only a single measure were recorded. Multiplying demand savings by the quantity of faucet aerators installed at this project results in an overall demand realization rate of 433%.

Realization rates for measures present in sampled projects are displayed in Table 91. Similar measures are grouped together. For example, the various types of LED bulbs and fixtures installed at sampled projects are included in the lighting category, while clothes washers, dishwashers, and refrigerators are included in the appliances category. We grouped measures that were installed at only one FY2019 project in the other category, including air sealing, custom HVAC motors, and comprehensive building-wide savings. There were a few types of measures that were installed during FY2019 that are not present in Table 91. This is because these measures were not installed at sampled projects and therefore the NMR team did not evaluate them during the desk reviews.[24]

[22]Electronic Code of Federal Regulations: Energy and water conservation standards and their compliance dates. Section (g)(4) https://www.ecfr.gov/cgi-bin/text-idx?SID=86e70cbc87e5af18caca2e5c205bd107&mc=true&node=se10.3.430_132&rgn=div8

[23]https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/purchase-energy-saving-products

[24] FY2019 measures not sampled include ductless mini-split heat pumps, package terminal air conditioners, unitary air conditioning systems, clothes dryers, water heaters, refrigeration controls, exterior LED fixtures, and pipe insulation.

Table 91: Low-income Multifamily Comprehensive Realization Rates by Measure Type

Measure Category*	FY2019 Electric Savings Realization Rate	FY2019 Peak Demand Savings Realization Rate	FY2019 Gas Savings Realization Rate
Lighting	104%	101%	117%
Cooling	100%	100%	--
VFDs	100%	100%	--
Heat Pumps	100%	100%	--
Appliances	54%	56%	100%
Low Flow Water Fixtures	100%	433%	--
Ventilation	100%	100%	--
Others	118%	100%	100%

*Sampled measures only.

3.4.2 Process Evaluation

For the process evaluation of the LICP program, the NMR team completed IDIs with program staff, a program partner, and participating property managers (Table 92). The results from these evaluation activities are presented below.

Table 92: Low-income Multifamily Comprehensive Process Evaluation Activities

Stakeholder	Completed
Program staff interview	1
Program partner (developer) interview	1
Property manager interviews	4

3.4.2.1 Key Findings

These were the key findings from the process evaluation of the Low-income Multifamily program:

- Participants are pleased with the program overall. Property managers rated it a 4.5 on a scale from 1 to 5, where 1 is “not at all satisfied” and 5 is “very satisfied.”
- Stakeholders identified the need to engage projects in the program in the earliest stages of design to maximize savings and participation, but this often does not occur in the LICP program, yet it is on the program staff’s radar.
- Though appreciative of the program, the program partner, a developer, reported that the application process lacked transparency and was burdensome. Therefore, they requested greater streamlining and coordination with other entities. In contrast, property managers were pleased with the application process and the amount of documentation required to participate.
- The program provides an array of technical assistance; however, stakeholders eyed opportunities for improvement, requesting greater assistance with modeling, online (versus in-person) trainings, and more centralized resources (i.e., a depository).

- Property managers were only somewhat satisfied with rebate and incentive amounts, rating their satisfaction a 3.5, on average. Overall, interviewees saw a benefit to increasing incentive amounts in order to maximize program savings.
- Program staff are exploring adding program measures, such as refrigeration. Other interviewees suggested adding more "innovative" measures, such as solar panel siding or passive house strategies; however, property managers and the program partner appeared unfamiliar with the array of eligible program measures.

3.4.2.2 Program Satisfaction

On a scale from 1 to 5, where 1 is "not at all satisfied" and 5 is "very satisfied," the four property managers rated their satisfaction with their overall program experience as a 4.5, on average.

- In particular, property managers were pleased with the application process, amount of documentation required to participate, time to receive the incentive, and their interactions with program staff – rating each 4.5, on average.
- Property managers also provided high ratings for the performance of the new equipment (4.8) and the assistance of the contractor who installed it (5.0).
- Only two property managers recalled receiving technical assistance from DCSEU, and they rated that experience a 3.0, on average.

3.4.2.3 Marketing and Outreach

The program successfully maintains relationships with developers and contractors to attract new projects. According to program staff, the program has the greatest impact if projects engage at the start of the design phase. However, this is often not the case. Therefore, recommended measures may not work within the project design, limiting the ability of program staff to maximize project savings. One property manager echoed this observation, recognizing that involving DCSEU after the project has been planned and permitted restricts the program's ability to impact savings.

The property managers recalled first learning of the program through DCSEU staff or word of mouth. Program staff view tenants as a useful mechanism for increasing participation, expecting that tenants will request new equipment. To improve program reach, staff are developing a tenant engagement pilot project. DCSEU staff would also like to further connect with the tenant community by planning events held in libraries and other public forums.

On the topic of awareness, during the interview fielding process, we found that potential interviewees were confused about the difference between the Low-income Multifamily program and the Low-Income Prescriptive Rebate program.

3.4.2.4 Administrative Requirements

On a scale from 1 to 5, where 1 is "very difficult" and 5 is "not at all difficult," the interviewed program partner rated the administrative requirements of the program a 2.0 due to a lack of transparency and the burden of additional paperwork. The program partner provided several recommendations to reduce administrative burden on participants:

- The interviewee indicated that the program requires partners to report meter reads and suggested that DCSEU collect that data directly from utilities.
- Finding the participation process difficult to navigate, the program partner also suggested implementing a more comprehensive package where the application process, financing, and eligibility information are more integrated, streamlined and transparent.
- The interviewee speculated that increasing coordination with DC Housing Authority (DCHA) and DCRA could facilitate the application process and pointed to the Maryland Department of Housing and Community Development (DHCD) program as an excellent "one-stop shop" example.

3.4.2.5 Technical Support

The LICP program supports multi-measure installations in low-income multifamily buildings by providing incentives and conducting other activities, such as providing project-specific case managers, modeling energy savings, and delivering training seminars. One property manager even recalled the program writing a letter of support to justify other funding needs. Despite all of the program's offerings, interviewees suggested ways that DCSEU could improve its support:

- One property manager suggested that DCSEU provide case studies as a resource for program participants and partners.
- Another property manager requested that information about other DCSEU programs be provided alongside support for participation in the program.
- The program partner and one property manager expressed frustration that the modeling process was not transparent. The property manager called the program's method for analyzing savings, "a black box;" the interviewee said, "Basically, the engineering department reviews our scope of work and spits out a number and it's impossible to predict what that number will be." The interviewee suggested the program allow participants to use their own modeling tools instead of having to rely on the program's "proprietary screening method."
- The program partner recommended enhancing online training tools, explaining that developers are too busy to attend on-site trainings. The interviewee also suggested that the DCSEU provide a centralized resource including industry trends, best practices, and recommended vendors.
- One property manager suggested using an independent third party to perform modeling and calculate savings. However, program staff indicated that much of the process is kept internal to maximize cost-effectiveness, and they emphasized that projects undergo internal peer review by multifamily building experts.

All four property managers considered the program website a useful informational tool. On a scale of 1 to 5, where 1 is "not at all useful" and 5 is "very useful," they rated it a 4.0, on average. None of the interviewees had specific suggestions to improve the website.

3.4.2.6 Incentives

Property managers were only somewhat satisfied with the LICP program's rebate and incentive amounts, rating them 3.5, on average. Two specified that if rebate amounts were higher, it would enable them to install even more energy-efficiency measures. Program staff explained that inadequate incentive amounts also restrict the efficiency *level* of measures. On that note, the program partner recommended that the program enter into commitments with developers and provide incentives upfront, explaining that developers often need bridge loans to cover construction costs while awaiting program payment.

3.4.2.7 Program Measures

While property managers rated their satisfaction with the type of eligible equipment at 4.0, on average, there appear to be opportunities and interest in broadening program-eligible measures:

- Program staff hope to expand program offerings. They are currently exploring smart metering devices and have sought to include more measures, such as refrigeration.
- While the program partner expressed appreciation for the program, the interviewee described disappointment that the program cannot fund more "innovative" energy-efficiency building practices, such as passive house or solar panel siding.
- Property managers suggested that the program include common area light fixtures, water-saving equipment, heat pumps, and solar panels. However, the first three measure types appear in the program tracking data and the fourth is listed as a program measure in the program description, so this may be a matter of awareness. In fact, the program partner also said it was not clear which measures the program supports.

3.4.2.8 Accessibility

According to program staff, the program aims to improve energy equity in DC in the short-term and support affordable housing in the long-term. Furthermore, staff indicated that the program has recently expanded to include support for end-users such as shelters and clinics.

Only one of the four property managers was optimistic about the direction of the low-income housing market in the next few years, expecting increased growth with more developers building mixed-income and workforce housing. The other three predicted more challenging times ahead with the effects of gentrification combined with the fact that DC is a constrained entity in terms of land, making housing more expensive and decreasing the availability and focus on low-income housing.

The program partner suggested that the program adjust its qualifications to allow buildings that are moderate income, such as those above 60% of the area median income. Further, with an eye toward expanding program participation, the program partner suggested using tax credit records to identify eligible buildings that may be due for new HVAC equipment or other measures.

3.4.3 Recommendations

Based on the findings of our analysis, we offer the following recommendations for the LICP program:

- Update measure quantities and model information when data verified during project inspections differs from initial assumptions.
- Confirm that lighting installation locations and heating fuel types are recorded correctly so that the appropriate HOU and waste heat factors are applied.
- Calculate air sealing cooling and peak demand savings for projects heated with heat pumps where air sealing was performed.
- Calculate savings utilizing site-specific inputs as opposed to TRM defaults where available.
- Confirm that the current federal baseline standards are used to accurately compute energy savings.
- Continue holding events and conducting outreach to attract projects early in design. Stakeholders identified the need to engage projects in the program in the earliest stages. One way to influence a project in its earliest phase is to incorporate energy efficiency into its requests for proposals (RFPs). The program may consider drafting *boilerplate* language for organizations to use in their RFPs that stipulate energy-efficient design and suggest taking advantage of DCSEU program offerings.
- Create a more streamlined experience for participating in the LICP program that integrates the application process, financing, and eligibility information. Specific recommendations include the following:
    - Improve the transparency of application and modeling requirements and processes – this may include (1) using clearer descriptions of modeling algorithms in program applications or participant-facing materials and (2) conducting more direct outreach during the participation process via email, telephone, or in-person to ensure that program processes are fully understood.
    - Continue leveraging and even deepening the usage of the program website for sharing program participation information, such as guidance on measures or any other information participants might find useful as the website appears to be an effective mechanism for connecting with participants.
    - Additionally, consider furthering coordination with organizations such as DCHA and DCRA.
- Bolster technical support activities, in particular increase communication around modeling, develop a repository of resources for participants and partners that details best practices and lists recommended vendors, and hold trainings via webinar rather than in-person.
- Continue exploring the impact of expanding measure offerings and increasing incentive levels. In addition, clearly identify and communicate the program-eligible measures to partners and customers.

