Evaluation of DC Sustainable Energy Utility FY2018 Programs

FINAL

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SUBMITTED TO:
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Table of Contents

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 2018 (FY2018) programs.

In FY2018, 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 43% of portfolio savings, while heating measures contributed 32% of portfolio savings.

Evaluation Methodology

For the FY2018 evaluation, we completed the following activities:

Gross Savings Verification

- Tracking database review
- Desk reviews
- On-site Visits

Process Evaluation and Net Savings Estimation

- Interviews with Program Staff and Partners
- Participating Customer Surveys

We targeted a subset of 11 programs for evaluation: five commercial programs, three multifamily programs, two retail programs, and one solar program (Table 1). The NMR team selected the programs for the FY2018 evaluation because the programs either represented a large share of portfolio savings; had not recently been evaluated; included a key measure of interest, such as commercial HVAC; or contributed to the DCSEU's performance benchmarks. See Section 1.4 for details of our sampling approach.

Appendix A provides descriptions for each of the program tracks offered by DCSEU in FY2018.

Table 1: FY2018 Program Evaluation Summary

Sector	Program Name	Track Number	Percent of FY2018 Tracked Gross Electric & Gas Savings (MMbtu)	FY2018 Evaluation	
				Gross Savings Verification	NTG & Process Evaluation
Solar	Solar PV Market Rate	7101PVMR	1.5%	✓	✓
Single-family Residential	Low-income Emergency Equipment Replacement	7413LIER	0.0%		
Commercial	C& I RX - Equipment Replacement	7511CIRX	13.2%	✓	✓
	Market Transformation Value	7512MTV	1.3%	✓	
	Commercial Upstream (Lighting)	7513UPLT	4.2%		
	Retrofit - Custom	7520CUST	44.3%	✓	✓
	Market Opportunities - Custom	7520MARO	1.4%	✓	
	New Construction - Custom	7520NEWC	16.5%	✓	✓
Multifamily	Implementation Contractor Direct Install	7610ICDI	0.9%		
	Income Qualified Efficiency Fund	7610IQEF	0.7%	✓	
	LI Custom Projects	7610LICP	0.0%		
	Low-income Multifamily Comprehensive	7612LICP	2.4%	✓	
	Low-income Prescriptive Rebate	7613LIRX	2.0%	✓	
Efficient Products	Retail Efficient Appliances	7710APPL	0.1%		
	Home Energy Conservation Kit - Market Rate	7710HEKT	0.0%		
	Retail Heating and Cooling	7710HTCL	0.1%		
	Retail Lighting	7710LITE	7.6%	✓	
	Retail Smart Thermostats	7710STAT	3.5%	✓	✓
	Retail Lighting Food Bank	7717FBNK	0.0%		
	Home Energy Conservation Kit - Low-income	7717HEKT	0.2%		
	Residential Upstream	7725RSUP	0.0%		

The NMR team assigned FY2018 programs that did not undergo an evaluation a default gross savings realization rate based on either (1) FY2018 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.

EVALUATION RESULTS

Table 2 displays the FY2018 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 99% of the DCSEU tracked electric savings, the actual portfolio peak demand reduction is 105% of the DCSEU tracked peak demand reduction, and the actual portfolio gas savings is 94% of the DCSEU tracked gas savings.

Table 2: DCSEU FY2018 Portfolio-level Gross Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
Electric Savings (MWh)	125,420	99%	124,337
Peak Demand Savings (MW)	19.2	105%	20.2
Gas Savings (MMBtu)	181,517	94%	170,839

Table 3 compares the electric and demand 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 99%, the electric savings realization rate for DCSEU is similar to the 98% value for PECO, which both exceed the 93% value for BG&E. At 105%, the demand savings realization rate for DCSEU is greater than the 95% value for BG&E though lower than the 118% figure for PECO.

Table 3: Comparison of Portfolio-level Realization Rates

Savings Type	DCSEU FY2018	PECO Energy Program Year 9[1]	Baltimore Gas & Electric 2017[2]
Electric Savings	99%	98%	93%
Peak Demand Savings	105%	118%	95%

Table 4 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, indicating that the accuracy of tracked savings could be substantially improved for these programs. We offer our resulting recommendations in the following section.