3.5 LOW-INCOME PRESCRIPTIVE REBATE (7613LIRX)

The DCSEU Low-Income Prescriptive Rebates (LIRX) program offers increased rebates for the installation of energy-efficient lighting and lighting controls in buildings that serve low-income DC residents. These include affordable housing, clinics, and shelters. By lowering energy costs, the LIRX program enables funding to improve client services and implement building upgrades rather than pay for unnecessary energy use. Rebates are available for lighting controls and sensors and a range of LED bulbs and fixtures.[25]

In FY2019, the program provided incentives for 37 projects. Table 93 provides the breakdown of tracked savings by measure type. The bulk of total energy savings are derived from screw-base LEDs.

Table 93: LIRX Program Savings Contributions

Measure Type	Percent of FY2019 Combined Energy Savings	Percent of FY2019 Electric Savings	Percent of FY2019 Peak Demand Savings	Percent of FY2019 Gas Savings
LED Screw-Base Bulb	74%	74%	78%	74%
LED Downlights	19%	19%	14%	19%
Linear LEDs	3%	3%	5%	3%
Indoor LED Fixtures	2%	2%	3%	2%
Occupancy Sensors	1%	1%	1%	2%
Outdoor LED Fixtures	1%	1%	<1%	N/A
LED Pin-based CFL Replacements	<1%	<1%	<1%	<1%
Daylighting	<1%	<1%	<1%	<1%

For the FY2019 Low-income Prescriptive Rebate program, we completed the following evaluation activities:

- Gross Savings Verification
- Process Evaluation

[25] https://www.dcseu.com/commercial-and-multifamily/income-qualified-lighting

3.5.1 Gross Savings Verification

Table 94 displays the tracked savings, realization rates, evaluated savings, and sample precisions for the Low-Income Prescriptive Rebate program.

Table 94: Low-income Prescriptive Rebate Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2019 Electric Savings (MWh)	6,592	39%	2,569	±89.1% @ 80%
FY2019 Peak Demand Savings (MW)	0.7	100%	0.7	±0.3% @ 80%
FY2019 Gas Savings (MMBtu)	-2,137	39%	-832	±89.4% @ 80%

3.5.1.1 Methodology

We performed measure reviews to verify that tracked savings were reasonable and to determine which measures merited further review. Each audit examined product documentation to identify the source of any discrepancies between tracked and evaluated savings and to assess the accuracy of the savings parameters. In addition, we conducted on-site verification visits at three sampled sites.

3.5.1.2 Sampling Plan

We conducted desk reviews for the 11 projects with the most energy savings. For the Low-Income Prescriptive Rebate program, the top 11 sites represented 89% of the tracked energy savings from all 37 projects that participated in the program in FY2019.

3.5.1.3 Results

DCSEU applies prescriptive inputs to calculate savings for the Low-Income Prescriptive Rebate program. These prescriptive inputs include baseline wattages, efficient wattages, in-service rate, percentage of buildings with fossil fuel heating, fossil fuel heating system efficiency, and waste heat factors. The sole exception is HOU; annual HOU entered on rebate forms by applicants are used in energy savings calculations. However, the evaluation team found that the self-reported HOU for residential in-unit installations are abnormally high. Table 95 displays the total number of residential in-unit installations by room type across the entire LIRX program (not just the 11 sampled projects), the number of those installations for which applicants reported 12 or more HOU per day, and the average HOU reported by applicants by room type. On the rebate form, applicants assigned one HOU for each measure type (e.g., linear LEDs, screw-base LEDs, indoor LED fixtures) installed in each location (e.g., bathroom, bedroom, kitchen). Each installation in Table 95 represents one HOU entry by an applicant (i.e., one instance of a specific measure type

installed in a particular room type).[26] Of the 19 total residential in-unit installations, 13 had daily HOU of 12 hours or more. The average HOU across all residential in-unit room types is 16.8.

Table 95: Low-income Prescriptive Rebate Applicant-Reported Daily Hours of Use for In-unit Installations

Location	Total Number of Installations*	Number of Installations with 12+ Daily HOU	Average Daily HOU
Bathroom	6	5	18.7
Bedroom	2	2	24.0
Dining	3	3	24.0
Kitchen	7	3	11.4
Living	1	0	8.0
All in-unit	**19**	**13**	**16.8**

*An installation represents a specific measure type installed at a specific room type at a project.

Table 96 displays daily HOU from TRMs for regions comparable to Washington DC, including the Pennsylvania[27] and Mid-Atlantic[28] TRMs. The Pennsylvania HOU are based on a 2014 metering study of single-family and multifamily homes.[29] The 1.9 HOU estimate from the Mid-Atlantic TRM comes from a 2016 Maryland metering study of single-family and multifamily homes, while the 16.3 multifamily common area HOU estimate comes from a 2010 Wisconsin deemed savings desk review.[30] One advantage of the Pennsylvania TRM is that the HOU values are provided by room type. We recalculated savings for in-unit installations in sampled projects using the Pennsylvania TRM HOU values, and applied the Mid-Atlantic TRM common area HOU for common area installations. This change decreased savings for in-unit installations but increased savings for common area installations.

[26] For example, a project where 200 screw-base LEDs were installed in bathrooms, 100 recessed LEDs were installed in dining rooms, and 300 linear LEDs were installed in kitchens would have three installations in Table 94 (one in bathrooms, one in dining rooms, and one in kitchens).

[27] http://www.puc.pa.gov/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx

[28] https://neep.org/sites/default/files/resources/Mid_Atlantic_TRM_V9_Final_clean_wUpdateSummary%20-%20CT%20FORMAT.pdf

[29] While the study did not present HOU separately for single-family and multifamily homes, it found no statistically significant differences between the two.

[30] Note that the common area HOU of 16.3 from the 2010 Wisconsin deemed savings desk review is the prescribed HOU in the DCSEU Multifamily T12 Replacement Program TRM Characterization for common areas.

Table 96: Daily Hours of Use from Other TRMs

Location	Pennsylvania TRM Daily HOU	Mid-Atlantic TRM Daily HOU
Bathroom	2.8	1.9
Bedroom	2.3	1.9
Dining	3.2	1.9
Kitchen	4.4	1.9
Living	4.1	1.9
Unknown	3.0	1.9
Common	N/A	16.3

During the multifamily site visits, we discovered some inaccuracies in the locations in which measures were reported to have been installed. For one of the three projects visited, all measures were recorded as common area lighting, but a number of the measures were installed inside residential units and outside the building. We adjusted savings to account for the HOU and waste heat factors appropriate for the in-unit and exterior installations at this project.

Realization rates for measures present in sampled projects are displayed in Table 97.[31] The reduction of HOU for in-unit installations is the driving factor for realization rates that are less than 100%. Reclassifying common area installations as in-unit installations based on on-site observations also reduced realization rates. Applying the common area HOU from the Mid-Atlantic TRM increased the high- and low-bay LED fixture realization rates because it exceeds the self-reported HOU values from the rebate applications at the sampled projects.

Table 97: Low-income Prescriptive Rebate Realization Rates by Measure Type

Measure Category*	Electric Savings Realization Rate	Peak Demand Savings Realization Rate	Gas Savings Realization Rate
LED Screw Base Lamp	39%	100%	39%
LED Recessed Surface or Pendant Downlight	32%	100%	32%
LED Linear Replacement Lamp	71%	100%	71%
LED High- and Low-Bay Fixtures	136%	100%	136%

*Sampled measures only

[31] Measures that were installed during FY2019 but were not present in sampled projects include recessed 2X2 and 2X4 fixtures, pin-base LEDs, occupancy sensors, daylighting, and surface and suspended linear fixtures.

3.5.2 Process Evaluation

For the process evaluation of the Low-Income Prescriptive Rebate program, the NMR team completed IDIs with program staff, program partners, and participating property managers (Table 98). The results from these evaluation activities are presented below.

Table 98: Low-income Prescriptive Rebate Process Evaluation Activities

Stakeholder	Completed
Program staff interview	1
Program partner (distributor) interview	1
Property manager interviews	3

3.5.2.1 Key Findings

These were the key findings from the process evaluation of the Low-income Prescriptive Rebate program:

- Program satisfaction is high and program staff are successfully meeting participants' expectations.
  - The three property managers rated it a 5.0 on a scale from 1 to 5, where 1 is "not at all satisfied" and 5 is "very satisfied."
  - Property managers all rated their satisfaction with their interactions with program staff a 5.0.
  - The program partner deemed the rebate processing consistent and organized.
  - Property managers were satisfied with the amount of time to receive the rebates and the application process (both 4.3, on average).
- The program partner reported that their distribution company's sales increased because of the program and considered rebate amounts adequate. The property managers rated their satisfaction with the rebate amounts a 4.7, on average.
- Interviewees described how the program must compete with hurdles, such as skepticism amongst smaller institutions, lack of time among property managers, and small operating budgets. They pointed to the resonance of case studies and efficacy of direct outreach by DCSEU representatives. On the topic of participation levels, program staff suggested that adding HVAC measures may appeal to a broader client base.
- Interviewees felt knowledgeable about the program offerings – particularly the program partner – however, two of the property managers hoped for more transparency in the pre-approval process and eligibility requirements and one was unaware of the option to apply online.

3.5.2.2 Program Satisfaction

Stakeholders appeared satisfied with the program:

- When asked to rate overall program satisfaction on a scale of 1 to 5, where 1 is "not at all satisfied" and 5 is "very satisfied," the program partner and all three property managers rated it a 5.0. Additionally, they all rated their interactions with program staff a 5.0.
- The program partner applauded DCSEU in its consistency and organization in its rebate processing. Similarly, property managers were fairly happy with it, too, rating their satisfaction with the time it took to receive the incentive a 4.3, on average.
- The program partner and program staff believe that current rebate amounts are adequate. The property managers were satisfied with them, too; they rated their satisfaction with the rebate amounts a 4.7, on average. That said, one property manager thought it would still be beneficial to increase rebate levels.
- The program partner stated that the program has been a boon for their distribution business, declaring that it is "a triple winner" because it also benefits residents and owners.
- Aligned with program staff's goal of ensuring a positive resident experience, one property manager said the tenants like the brightness of the new lighting in their units and the hallways. Though, another property manager said that some tenants initially complained about the brighter lighting, but their complaints have subsided.

3.5.2.3 Marketing and Outreach

The program partner confirmed that their distribution company actively promotes the program to all qualifying customers. At one point, the company even had a salesperson dedicated to engaging hard-to-reach customers. Two property managers recalled first learning about the program through an email from DCSEU, and the third first learned about it from a vendor.

According to program staff, DCSEU would like to expand the use and reach of the program moving forward. Interviewees offered guidance for increasing participation and program outreach:

- According to the program partner, the most successful outreach is directly through DCSEU representatives.
- One property manager suggested additional outreach to inform building owners and management companies about ways to save energy, speculating that emails and case studies would be most effective.
- Program staff suggested that promoting HVAC measure options to contractors and installers and promoting use of the program for buildings that may not need lighting upgraded – but desire other measures – may increase its reach.

On the topic of awareness, during the interview fielding process, we found that potential interviewees were confused about the difference between the Low-income Prescriptive Rebate program and the Low-Income Comprehensive program.

3.5.2.4 Program Administration

The program partner had no issues or difficulties participating in the program and expressed a high level of familiarity with its processes. Comparing the experience with a similar program in a neighboring state, the partner stated that the LIRX program eligibility requirements are clear and easy to understand. As mentioned, interviewees are pleased with rebate processing.

On a scale from 1 to 5, where 1 is "very dissatisfied" and 5 is "very satisfied," property managers rated the application process a 4.3, on average. While all three property managers rated their satisfaction with the pre-approval process a 5.0, two commented on the lack of transparency of the pre-approval process and awarding of projects. In the words of one,

> *"It was unclear how these would be awarded based on the different criteria and impacts to residents. For example, one of the categories you'd be putting in was what percent of this total project cost would the ownership or the property be contributing towards this work, and I had no idea whether I should put in 0, 5%, 50%, etc. [I wondered,] am I shooting myself in the foot by saying I'll pay for half of [the project] when [another organization]is submitting something and they're saying 5% and they're also getting the same award? It was unclear how the different categories were weighted in terms of awarding it – we got awarded everything we applied for, so I guess it didn't matter in the end."*

Property managers indicated that the program website has been somewhat useful. Though, one property manager requested that the applications be available directly on the website. This may be an issue of awareness or navigability of the program website because the program currently has a link to an editable PDF application and a downloadable spreadsheet (*Data Intake Tool*) to submit to contractors.[32]

3.5.2.5 Barriers

The program partner observed that some smaller institutions are skeptical of the program, seeing LEDs priced so low that they question the program's motivations or the quality of the products. Though, the interviewee explained that engaging and leveraging property management firms to vouch for the program to building owners is effective in overcoming that hurdle. Additionally, program staff suggested that some potential participants may not participate because they cannot take the time to apply or have difficulty fulfilling requirements for low-income verification forms.

Interviewees discussed their expectations about the future:

- The program partner doubted their participation in the program would increase over the next year because the majority of the company's three largest portfolios already participated.
- One property manager stated that it is very expensive to maintain low-income properties in DC and expected that this would limit bandwidth to invest in building improvements.
- Another property manager predicted an increased focus on energy conservation and retrofitting existing buildings would increase participation. However, the interviewee

[32] Visited March 11, 2020: https://www.dcseu.com/commercial-and-multifamily/income-qualified-efficiency-fund

explained that low-income property managers have to contend with limited budgets and competing priorities, so incentives are not always sufficient to encourage program participation.

3.5.3 Recommendations

Based on the findings of our analysis, we offer the following recommendations for the Low-Income Prescriptive Rebate program:

- Employ prescriptive HOU from recent metering studies instead of HOU estimates provided by applicants. We recommend using the HOU from the Pennsylvania TRM for in-unit installations and from the Mid-Atlantic TRM for common area installations.
- Confirm that lighting installation locations are recorded correctly so that the appropriate HOU and waste heat factors are applied.
- Explore the impacts of supporting HVAC measures.
- DCSEU representatives should continue implementing their effective outreach. To maximize marketing and outreach efforts, the program should develop robust case studies with participant testimonials that demonstrate positive participant/occupant experiences and realization of meaningful energy savings.
- Program staff should applaud their high level of organization and efficiency. To further improve program delivery, make efforts to improve the transparency of the pre-approval process and eligibility criteria by sharing the implications of selections such as property owners' planned investment amounts. Further, ensure participants are aware of the online application method.
- One focus of program support should address administrative requirements for property managers. If possible and appropriate, consider providing property managers more support in obtaining and completing the required paperwork. Easing their burden may increase participation levels.

Section 4 Default Realization Rates and Net-to-Gross Values

This section provides a description of the reviews undertaken to assign default realization rates and NTG values for programs that the NMR team did not select for the FY2019 evaluation.

4.1 Default Realization Rates

As described in Section 1.5, the FY2019 evaluation verified the gross savings for 12 programs. In order to assign default realization rates for the nine programs that the NMR team did not evaluate for FY2019, we reviewed previous realization rates for these DCSEU programs, as well as the calculated FY2019 realization rates for other programs. Because realization rates can change over time as measure offerings and markets evolve, we opted to apply the FY2018 or FY2017 realization rate for the same program or the FY2019 realization rate from similar programs or similar measures if they exist.

Table 99 lists each of the nine programs that did not undergo an evaluation in FY2019, the source of the realization rate, and the default realization rate values.

Table 99: FY2019 Default Realization Rates

Sector	Program Name	Source for Default Realization Rate	Default Realization Rates		
			Electric Savings	Peak Demand Savings	Gas Savings
Solar	Solar Photo Voltaic (7107PV)	FY2019 Evaluation for Solar PV Market Rate	102%	103%	n/a
	Low-income Solar Renewable Credit (7107SREC)	FY2019 Evaluation for Solar PV Market Rate	102%	103%	n/a
Commercial	Market Transformation Value (7512MTV)	FY2018 Evaluation	108%	139%	107%
Multifamily	Implementation Contractor Direct Install (7610ICDI)	FY2017 Evaluation	100%	99%	100%
Efficient Products	Retail Efficient Appliances (7710APPL)	FY2017 Evaluation	100%	100%	100%
	Retail Heating and Cooling (7710HTCL)	FY2017 Evaluation	100%	100%	100%
	Retail Lighting Food Bank (7717FBNK)	FY2019 Evaluation for Retail Lighting	100%	100%	100%
	Home Energy Conservation Kit - Low-income (7717HEKT)	FY2017 Evaluation	100%	100%	99%
	Residential Upstream (7725RSUP)	FY2019 Evaluation for Retail Lighting	100%	100%	100%

4.2 NET-TO-GROSS REVIEW

The NMR team estimated NTG values for four FY2019 programs. For the 17 programs where a NTG value was not estimated, we primarily based the FY2019 NTG values on the most recently available DCSEU NTG estimates from FY2018. If the NTG for a particular initiative was not measured in FY2018, we applied the FY2014 or FY2013 estimates. For programs where NTG was not assessed in FY2018, FY2014, or FY2013 (and for recently launched programs), the NMR team derived NTG values for similar programs from other jurisdictions or applied assumed values. Table 100 presents the recommended NTG estimates for these FY2019 programs.

Table 100: Recommended Default FY2019 NTG Estimates

Sector	Program Name	Track Number	NTG Value	Source
Solar	Solar Photo Voltaic	7107PV	100%	Assumed
	Low-income Solar Renewable Credit	7107SREC	100%	Assumed
Commercial	C&I RX - Equipment Replacement (standard program)	7511CIRX	66%	FY2018
	Market Transformation Value	7512MTV	75%	Lit Review
	New Construction - Commercial Custom	7520NEWC	46%	FY2018
	P4P	7520P4PX	100%	Assumed
Multifamily	Implementation Contractor Direct Install	7610ICDI	100%	FY2013
	Income Qualified Efficiency Fund	7610IQEF	100%	Assumed
	Low-income Multifamily Comprehensive	7612LICP	100%	Assumed
	Low-income Prescriptive Rebate	7613LIRX	100%	Assumed
Efficient Products	Retail Efficient Appliances	7710APPL	60%	FY2014
	Retail Heating and Cooling	7710HTCL	70%	FY2014
	Retail Lighting	7710LITE	51%	FY2013
	Retail Smart Thermostats	7710STAT	100%	Comparison Group Approach
	Retail Lighting Food Bank	7717FBNK	100%	Assumed
	Home Energy Conservation Kit - Low-income	7717HEKT	100%	Assumed
	Residential Upstream	7725RSUP	51%	Retail Lighting

To inform the derived FY2019 NTG estimates, the NMR team reviewed the previous DCSEU NTG values and also examined NTG results from other mid-Atlantic and northeastern jurisdictions. When we were not able to locate NTG studies for similar programs, we provided assumed values. Table 101 compares the most recent DCSEU NTG estimates with the NTG values from other jurisdictions. The table also includes the evaluation team's assumed estimates, which we used when NTG studies for comparable programs were not available. Overall, the DCSEU NTG estimates are aligned with those in other areas, which suggests that the recommended NTG values included in Table 100 are reasonable values for FY2019.

Table 101: DCSEU NTG Values Compared to Other Jurisdictions

Sector	Track	Initiative	DCSEU NTG	Year Assessed	Benchmark NTG	Benchmark Source Program Administrator (Program Year)
Solar	7101PVMR	Solar PV Market Rate	56%	FY2019	-	-
Commercial	7511CIRX	C& I RX - Equipment Replacement	66%	FY2018	Lighting: 64%-77% Prescriptive: 44%-54%	PA First Energy Companies (2018-2019)[b]
					75%	PA PECO (2018-2019)[d]
					Lighting: 77% Equipment: 64%	PA PPL (2018-2019)[a]
					88%	EMPOWER Maryland (2018)[c]
	7512MTV	Market Transformation Value	75%	Lit Review	Lighting: 64%-77% Prescriptive: 44%-54%	PA First Energy Companies (2018-2019)[b]
					75%	PA PECO (2018-2019)[d]
					Lighting: 77% Equipment: 64%	PA PPL (2018-2019)[a]
					88%	EMPOWER Maryland (2018)[c]
	7513UPLT	Commercial Upstream Lighting	62%	FY2019	85%	PA PPL (2017-2018)[e]
					74% A-line LEDs 67% Other LEDs	PA Duquesne (2018-2019)[f]
					80%	EMPOWER Maryland (2018)[c]
	7520CUST	Retrofit - Custom	53%	FY2019	Lighting: 66%-85% Custom: 37%-56%	PA First Energy Companies (2016-2017)[g]
					60%	EMPOWER Maryland (2018)[c]
					65%	PA PPL (2018-2019)[a]
					77%	PA PECO (2017-2018)[h]
	7520MARO	Market Opportunities - Custom	79%	FY2019	Lighting: 66%-85% Custom: 37%-56%	PA First Energy Companies (2016-2017)[g]
					60%	EMPOWER Maryland (2018)[c]
					65%	PA PPL (2018-2019)[a]
					77%	PA PECO (2017-2018)[h]
	7520NEWC	New Construction - Custom	46%	FY2018	Small: 27% Large: 41%	PA PECO (2017-2018)[h]
	7520P4PX	P4P	100%	n/a	n/a	Assumed
Multifamily	7610ICDI	Implementation Contractor Direct Install	100%	FY2013	100%	Efficiency Maine (2012-2013, assumed)[i]

Sector	Track	Initiative	DCSEU NTG	Year Assessed	Benchmark NTG	Benchmark Source Program Administrator (Program Year)
Efficient Products	7610IQEF	Income Qualified Efficiency Fund	100%	Assumed	45%	PA Duquesne (2017-2018)[j]
	7612LICP	Low-income Multifamily Comprehensive	100%	Assumed	Large: 93% Small: 92%	PA PECO (2018-2019)[d]
	7613LIRX	Low-income Prescriptive Rebate	100%	Assumed	45%	PA Duquesne (2017-2018)[j]
	7710APPL	Retail Efficient Appliances	60%	FY2014	66%	PA PECO (2017-2018)[h]
					47%-52%	PA First Energy Companies (2018-2019)[b]
					56%	EMPOWER Maryland (2018)[c]
					45%	PA Duquesne (2017-2018)[j]
	7710HTCL	Retail Heating and Cooling	70%	FY2014	56%	PA PECO (2017-2018)[h]
					45%-56%	PA First Energy Companies (2018-2019)[b]
					52%	EMPOWER Maryland (2018)[c]
					64%	PA PPL (2016-2017)[k]
	7710LITE	Retail Lighting	51%	FY2013	Standard LED: 51% Specialty LED: 46%	PA PECO (2017-2018)[h]
					23%-31%	PA First Energy Companies (2018-2019)[b]
					31%	EMPOWER Maryland (2018)[c]
					Standard LED: 43% Specialty LED: 43%	PA Duquesne (2017-2018)[j]
					83%	PA PPL (2016-2017)[k]
	7717FBNK	Retail Lighting Food Bank	100%	Assumed	--	--
	7717HEKT	Home Energy Conservation Kit - Low-income	100%	Assumed	100%	PA PPL (2018-2019, assumed)[a]
					100%	PA Duquesne (2018-2019, assumed)[f]
					100%	PA First Energy Companies (2018-2019, assumed)[b]
	7725RSUP	Residential Upstream	51%	Retail Lighting	Standard LED: 51% Specialty LED: 46%	PA PECO (2017-2018)[h]
					23%-31%	PA First Energy Companies (2018-2019)[b]
					31%	EMPOWER Maryland (2018)[c]
					Standard LED: 43% Specialty LED: 43%	PA Duquesne (2017-2018)[j]
					83%	PA PPL (2016-2017)[k]