[1] Pennsylvania SWE Annual Report Act 129 Program Year 9. NMR Group, Demand Side Analytics, Brightline Group, EcoMetric Consulting. February 28, 2019.
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 4: DCSEU Gross Meter-level Program Realization Rates and Savings

Sector	Program Name	FY2018 Electric Savings (MWh)			FY2018 Peak Demand Savings (MW)			FY2018 Gas Savings (MMBtu)		
		Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated
Solar	Solar PV Market Rate	2,606	100%	2,606	0.6	100%	0.6	-	-	-
Single-family Res.	Low-income Emergency Equipment Replacement	1	100%	1	0.0	100%	0.0	60	100%	60
Commercial	C& I RX - Equipment Replacement	25,640	99%	25,505	2.6	132%	3.5	-7,084	121%	-8,597
	Market Transformation Value	2,542	108%	2,746	0.1	139%	0.2	-586	107%	-627
	Commercial Upstream (Lighting)	8,295	109%	9,041	1.2	108%	1.2	-2,694	192%	-5,172
	Retrofit - Custom	38,992	97%	37,896	5.7	99%	5.6	137,196	102%	140,145
	Market Opportunities - Custom	958	102%	974	0.2	106%	0.2	5,243	101%	5,290
	New Construction - Custom	14,742	100%	14,780	4.0	97%	3.9	50,130	102%	51,225
Multifamily	Implementation Contractor Direct Install	1,704	100%	1,704	0.2	99%	0.2	-201	100%	-201
	Income Qualified Efficiency Fund	1,330	98%	1,330	0.1	100%	0.1	-31	100%	-31
	LI Custom Projects	27	98%	26	0.0	102%	0.0	34	108%	37
	Low-income Multifamily Comp.	2,968	98%	2,913	0.5	102%	0.5	4,307	108%	4,668
	Low-income Prescriptive Rebate	3,936	100%	3,935	1.4	102%	1.4	-1,256	101%	-1,268
Efficient Products	Retail Efficient Appliances	129	100%	129	0.0	100%	0.0	117	100%	117
	Home Energy Kit - Market Rate	5	100%	5	0.0	100%	0.0	-4	99%	-4
	Retail Heating and Cooling	29	100%	29	0.0	100%	0.0	505	100%	505
	Retail Lighting	19,180	100%	19,197	2.2	100%	2.2	-19,266	100%	-19,299
	Retail Smart Thermostats	1,771	54%	955	0.2	200%	0.4	15,571	29%	4,513
	Retail Lighting Food Bank	114	100%	114	0.0	100%	0.0	-96	100%	-96
	Home Energy Kit - Low-income	356	100%	356	0.0	100%	0.0	-299	99%	-296
	Residential Upstream	94	100%	95	0.0	100%	0.0	-131	100%	-131
Portfolio		**125,420**	**99%**	**124,337**	**19.2**	**105%**	**20.2**	**181,517**	**94%**	**170,839**

Table 5 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 8% and all gross meter-level demand savings by 6% 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 5: DCSEU Modified Gross Generator-level Program Savings

Sector	Program Name	FY2018 Electric Savings (MWh)		FY2018 Peak Demand Savings (MW)		FY2018 Gas Savings (MMBtu)	
		Tracked	Evaluated	Tracked	Evaluated	Tracked	Evaluated
Solar	Solar PV Market Rate	3,236	3,236	0.7	0.7	-	-
Single-family Res.	Low-income Emergency Equipment Replacement	1	1	0.0	0.0	60	60
Commercial	C& I RX - Equipment Replacement	27,691	27,546	2.8	3.7	683	683
	Market Transformation Value	2,746	2,965	0.2	0.2	-	-
	Commercial Upstream (Lighting)	8,958	9,765	1.2	1.3	-	-
	Retrofit - Custom	42,112	40,928	6.1	6.0	151,182	154,431
	Market Opportunities - Custom	1,034	1,052	0.2	0.2	5,257	5,304
	New Construction - Custom	15,922	15,962	4.3	4.1	50,548	51,651
Multifamily	Implementation Contractor Direct Install	1,841	1,841	0.2	0.2	718	718
	Income Qualified Efficiency Fund	1,436	1,436	0.1	0.1	418	418
	LI Custom Projects	29	28	0.0	0.0	50	54
	Low-income Multifamily Comp.	3,229	3,169	0.6	0.6	4,892	5,302
	Low-income Prescriptive Rebate	4,251	4,250	1.4	1.5	-	-
Efficient Products	Retail Efficient Appliances	139	139	0.0	0.0	117	117
	Home Energy Kit - Market Rate	5	5	0.0	0.0	-	-
	Retail Heating and Cooling	31	31	0.0	0.0	505	505
	Retail Lighting	20,714	20,732	2.3	2.3	-	-
	Retail Smart Thermostats	1,913	1,031	0.2	0.4	15,571	4,513
	Retail Lighting Food Bank	123	123	0.0	0.0	10	10
	Home Energy Kit - Low-income	384	384	0.0	0.0	30	30
	Residential Upstream	102	102	0.0	0.0	-	-
Portfolio		**135,898**	**134,728**	**20.3**	**21.4**	**230,039**	**223,796**

Findings and Recommendations

Our evaluation of the FY2018 programs found that DCSEU expended the appropriate amount of effort and rigor on their savings calculations. In general, the documentation provided was thorough, 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 several key findings and recommendations, as described below. While DCSEU prescriptive savings estimates were reasonable, in aggregate, for FY2018 programs, the NMR team believes the DCSEU can continue to improve calculation methods, but should prioritize those improvements which offer the most cost effective outcomes. The bullet below outlines a recommendation that applies to all of the prescriptive programs.