Sector	Track	Initiative	DCSEU NTG	Year Assessed	Benchmark NTG	Benchmark Source Program Administrator (Program Year)

[a] The Cadmus Group. November 15, 2019. Annual Report to the Pennsylvania Public Utility Commission Phase III of Act 129 Program Year 10 (June 1, 2018-May 31, 2019) for Pennsylvania Act 129 of 2008 Energy Efficiency and Conservation Plan. Prepared for PPL Electric Utilities.
[b] ADM Associates and Tetra Tech. November 15, 2019. Final Annual Report to the Pennsylvania Public Utility Commission, Phase III of Act 129 Program Year 10 (June 1, 2018-May 31, 2019). Prepared for Metropolitan Edison Company, Pennsylvania Electric Company, Pennsylvania Power Company, West Penn Power.
[c] Navigant. 2019. Overview Memo - Calendar Year 2018 Deliverables. Submitted to: Sheldon Switzer and Mary Straub (BGE); David Pirtle and Joe Cohen (Pepco and DPL); Diane Rapp and Lisa Wolfe (PE); Jennifer Raley (SMECO); Joe Loper (Itron); Dan Hurley and Amanda Best (MD PSC); and other EmPOWER stakeholders.
[d] Navigant, A Guidehouse Company. November 15, 2019. Final Annual Report to the Pennsylvania Public Utility Commission, Phase III of Act 129 Program Year 10 (June 1, 2018-May 31, 2019). Prepared for PECO.
[e] The Cadmus Group. November 15, 2018. Annual Report to the Pennsylvania Public Utility Commission Phase III of Act 129 Program Year 9 (June 1, 2017-May 31, 2018) for Pennsylvania Act 129 of 2008 Energy Efficiency and Conservation Plan. Prepared for PPL Electric Utilities.
[f] Navigant, A Guidehouse Company. November 15, 2018. Final Annual Report to the Pennsylvania Public Utility Commission, Phase III of Act 129 Program Year 10 (June 1, 2018-May 31, 2019). Prepared for Duquesne Light Company.
[g] Navigant Consulting. November 15, 2017. Final Annual Report to the Pennsylvania Public Utility Commission, Phase III of Act 129 Program Year 8 (June 1, 2016-May 31, 2017). Prepared for Metropolitan Edison Company, Pennsylvania Electric Company, Pennsylvania Power Company, West Penn Power.
[h] Navigant Consulting. November 15, 2018. Final Annual Report to the Pennsylvania Public Utility Commission, Phase III of Act 129 Program Year 9 (June 1, 2017-May 31, 2018). Prepared for PECO.
[i] NMR Group. January 14, 2016. Efficiency Maine Low-Income Multifamily Weatherization Evaluation Report. Submitted to Efficiency Maine. https://www.efficiencymaine.com/docs/Low-Income-Multifamily-Final-Evaluation-Report-2016.pdf
[j] Navigant Consulting. November 15, 2018. Final Annual Report to the Pennsylvania Public Utility Commission, Phase III of Act 129 Program Year 9 (June 1, 2017-May 31, 2018). Prepared for Duquesne Light Company.
[k] The Cadmus Group. November 15, 2017. Annual Report to the Pennsylvania Public Utility Commission Phase III of Act 129 Program Year 8 (June 1, 2016-May 31, 2017) for Pennsylvania Act 129 of 2008 Energy Efficiency and Conservation Plan. Prepared for PPL Electric Utilities.

Appendix A Program Descriptions

This appendix provides a description for each of the program tracks offered by DCSEU in FY2019.

A.1 Commercial Sector

7520CUST - Retrofit – Commercial Custom

The Custom Retrofit program offers incentives to owners of large buildings to install energy-efficient equipment or make operational changes to their facility that result in energy savings. The program focuses on retrofit projects where the equipment is being replaced prior to the end of its life. Incentives are offered for a variety of equipment types, including lighting, chillers, boilers, heat pumps, steam systems, insulation, refrigeration, and various building or equipment controls. Through this program, the DCSEU offers technical assistance to help decision makers design, scope, and fund their projects. Rebates are paid on a traditional per-unit of energy saved basis.

7520MARO - Market Opportunities – Commercial Custom

The Market Opportunity Custom program focuses on retrofit projects where equipment is at the end of its life. It offers incentives to large building owners who update equipment to energy-efficient options or update operational controls to achieve energy savings. This track includes measures in lighting, HVAC, and various commercial/residential appliances. Key objectives of the incentive are to offset the costs of adding energy-efficient equipment beyond the current energy code; provide comprehensive technical services to help decision makers design, scope, and fund their projects; and share the economic benefits with the customer. Funding is available through a traditional rebate structure where participants are paid per unit of energy saved.

7520NEWC - New Construction – Commercial Custom

This program focuses on construction of new buildings or facilities that exceed energy code standards. The New Construction Track covers a large range of new construction measures including lighting; HVAC; building controls; building envelope elements such as insulation and windows; and plug loads such as icemakers, refrigerator and freezers. DCSEU provides technical assistance in the design stage to help decision makers design, scope, and fund their projects.

7520P4PX - Pay for Performance

The P4P program launched in FY19 to incentivize complex, multi-measure energy-efficiency projects that are not covered under existing program tracks. It focuses on existing commercial and industrial buildings, which implement multiple measures simultaneously or behavioral or operational changes where it is difficult to estimate savings. This may include re-/retro-commissioning, upgrades to the building controls, or fault detection. Incentives are paid based on pre- and post-metered energy usage data.

7511CIRX - C&I RX – Equipment Replacement

The BER initiative provides small- to medium-sized businesses located in DC with a comprehensive set of services and financial incentives to help them transition to more energy-efficient equipment. The initiative provides prescriptive incentives for lighting, refrigeration, HVAC, compressed air, and food service and vending equipment. Rebates require written pre-approval and are given for facility improvements that result in a permanent reduction in electrical and/or natural gas energy usage persisting for a minimum of five years.

7512MTV – Market Transformation Value

The Market Transformation Value program offers rebate incentives to large businesses and institutions for upgrades to energy-efficient equipment. This program provides per-unit rebates and includes measures for LED lighting, lighting controls, motors, and condensing gas boilers and furnaces.

7513UPLT – Commercial Upstream

The Commercial Upstream/Midstream Lighting Program provides customers with point-of-purchase rebates when they buy qualified lighting products from participating distributors. Through this program, customers can receive rebates for ENERGY STAR 2.0 certified LED directional, omnidirectional, and decorative bulbs, as well as DLC certified linear LED tubes. This program format enables closer and more efficient tracking of product purchases. Distributors provide sales information directly to DCSEU, enabling higher levels of quality control.

A.2 SOLAR SECTOR

7101PVMR – Solar PV Market Rate

The PV Market Rate program provides incentives to buildings that install solar panels to reduce their consumption from the electric grid. The program contributes to electricity and natural gas savings, installed renewable energy capacity, the formation of green jobs, and low-income spending and savings. It also helps meet the DCSEU performance benchmark and address the needs of the solar market by serving as a low or no cost technical assistance center for solar installations.

A.3 MULTIFAMILY SECTOR

7610ICDI - Implementation Contractor Direct Install

The Low-Income Multifamily Implementation Contractor Direct Install (ICDI) initiative supports low-income multifamily communities in DC. DCSEU hires implementation contractors to install energy-efficient equipment in eligible buildings and covers 100% of the product and direct installation costs. The opportunity is promoted to property owners, property managers, developers, architects, and engineers and is designed to serve a wide variety of energy-efficiency needs. Included measures allow for all spaces in multifamily buildings to be served, and may include the installation of heating and cooling systems, domestic hot water systems, lighting, refrigeration, and controls. While this track is aimed at low-income residences, multifamily resident

buildings that do not qualify as low-income can still have common space fixtures incentivized under this program.

7612LICP - Low-Income Multifamily Comprehensive

The Low-Income Multifamily Comprehensive program is designed to support low-income multifamily housing, specifically new construction or gut-rehab, in the installation of energy-efficient measures, and allows DCSEU to provide technical expertise and funding. Each project is evaluated independently, and energy-efficient measures are selected to best meet the project's needs. Measures include domestic hot water systems, lighting, appliances, building controls, and thermal envelope measures.

7610IQEF - Income Qualified Efficiency Fund

The Income Qualified Efficiency Fund program is designed to serve low-income multifamily housing, shelters, and approved clinics. Funding and priority are competitively awarded to approved contractors for energy-efficiency projects that generate significant energy savings and pass the associated financial benefits on to low-income DC residents. Efficiency measures that maximize energy savings, reach a large number of low-to-moderate income residents, and/or assist residents who face a loss of heating or air conditioning due to inoperable equipment receive priority. Supported measures include domestic hot water systems, lighting, appliances, controls, and measures improving the thermal envelope.

7413LIER – Low-Income Emergency Equipment Replacement

The Low-Income Emergency Equipment Replacement initiative is designed to serve the low-income homeowner that is referred to the DCSEU from the DC Department of Energy & Environment Low-income Home Energy Assistance Program (LIHEAP). Approved energy conservation measures for this track include furnaces, boilers, domestic hot water systems, appliances, and controls.

7613LIRX - Low-Income Prescriptive Rebate

The Low-Income Prescriptive Rebate program provides financial support for lighting installations in low-income multifamily housing and low-income shelters and clinics. Approved installations must be EnergyStar or DLC qualified. This initiative enables DCSEU to provide incentives and custom technical services for lighting improvements to low-income multifamily establishments.

7717HEKT - Home Energy Conservation Kit – Low-Income

The Home Energy Conservation Kit – Low-Income program sends home energy conservation kits to low-income District residents. These kits include an advanced power strip, a faucet aerator, and six LED bulbs. They offer low-income DC residents a free, easy way to implement energy saving measures.

A.4 EFFICIENT PRODUCTS SECTOR

7710APPL - Retail Efficient Appliances

The Retail Efficient Appliances program offers mail-in and online rebates for qualifying refrigerators, clothes washers, clothes dryers, heat pumps, air conditioners, boilers, furnaces, thermostats, and other products. Under this initiative, DCSEU partners with local retailers and contractors to promote these rebates, providing rebate forms in retail stores when possible.

7717FBNK - Retail Lighting Food Bank

The Food Bank Energy Efficient Lighting Distribution initiative provides LED lighting to low-income households in DC that receive goods from participating food banks. The DCSEU provides LEDs to these residents after verifying that their household is located in the District and conducting a short survey with the client to determine the appropriate number of bulbs needed.

7710LITE - Retail Lighting

The Retail Efficient Lighting program coordinates with lighting retailers and manufacturers to increase the availability of LEDs and offer them at lower prices for District residents and small businesses. This initiative works to educate customers on the benefit of LED lights and increase awareness as LEDs are less familiar to residents than CFLs or incandescent bulbs. Retailers and manufacturers are provided incentives on a per-bulb basis.

7710HTCL - Retail Heating and Cooling

The Retail Heating and Cooling program works with contractors in the District to install heating and cooling equipment in residential applications. Measures include advanced and programmable thermostats (not smart thermostats), central air conditioners, domestic hot water heaters, boilers, furnaces, and ductless and air-source heat pumps.

7710STAT - Retail Smart Thermostats

The Retail Smart Thermostats program offers incentives for the reduction of HVAC energy consumption through the installation of smart thermostats in houses in the District. DCSEU partners with Nest and local retailers to offer point-of-sale or conventional rebates for qualifying thermostats. Residents who install Nest thermostats can enroll in the Nest Thermostat Seasonal Savings program to garner additional energy savings.

7725RSUP – Residential Upstream

The Residential Upstream program is used to track residential, efficient lighting projects purchased through electrical distributors. Participating electrical distributors buy down the price of the lighting products and offer a point-of-sale rebate to their customers. After sale, they submit documentation to the DCSEU for reimbursement on the products.

A.5 INNOVATION

7913INLI - Innovation – Low-Income

In order to support the development and deployment of new and innovative energy-efficiency and renewable energy initiatives, funds are allocated into one or more *innovation funds* to support pilot programs. This program works with and funds low-income customers to install innovative energy-efficient projects. DOEE must approve all incentivized measures under this track. Savings/spending counts towards the low-income savings/spending benchmark.

7915INMR - Innovation – Market Rate

In order to support the development and deployment of new and innovative energy-efficiency and renewable energy initiatives, funds are allocated into one or more *innovation funds* to support pilot programs. This program works with and funds market rate customers to install innovative energy-efficient projects. DOEE must review and approve all measures incentivized under this track.

Appendix B Nest Seasonal Savings Analysis

The Nest Seasonal Savings offering operates by making small, incremental adjustments to participant's heating or cooling schedules. For FY2019, the program was implemented in winter 2018/2019. For analysis, the program randomly split users into an ITT group and a control group. This randomization allows for DiD modeling to compare how changes in the ITT group compare to changes in the control group over time. A summary of the evaluation results is provided in Table 102.

Table 102: Results Summary

Resource Type	Reported Savings	Realization Rate	Verified Gross Savings
Electric Savings (kWh)	495,805	42.2%	209,232
Natural Gas Savings (MMBtu)	7,268	43.2%	3,138

B.1 Introduction

Seasonal Savings is a thermostat optimization measure offered by Nest Labs that delivers energy savings by offering Nest owners the opportunity to implement more conservative thermostat setpoints for a season. The Seasonal Savings program provides impacts that are above and beyond the expected savings from the initial installation of the smart thermostat. Table 103 summarizes the reported savings for FY2019.

Table 103: FY2019 Claimed Impacts from Seasonal Savings

Measure ID	Qty.	Per-Unit kWh	kWh Total	Per-Unit MMBtu	MMBtu Total
327413	8,075	61.4	495,805	0.9	7,268

The "Qty." column represents the number of devices that opted into the Seasonal Savings algorithm during Winter 2018/2019. The per-unit kWh and MMBtu assumptions come from a TRM entry that assumes the values shown in Table 104.

Table 104: TRM Basis for Seasonal Savings Per-Unit Assumptions

ΔMMBtu	$\Delta kWh_{heating}$	$\Delta kWh_{cooling}$	ΔkWh_{total}
0.9	61.4	0	61.4

The NMR team requested daily thermostat operating data for all thermostats in the winter 2018/2019 deployment and performed an independent assessment of the energy savings achieved by the offering.

The Seasonal Savings program was deployed as a RED. The RED is similar to a randomized controlled trial (RCT), which often used with behavioral conservation programs, like Home Energy Reports, except that it includes an opt-in component. Figure 7 provides a visual overview of the Seasonal Savings RED. In the RED process, thermostats in the target population are first

randomly assigned to either a control group or an ITT group. The thermostats in the ITT group are *offered* the opportunity to participate in the program. Customers eligible to be included in the RED study (ITT or control group) first had to meet the following criteria:

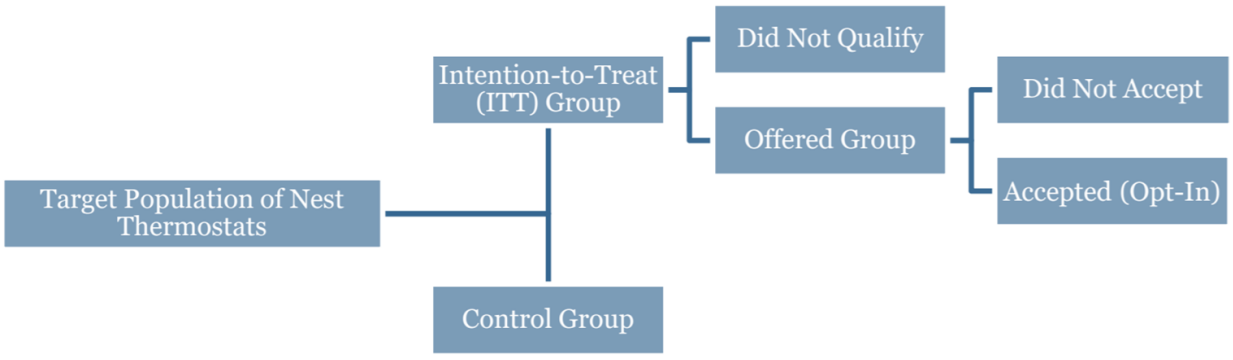
- Have a Nest installed and an online account;
- Have a forced-air heating system connected to thermostat (e.g., a furnace or ducted heat pump); and
- Be located in a list of DC SEU eligible zip codes.

The thermostats in the ITT group were then screened for technical eligibility, including the following criteria:

- Thermostat connected to internet; and
- Actively operating a heating schedule.

Nest sent a notification to all eligible ITT thermostats, inviting them to opt-in to Seasonal Savings. Some of the eligible ITT customers that received the offer accepted it (opt-ins) and others did not accept.

Figure 7: Randomized Encouragement Design



The tracking data shows 8,075 enrolled (opt-in) devices; however, a small fraction of devices did not have the runtime data, which is required for the statistical analysis. The evaluation team's analysis and estimates consider only those devices in the control and ITT group with thermostat runtime data. Table 105 shows the differences between the full population and the thermostat counts used for analysis.

Specifically focusing on the devices with runtime data, there are 1,921 devices in the control group and 14,599 in the ITT group. The randomization occurs at this phase of the grouping and this distinction is used for the impact estimation. A subset of the devices categorized into the ITT group did not qualify and a further subset did not choose to opt-in to the program. There were 8,044 devices with runtime data that were selected, qualified, and ultimately chose to participate in the program. All impacts are assumed to come from the opt-in devices and the average impact per opt-in thermostat is calculated by dividing the ITT impact estimate by the opt-in rate.

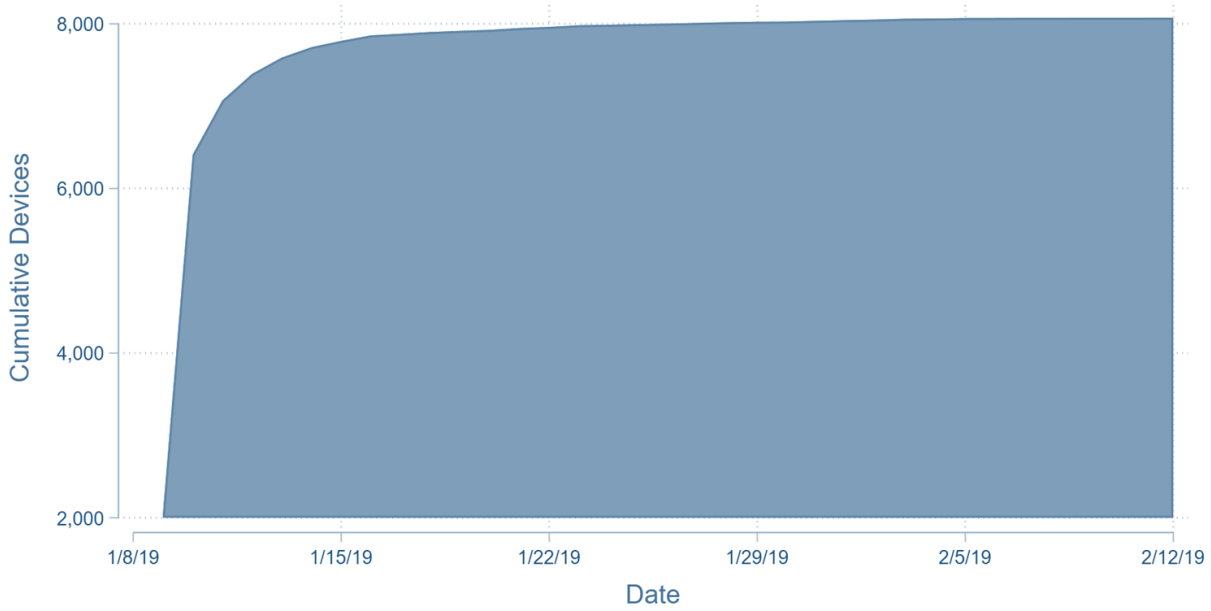
Table 105: Qualification and Opt-In Rates

Row	Study Group	All Devices	Devices with Runtime Data
1	Control	2,000	1,921
2	ITT Group	15,150	14,599
3	Did Not Qualify	3,212	2,706
4	Did Not Accept	3,863	3,849
5	Opt-In	8,075	8,044
	Qualification Rate = (Row 4 + 5) / Row 2	78.80%	81.46%
	Opt-In Rate Among Offered = Row 5 / (Row 4 + 5)	67.64%	67.64%
	Effective Opt-In Rate = Row 5 / Row 2	53.30%	55.10%

The thermostat characteristics file provided by Nest indicated the heating system type so the evaluation team split the analysis into furnaces and heat pumps. The opt-in rate across the two heating types was slightly different and the system specific opt-in rates were used in the analysis. Furnaces had an opt-in rate of 56.9%, while heat pumps had an opt-in rate of 52.4%

The program start date was January 9, 2019, but not all opt-ins accepted on this date. Figure 8 shows the cumulative number of devices that opted into the Seasonal Savings program from the program deployment date, January 9, 2019, to the last enrollments on February 12, 2019. There were 8,044 devices enrolled in the program by February 12, 2019; 2,048 of these devices enrolled on the first day of the offer, and 4,363 devices enrolled on the second day. While the program start date is used for both control and treatment groups as the separator for the pre and post periods, two confounding factors affect the magnitude of the impacts during the enrollment phase, which ends with the last opt-in of the winter on February 12, 2019. The confounding factors include the gradual enrollments and the treatment's three week ramp up period. Once a device has opted in, the Seasonal Savings program makes minor adjustments each day to slowly decrease the thermostat's scheduled setpoints. The ramp up period minimizes participant awareness of the change.