- **Apply project-specific efficiency levels and capacities to improve the accuracy of tracked savings when feasible**. Deemed values or ranges for efficiency levels, wattages, capacities, and configurations were input into savings algorithms when site specific information was available. This issue was most prominent for commercial lighting where the actual wattage values for program-incentivized lighting were often lower than the tracked wattage values resulting in higher electricity savings as well as a larger gas heating penalty. Also, efficiency and capacity values for HVAC equipment were sometimes based on nominal ratings rather than project-specific values. 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 for instances where these data are already collected from customers.

For the CI RX Equipment Replacement and Market Transformation Value programs, we offer the following recommendations.

- **Calculate summer coincidence factors for lighting to ensure that peak demand savings are not understated due to an incongruency in energy and demand load shapes.** The DCSEU uses a blended interior commercial lighting coincidence factor[4] (CF) of 58%; however, the hours of use (HOU) is a continuous variable that can be adjusted. The CF and HOU values typically have a proportional relationship that should be maintained for savings to be accurately estimated. The bulk of discrepancies stem from the blended CF being used for lighting that operates continuously 24/7. At a minimum, a flag should be used to apply a CF of 100% to any lighting that continuously operates.
- **Reduce summer coincidence factor to 0% for exterior LEDs.** The TRM assigns a 3.7% summer coincidence factor for exterior lighting. However, most exterior LEDs come standard with integral photocells and an analysis of historical sunrise and sunset times shows that fixtures controlled by photocells will not have any summer coincidence. As

[4] A coincidence factor quantifies the likelihood that the lighting measures will be turned on during DCSEU's peak demand window of 2:00 PM to 6:00 PM from June through August.

noted above, exceptions should be made for 24/7 lighting where the summer CF equals 100%.

- **Apply the waste heat factor based on the installation location of the lighting product**. SEU currently assumes that 26% of lighting products are installed in exterior or unconditioned spaces. Waste heat factors [5] are applied to all measures that are considered likely to be interior equipment regardless of the location under the assumption that the waste heat factor appropriately captures the likelihood of the measure being exterior. However, our review indicates that installation location data is generally available and, if not, could be assigned based on the type of bulb or fixture. We found the location data to be accurate based on available project details and submitted lamp specification sheets. Assigning waste heat factors in this fashion should be straightforward to implement and would improve the accuracy of tracked savings.
- **Update the DCSEU lighting calculator to reflect the current TRM lighting assumptions.** The DCSEU calculator used assumptions from the 2017 TRM rather than the 2018 TRM. The evaluation team understands the calculator is used internally at DCSEU and does not impact final savings claims. However, the NMR team believes maintaining internal consistency is beneficial to avoid technical errors and maintain consistent customer communication.

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

- **Streamline the CI RX application and use simpler, more accessible language for potential applicants.** The results from the CI RX program staff and partner interviews indicated that application requirements might be burdensome for some customers. Partners noted that some commercial customers might not understand the technical language on the application.
- **Maintain existing CI RX digital marketing and outreach efforts but consider additional options for face-to-face engagement.** Nearly two-thirds of CI RX participating customers reported that they had visited the DCSEU website for information, indicating that the website is known and accessible to the majority of customers. However, face-to-face engagement may help foster personal relationships and develop other connections with specific market segments such as small businesses and contractor networks.

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

- **Calculate peak demand savings independently from energy savings for Custom Retrofit projects.** When sufficient information exists for Custom Retrofit projects, peak demand savings should be calculated independently of energy savings, incorporating an appropriate summer coincidence factor, because peak demand savings do not necessarily scale linearly with hours of use.

[5] The waste heat factor accounts for cooling savings from efficient lighting.

- **Utilize rated efficiencies at standard test conditions whenever possible.** Code minimums must be met at standard conditions, and adjustments should only be made if the equipment cannot be tested at standard conditions.
- **Continue promoting the value of technical assistance**. Program staff and partners noted that the limited incentives for the Custom Retrofit program might pose a barrier to participation. However, technical assistance and sharing of best practices provide supplemental benefits to engaging with the DCSEU.