Figure 8: Cumulative Opt-In Devices

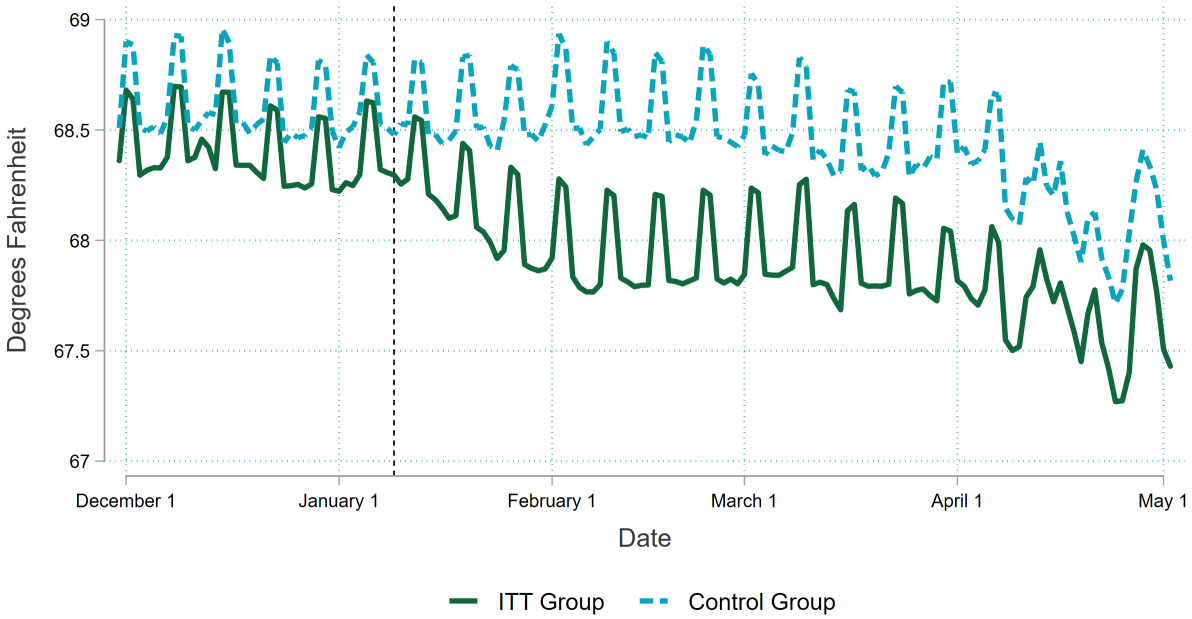


Any devices that drop out during the winter season remain categorized as the opt-in ITT group. Attrition dilutes measured impacts and occurs through program opt-out, technical issues that disconnect the thermostat, manual thermostat adjustments, or other actions and settings that pause or exit the program. While we don't have adequate information to track attrition, the occurance is evident in the increasingly irregular set point of the ITT group throughout April in Figure 9.

B.2 METHODOLOGY

The Seasonal Savings program makes minor adjustments to the scheduled set points for enrolled thermostats. Figure 9 shows the average scheduled set point for both the ITT group and the control group. The black line indicates the program start date of January 9, 2019. Prior to the program start date, the average scheduled set point was slightly lower for the ITT group. Beginning January 9, 2019, the Seasonal Savings program begins the ramp up period, where the scheduled set points are slowly modified from their user settings. Following the ramp up period, the ITT Group exhibits clearly lower average scheduled set points than the control group. By April, the difference between the groups declines slightly and both seem to be decreasing their setpoints on average. This trend could be due to individuals updating the heating setpoints as the weather warms.

Figure 9: Average Scheduled Set Point



The scheduled set points do not necessarily indicate the actual set points because users can manually adjust the thermostat settings via the smart phone app or directly on the thermostat. Figure 10 shows the difference in the ITT and control group scheduled and executed set points. Following the enrollment period, the average set point of the ITT group is scheduled to be on average 0.454°F lower than the control group, shown by the blue dotted line. The actual set point difference, shown by the green line, indicates that the ITT group is on average 0.329°F lower than the control, suggesting that the control group and ITT group are occasionally running a closer than average setpoint than the program intends. The black line indicates the program start date of January 9, 2019.

Figure 10: Net Differences in Heating Set Points

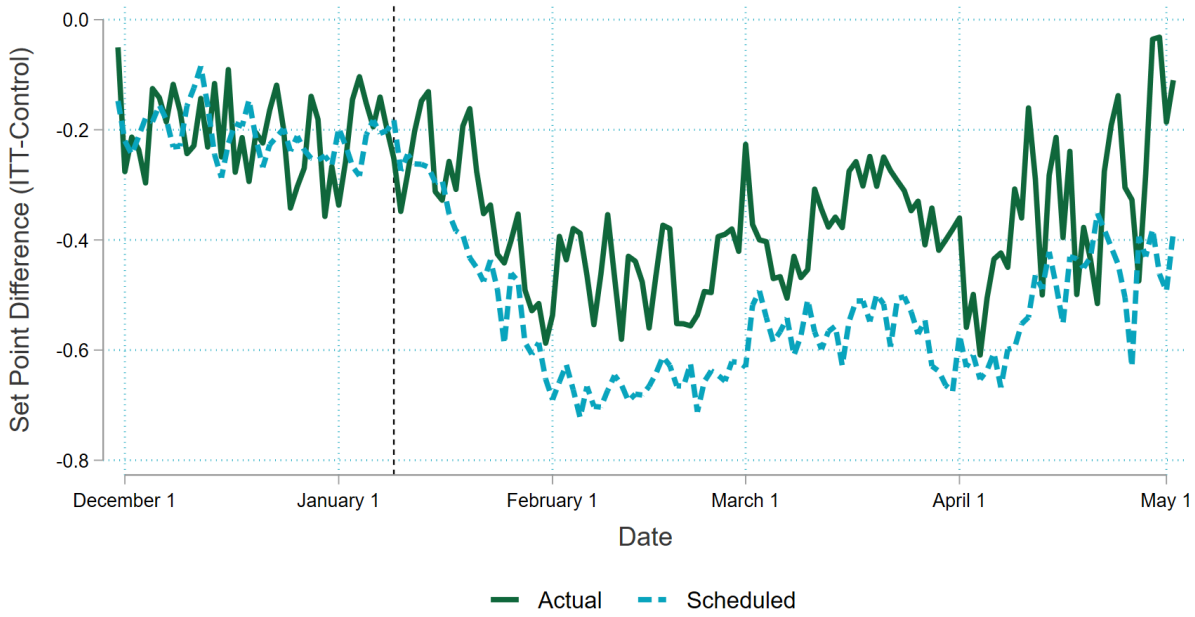
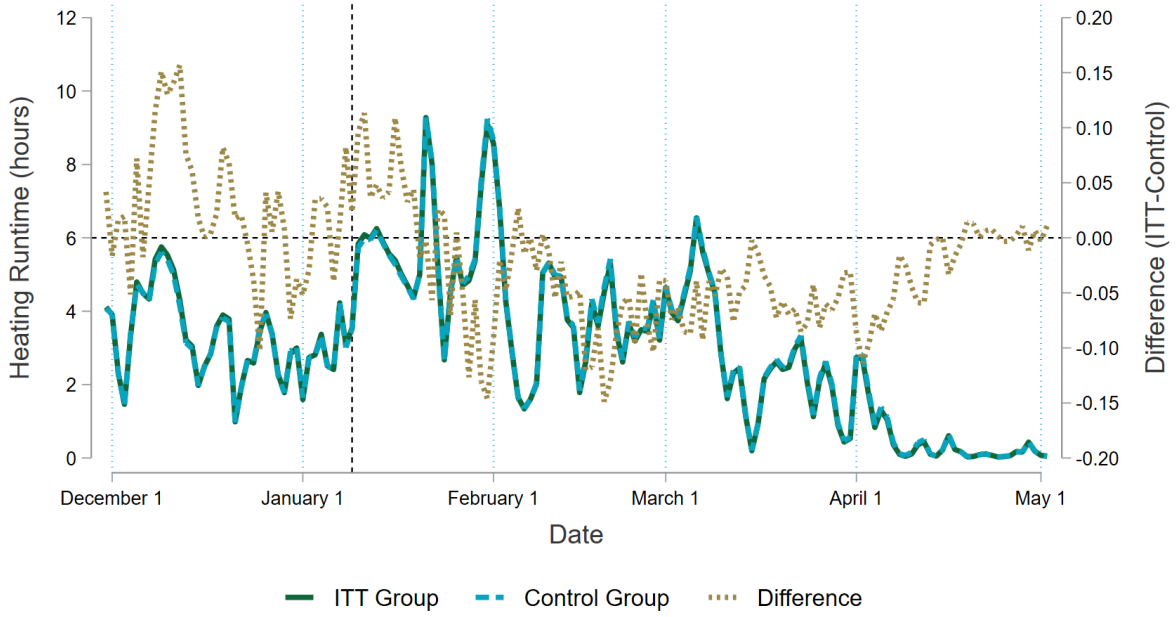


Figure 11 shows the average daily heating runtime for the treatment and control groups during the 2018/2019 winter season. The difference curve, represented by the brown dotted line, is the ITT heating runtime minus the control group heating runtime. A positive difference for this line indicates that the ITT group has higher heating runtime than the control group. Effective program implementation occurs when the difference curve drops below zero. Note that the difference curve is scaled up for visibility and relates to the y-axis on the right. At this granularity, differences can be seen, but regression analysis is necessary to capture the program impact.

Figure 11: Heating Runtime, by Group and Date



The RED allows for a clean control group and an ideal set up for a DiD model. The core DiD formula is provided below, but eight variations were estimated. All models have device fixed effects, a standalone indicator variable for the post-implementation period (*post*), and an interaction between post period and treatment group (*post*treatment*). These are the foundations of the DiD model. Possible adjustments include the inclusion of date (*date*) fixed effects, a weekend indicator (*weekend*), a heating degree day variable calculated at base 65°F (*hdd*), and a mix of interactions between the heating degree day variable (*hdd*), post (*post*), and treatment (*treat*). These interactions are denoted with the use of "*" between the appropriate variables. The specific models are shown in Table 106.

$$Cooling\ Runtime_{it} = \beta_0 + \beta_1 post_t + \beta_2 treat_i + \beta_3 post_t * treat_i$$

Table 106: Regression Models

Model	DiD Variables	Control Variables	Fixed Effects Variables
1	post, post*treat		device
2	post, post*treat	date	device
3	post, post*treat	hdd	device
4	post, post*treat	hdd, date	device
5	post, post*treat	weekend, hdd, hdd*treat, hdd*post, date	device
6	post, post*treat	hdd, hdd*treat, hdd*post, hdd*post*treat	device
7	post, post*treat	hdd, hdd*treat, hdd*post, hdd*post*treat	device, date
8	post, post*treat	weekend, hdd, hdd*post, hdd*treat, hdd*post*treat	device

The impacts provided by a RED are for the ITT group. The true program impacts, the ATT, are created by the devices that opted into the program and can be calculated by dividing the ITT

estimates by the percent of ITT devices that opt-in. The coefficient estimates from the regression models are multiplied by the average number of post days for the opt-in group and a connected load assumption in order to arrive at the estimate for kWh and MMBTU savings per season.

$$ITT\ Effect = Coefficient * PostDays * ConnectedLoad$$

$$ATT = \frac{ITT\ Effect}{Opt\ In\ Rate}$$

For the ITT group, there were a maximum of 114 possible post period days. On average, opt-in devices had 111 days of post period data. Daily savings multiplied by this average provides the heating runtime savings for the winter 2018/2019 season. This calculation assumes that no savings occurred on days without runtime data.

The connected load assumption is used to convert hourly runtime of a heating system to kWh or MMBTU of energy use depending on what type of heating unit the household has. This rate depends on average unit efficiency and system size. The evaluation team used FY2017 DC SEU evaluation work and the 2018 DC SEU TRM for the average capacity assumption and efficiency parameters, as well as the Energy Trust of Oregon Seasonal Savings Evaluation[33] to arrive at the connected load assumptions provided in Table 107.

Table 107: Connected Load Assumption

Parameter	Furnace	Furnace Fan	ASHP Compressor	ASHP Auxiliary Heat
Capacity	75,548 BTU/hr	0.75 Horsepower	28,373 BTU/hr	28,373 BTU/hr
Efficiency	N/A	N/A	2.75 COP	1.0 COP (Electric Resistance)
Connected Load	0.075548 MMBTU/hr	0.5595 kW	3.0239 kW	8.3157 kW
Source	DC SEU FY2017 evaluation sample	Energy Trust of Oregon Seasonal Savings Evaluation	DC SEU TRM average of Tier 1 and Tier 2. Engineering rule of thumb for COP	DC SEU TRM average of Tier 1 and Tier 2. Engineering rule of thumb for COP

[33] https://www.energytrust.org/wp-content/uploads/2017/12/Energy-Trust-of-Oregon-Nest-Seasonal-Savers-Pilot-Evaluation-FINAL-wSR.pdf

B.3 HEATING SYSTEM TYPES

For the winter seasonal savings analysis, an additional layer of complexity must be taken under consideration. Homes in DC are predominantly either heated by gas powered furnaces or electrically powered air-source heat pumps. Houses heated by furnaces that participate in the Seasonal Savings program contribute towards natural gas (MMBtu) savings and a small amount of electric (kWh) savings through reduction in furnace fan runtime. Houses heated by air-source heat pumps do not use natural gas for heating, and will therefore only contribute towards electric (kWh) savings. Furthermore, the evaluation team considered that air-source heat pumps have two components that have electric consumption. The compressor and the auxiliary heating system consume electricity, but at different rates. Auxiliary heat for air source heat pumps is electric resistance strips at the air handler – typically in 5, 10, or 15 kW banks. Therefore, the NMR team ran regressions against each component separately, and calculated two separate connected load assumptions. This ensured an accurate estimation of Seasonal Savings for air-source heat pumps.

With this in mind, the evaluators assessed the Seasonal Savings impact for each system type separately. For each system type and system component, the NMR team calculated a different connected load assumption for maximum accuracy. The NMR team then calculated the total verified savings by multiplying the estimated savings for each system type by the total number of participants with that specific system (rather than the total number of participants).

In this study, there were 14,599 devices in the ITT group. Of those devices, 8,824 were connected to furnaces and 5,775 were connected to heat pumps. Of the 8,044 devices that opted into the program, 5,020 were connected to furnaces and 3,024 were connected to heat pumps.

B.4 FINDINGS

The winter 2018/2019 ITT and ATT impacts for both furnace and heat pump systems for each of the eight models, along with an average impact, are provided in Table 108 (furnace impact) and Table 109 (heat pump impact). The ITT column shows the impact estimate and the ATT column inflates this estimate by dividing by the opt-in rate specific to the system type. Effectively, the ITT shows the average impact of being randomly selected into the ITT group and the ATT shows the average impact of opting into the program. The last column shows the minutes of heating runtime saved in the ITT group on an average day.

By comparing Table 108 and Table 109, it is evident that the Seasonal Savings impact is larger for devices connected to heat pumps compared to devices connected to furnaces. The calculated ATT percent savings for devices connected to furnaces is 2.55%, while the calculated ATT percent savings for devices connected to heat pumps is 5.11%.

Table 108: Seasonal Savings Impacts - Furnace

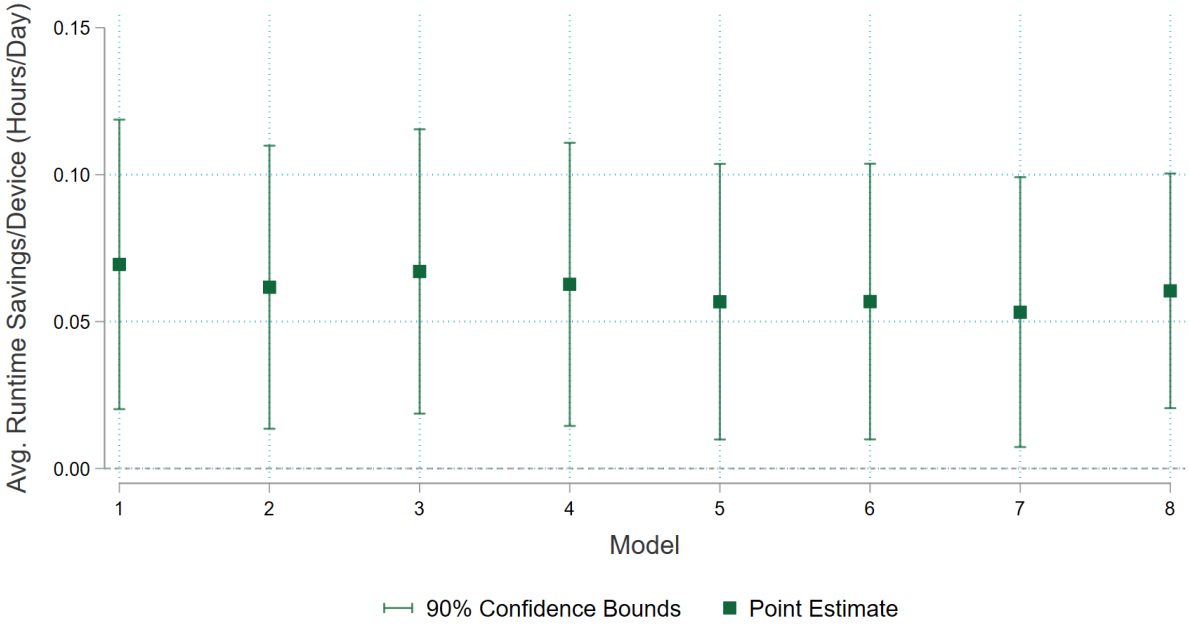
Model Number	ITT (MMBTU)	ITT (kWh)	ATT (MMBTU)	ATT (kWh)	Daily Runtime Savings (minutes)
1	0.373	2.765	0.656	4.859	2.6
2	0.350	2.594	0.616	4.559	2.5
3	0.398	2.950	0.700	5.185	2.8
4	0.360	2.669	0.634	4.692	2.6
5	0.353	2.614	0.620	4.595	2.5
6	0.354	2.622	0.622	4.608	2.5
7	0.295	2.186	0.519	3.842	2.1
8	0.360	2.669	0.634	4.692	2.6
Average	**0.356**	**2.634**	**0.625**	**4.629**	**2.5**

Table 109: Seasonal Savings Impacts – Heat Pump

Model Number	ITT (kWh)	ATT (kWh)	Daily Runtime Savings (minutes)
1	41.3	78.9	6.8
2	33.0	63.0	5.6
3	35.6	68.0	6.0
4	33.2	63.4	5.7
5	30.6	58.4	5.0
6	30.6	58.4	5.0
7	31.7	60.5	5.1
8	21.7	41.5	4.8
Average	**32.2**	**61.5**	**5.5**

The ITT runtime impacts for all devices are presented graphically in Figure 12. The NMR team used the 90% confidence intervals to assess model results. While the RED structure allows for unbiased results, the small size of the control group, under 2,000 devices, leads to wide confidence intervals. We support the validity of all eight models presented and suspect the true impact lies somewhere in between the overlapping confidence intervals. Because of this, we support taking an average of all eight models represented in this analysis.

Figure 12: ITT Impacts and Confidence Intervals



On average, the models estimated that customers in the ITT group decreased their runtime by 0.06101 hours/day. This translates to 3.66 minutes per day for all 14,599 devices in the ITT group. Table 110 compares the reported and verified savings for the Seasonal Savings offering in winter 2018/2019. The evaluation team believes that the difference between the reported and verified savings might be a result of the Nest heating device baseline being an estimate of a full year of heating consumption rather than calculated for only the program runtime (described in further detail below).

Table 110: Final Program Savings

Deployment Period	Reported		Verified		Realization Rate	
	kWh	MMBtu	kWh	MMBtu	kWh	MMBtu
Winter 2018/2019	495,805	7,268	209,232	3,138	42.2%	43.2%

B.5 RECOMMENDATIONS

- The reason for the differences between the reported and verified impacts is the baseline heating consumption assumption in the TRM measure characterization considered the heating consumption (both gas and electric) for a full year winter season rather than the mid-winter deployment of January 9. Heating consumption in October, November, December, and early January cannot be reduced because the offering had not been deployed. For winter 2018/2019, the evaluation team projects a natural gas baseline consumption of 24.5 MMBtu per customer in the post period, and an electric consumption baseline of 1,508.4 kWh per customer in the post period. It is recommended that the estimated baseline be adjusted to reflect the Nest mid-season deployment approach.

- Households with different heating systems should be characterized differently. A thermostat connected to a furnace will not also be connected to an air-source heat pump. Therefore, thermostats connected to furnaces will see inherently different resource than air-source heat pumps. The evaluation team recommends assessing MMBtu and kWh winter seasonal savings for furnaces separately from kWh seasonal savings from air-source heat pumps.
- The TRM assumption used by DC SEU of 3.5% heating savings was taken from a Massachusetts evaluation of Seasonal Savings during the winter season. Based on the evaluated findings from 2018-2019, the 3.5% assumption appears to be accurate for winter Seasonal Savings estimates, as the NMR team's estimate is 3.66% savings for the opt-in devices.
    - Although the pooled result of 3.66% was very close to the 3.5% assumption in the TRM, percent savings estimates varied by heating system type. Furnaces were estimated to have 2.55% savings, while air-source heat pumps had an estimated 5.11% savings. Despite the fact that the difference is not statistically significant, the evaluation team would recommend using the heating system type-specific percent savings results for TRM measure characterization. The baseline consumption, average equipment capacity, and fuel type needs to be considered separately, so we believe it makes sense to use the system-specific percent savings assumptions as well.
- The allocation of devices to the ITT and control groups was unbalanced (88% ITT and 12% control). The tradeoff between control group size and aggregate energy savings is important. Small control groups increase the uncertainty of the savings estimate, but any device assigned to the control group achieves no energy savings. However, control group devices are also likely to not incur any fees from Nest. The evaluation team recommends a control group size of at least 3,000 for future Seasonal Savings implementations. Considering the winter analysis is split between furnace and heat pumps, the control group is further limited to devices for each system type. The winter 2018/2019 seasonal savings program had 1,921 control group devices with runtime data. Of these devices, 1,159 were connected to furnaces and 762 were connected to air-source heat pumps.

Appendix C Solar For All Evaluations

In this section, we describe the methodology and results of the evaluation of the Solar For All Low-Income Single-family program and Solar For All Community Renewables program.

C.1 Low-Income Single-Family

The Low-Income Single-family (LISF) initiative is a Solar for All program that strives to deliver sustainable energy services to low-income, single-family homes within the District of Columbia. This program aims to provide 100 low-income single-family homes with the benefits of solar technology each year. Participating developers agree to design projects that will lower household electricity costs by 50% or more with at least a 15-year commitment.

The LISF program, as part of DCSEU's Solar for All Program, allows low-income residents access to the energy and money saving benefits of solar energy. Participants receive a credit back on their monthly electricity bill. Participating households must provide proof of income to be eligible for these benefits.

In FY2019, the Solar For All Low-income Single-family program provided incentives for 86 projects and claimed 0.3 MW of generation capacity. We completed the following evaluation activity:

- Gross Savings Verification

C.1.1 Gross Savings Verification

Table 111 shows the tracked savings, realization rate, and evaluated savings for the LISF program. No gas savings were claimed for this program as it is entirely composed of solar panel installations, and no interactive effects are present. The electric savings program-level realization rate equals 131%, while the capacity realization rate equals 112%.

Table 111: LISF Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2019 Electric Savings (MWh)	408	131%	533
FY2019 Max. Generation Capacity (MW)	0.3	112%	0.3

C.1.1.1 Sampling

Due to the homogeneous makeup of the program, we randomly selected two to three LISF projects from each of the three participating contractors. Table 112 displays the participating contractors, their FY2019 participation, and the number of sampled sites for each. The evaluation team randomly selected seven of the 86 projects for review in the FY2019 evaluation.

Table 112: LISF Sampling Plan

Contractor	Percent of Program Energy Savings	FY2019 Participation	Number of Sampled Sites
Greenscape	52%	43	3
Grid Alternatives	22%	20	2
WDC	27%	23	2

C.1.1.2 Methodology

The NMR team conducted desk reviews for the seven sampled projects. We gathered key data values from project documents, such as invoices, project plan drawings, equipment spec sheets, and post-installation inspection forms. These inputs were used to calculate evaluated energy savings.

We used the NREL PV Watts Calculator[34] to calculate the energy savings. The PV Watts tool relies on several key inputs, including the following:

1. **Site Address** – The location (address or latitude/longitude) of the solar PV installation.
2. **DC System Size** – The direct current (DC) power output of the system.
3. **Module Type** – The type of solar panels (standard, premium, or thin film).
4. **Array Type** – Fixed, one-axis tracking, or two-axis tracking.
5. **System Losses** – Estimate of real-world system losses.
6. **Tilt** – Angle at which the panels are installed.
7. **Azimuth** – Direction panels face away from true north.
8. **DC to AC Size Ratio** – Ratio of the inverter's AC rated size to the array's DC rated size.
9. **Inverter Efficiency** – DC to AC conversion efficiency.
10. **Ground Coverage Ratio** – Ratio of module surface area to the area of the ground or roof occupied by the array.

PV Watts uses these inputs to orient the site and calculate the electricity generation. The NMR team used the PV Watts hourly data to calculate the energy savings.

We gathered variables such as DC and AC system size, module type, array type, tilt, azimuth, and inverter efficiency from the project documentation. When a project-specific input could not be found, we used the NREL PV Watts default value. Two of the seven projects lacked data on azimuth and tilt. To determine the azimuth angle, the NMR team used photos of the site installations and Google Earth to orient the solar panels. Since tilt could not be determined, we input the default PV Watts value. We attempted to visually confirm the installation of each PV system via google earth;[35] however, depending on the vintage of google earth images, this was not always possible.

[34] https://pvwatts.nrel.gov/
[35] https://www.google.com/earth/

C.1.1.3 Results

The program-wide impact evaluation results are shown in Table 113. The findings that contributed to the realization rates are detailed in the text that follows.

Table 113: LISF Program Impact Results

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2019 Electric Savings (MWh)	408	131%	533	±3.8% @ 80%
FY2019 Max. Generation Capacity (MW)	0.3	112%	0.3	n/a

The program-level realization rates are 131% for electric savings and 112% for capacity. The selected sample ultimately achieved a ±3.8% precision at 80% confidence for electric savings.

The evaluation team has leveraged the PV Watts solar calculation for evaluations in other jurisdictions and vetted its accuracy and reliability. The tool projects estimated energy production relative to typical meteorological year (TMY3) data,[36] providing a weather-normalized generation estimate.

Realizations rates are greater than 100% because the NMR team calculated savings using the PV Watts Calculator with site-specific inputs. In contrast, we understand that tracked savings values were determined using the Small Scale Residential Solar PV System TRM characterization. The TRM lists deemed electricity savings for solar installations in capacity increments of 500 watts and dictates that systems be mapped to the closest, smaller system size. Therefore, calculating savings base on the actual system size results in greater energy savings.

Overall, the evaluation team found that the project documentation was generally adequate to characterize the projects. However, two projects were missing azimuth and tilt angle inputs and one project did not provide a spec sheet for the solar module, though we were able to locate the spec sheet online.

C.1.2 Recommendations

Based on the findings of our analysis, we offer the following recommendation:

- Ensure that the project-specific parameters are fully recorded within the project documentation, including the installed panel and inverter spec sheets, and system azimuth and tilt values.

[36] https://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/

C.2 COMMUNITY RENEWABLES

The Community Renewable Energy Facilities initiative is a Solar for All program that strives to deliver sustainable energy services to residential, commercial, and industrial institutions. Community solar provides the benefits of solar technology to residents who traditionally would not be able to take advantage of solar power, such as renters, residents in multifamily buildings, or those with rooftops that need repairs.

CREF installations are community solar projects that provide direct benefits to residents through virtual net metering. Individuals or entities that subscribe to a CREF PV system receive credits on their electricity bill for their portion of the electricity the PV system generates. PV installations are not located on individual residences, but instead are offsite and can be sited on multifamily buildings, universities, commercial buildings and elsewhere.

For the FY2019 CREF program, we completed the following evaluation activity:

- Gross Savings Verification

C.2.1 Gross Savings Verification

Table 114 shows the tracked savings, realization rate, and evaluated savings for the CREF program. No gas savings are claimed for this program as it is entirely comprised of solar panel installations, and no interactive effects are present. The electric savings program-level realization rate was found to equal 99.6%, while the capacity realization rate equals 99.4%.

Table 114: CREF Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2019 Electric Savings (MWh)	6,225	99.6%	6,198
FY2019 Max. Generation Capacity (MW)	3.78	99.4%	3.76

C.2.1.1 Sampling

Due to the heterogeneous makeup of the program, the PVMR program sample design employed stratified random sampling. The NMR team created a large probability stratum, which ensured that we reviewed a sample of the largest projects from the program. Projects with more than 100 kW of capacity were assigned to the large probability stratum. The remaining projects were assigned to the small probability stratum (Table 115). Randomly sampling from the two groups enabled us to balance among projects with a larger contribution to the program savings while also evaluating smaller projects. The evaluation team selected seven of the 74 projects for review in the FY2019 evaluation.

Table 115: CREF Sampling Plan

Stratum	Percent of Program Energy Savings	FY2019 Participation	Number of Sampled Sites
Large Probability	27%	6	3
Small Probability	73%	68	4

C.2.1.2 Methodology

The NMR team conducted desk reviews for the seven sampled projects, through which we calculated the evaluated savings. The NMR team gathered important data values from verified project documents, such as invoices, project plan drawings, equipment spec sheets, and post-installation inspection forms.

The NMR team used the NREL PV Watts Calculator[37] to calculate the energy savings. The PV Watts tool relies on several key inputs including the following:

1. **Site Address –** The location (address or latitude/longitude) of the solar PV installation
2. **DC System Size** – the direct current (DC) power output of the system
3. **Module Type** – the type of solar panels. Either standard, premium, or thin film
4. **Array Type** – Fixed, one-axis tracking, or two-axis tracking
5. **System Losses** – Estimate of real-world system losses
6. **Tilt** – Roof angle where the panels are installed
7. **Azimuth** – Direction panels face away from true north
8. **DC to AC Size Ratio** – Inverter AC output compared to solar array DC output
9. **Inverter Efficiency** – DC to AC conversion efficiency
10. **Ground Coverage Ratio** – How close together the panels are placed

The NMR team determined variables such as DC system size, module type, array type, tilt, azimuth, and inverter efficiency using the project documentation. When a project-specific input could not be found, the NMR team used the NREL PV Watts default value. PV Watts uses the input data to orient the site and calculate the electricity generation. The NMR team used the PV Watts hourly data to calculate the electricity savings. We attempted to visually confirm the installation of each PV system using google earth;[38] however, depending on the vintage of google earth images, this was not always possible.

C.2.1.3 Results

The program-wide impact evaluation results for the program are shown in Table 116. The findings that contributed to the realization rates are detailed in the text that follows.

Table 116: CREF Program Impact Results

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2019 Electric Savings (MWh)	6,225	99.6%	6,198	±0.6% @ 80%
FY2019 Max. Generation Capacity (MW)	3.78	99.4%	3.76	n/a

The program-level realization rates are 99.6% for electric savings and 99.4% for generation capacity. The selected sample ultimately achieved a ±0.6% precision at 80% confidence for electric savings.

[37] https://pvwatts.nrel.gov/
[38] https://www.google.com/earth/

The NMR team found realizations rates to be slightly less than 100% because the NMR team's project-specific data entered into PV Watts, such as the PV module specifications, differed from the DCSEU's inputs. The savings for some projects received a slight increase due to site-specific inverter efficiencies being input into PV Watts instead of an assumed value of 96% (which is the PV Watts default inverter efficiency).

The evaluation team has leveraged the PV Watts solar calculation for evaluations in other jurisdictions and vetted its accuracy and reliability. The tool also projects estimated energy production relative to typical meteorological year (TMY3) data,[39] providing the DCSEU with a weather normalized generation estimate.

The evaluation team found that the project documentation was adequate to characterize the projects; however, small discrepancies were identified. These discrepancies include inconsistent module or inverter specifications and rounded or incorrect efficiencies. Several projects also used custom inputs instead of PV Watts default values; however, the source of the inputs could not always be verified with the provided project documentation.

C.2.2 Recommendations

Based on the findings of our analysis, we offer the following recommendations:

- Continue to utilize the PV Watts calculation model for predicting solar generation data when actual production data is not available. If solar generation data is available to the DCSEU, actual generation data should be prioritized over the theoretical estimates of the PV Watts tool.
- Utilize project-specific inverter efficiencies to accurately calculate PV system production. For example, use the project-specific inverter efficiency rather than the default PV Watts inverter efficiency or a rounded value to improve the accuracy of energy savings.
- Ensure that the project-specific inputs are fully recorded within the project documentation, including the installed panel and inverter specification sheets, system losses, DC to AC size ratio, and ground coverage ratio.

[39] https://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/