For the Custom New Construction program, we offer the following recommendations:

- **Confirm that building simulation models are fully updated for commercial new construction projects.** First, verify the savings claimed in the tracking database match the final version of savings from the building models. Second, cross-check the measures claimed within the models to ensure that specific equipment, such as variable speed drives, controls, or garage CO sensors, so that savings for code required measures are removed after any baseline scaling calculations. Third, verify the application of coincidence factors to estimate peak demand savings.
- **Review modeled outputs for excessive lighting interactive effects penalties.** Projects which utilized energy simulations included heating penalties for upgraded lighting. However, in two cases the heating penalty was uncharacteristically high. The DCSEU should carefully review the calculated heating penalties when different heating systems are used in the baseline and efficient case to ensure heating penalties remain reasonable.
- **Improve communication about projected incentive amounts.** Program partners expressed concern regarding the lack of information about anticipated incentives for new construction projects. They suggested sharing examples of historic incentive awards or offering an expected incentive range. Providing greater clarity regarding anticipated incentives will help reduce confusion and garner earlier buy-in.
- **Increase transparency of DCSEU staff roles and responsibilities.** Because new construction partners voiced confusion regarding the appropriate DCSEU staff to contact, they would benefit from an organizational chart including whom to contact for which issues. This information may also improve response times and partners' experiences with the approval process.

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

- **Continue to utilize the PV Watts 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.
- **With the expansion of the solar programs, the DCSEU should emphasize its technical expertise and assistance.** While financial incentives may be limited, the DCSEU should promote the value of non-financial contributions such as their technical expertise and assistance.

For the Retail Smart Thermostats program, we offer the following recommendations:

- **Continue to promote the smart thermostats' distinct characteristics in marketing materials**. Most smart thermostat participants reported positive experiences with their thermostat and provided high satisfaction ratings with its different features. Marketing materials should provide equal if not more emphasis on addressing concerns related to ease of use as on reducing costs.
- **Revise the approach to estimating savings from the Seasonal Savings initiative.** The impacts of the Seasonal Savings program are season specific. Therefore, a separate tracking record should be created for each season as the number of participating thermostats will vary. Second, because small control groups increase the uncertainty of the savings estimate, we recommend a control group size of at least 3,000 thermostats. Third, model specification is important when both the control group and effect are small, so consider selecting the model a priori to eliminate any perception of bias. Fourth, we recommend aligning the claimed savings with the same fiscal year when the Nest fees are incurred.

For the Low-income Multifamily Comprehensive program, we offer the following recommendation:

- **Confirm that heating fuel types are coded correctly so that the appropriate waste heat factors for lighting are applied.** We identified a few projects that were coded as having gas heat when in fact they had electric heat. This discrepancy affects both the electric savings and gas savings due to the application of fuel-specific waste heat factors.

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 completed for the evaluation of the Fiscal Year 2018 (FY2018) programs, including the following tasks:

- Gross Savings Verification
- Net Savings Estimation
- Process Evaluation

1.1 Gross Savings Verification

The gross savings verification includes the following tasks:

- Program tracking database review
- Desk reviews
- Participant surveys
- Onsite Inspections

1.1.1 Program Tracking Data Review

The first evaluation task was to conduct a comprehensive review of DC Sustainable Energy Utility's (DCSEU's) FY2018 program tracking database in order to assess evaluation priorities and identify key measures. The NMR team leveraged the database for multiple tasks, including developing the sample design, drawing samples for the desk audits, and calculating savings.

In order to identify evaluation priorities and develop sampling plans, the NMR team analyzed the participant 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 savings?
- Which programs and measures have the most and least uncertainty around their estimated savings?
- How much evaluation work has been done for each program and measure in the past?
- Which programs and measures contribute to the DCSEU performance benchmarks?

1.1.2 Desk Reviews

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

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

1.1.2.1 Prescriptive Measures

For prescriptive measures, we assessed the accuracy and reasonableness of the savings parameters. In particular, we 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. Evaluation efforts for prescriptive measures focused on the following:

- Confirming that the appropriate TRM algorithm is being applied;
- Verifying key inputs into the algorithms; and
- Developing recommendations on how TRM assumptions can be improved.

1.1.2.2 Custom Measures

Custom project analyses involved the review of calculations done by program implementers and contractors to verify the methods and equations used in the analysis. 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 the energy savings. For custom projects, the savings calculation reviews included the following:

- Review project description, documentation, specifications, and tracking system data.
- Review engineering analyses for technical soundness, appropriate baselines, and appropriateness for the specific application.
- Review methods of determining demand (capacity) savings to ensure they are consistent with approved methods for determining peak load/savings.
- Review input data for appropriate baseline specifications and variables, such as total annual hours, and confirm they are consistent with facility operation.
- Consider and review for interactive effects with affected systems, such as cooling energy reductions and heating energy increases for efficient lighting upgrades.
- Ensure the measure complies with program rules for eligibility and falls within the parameters outlined by the applicable energy code.

1.1.3 Participant Surveys

We completed telephone surveys with a random sample of participants for selected programs to inform the net-to-gross estimation and process evaluation tasks. These surveys covered the following topics:

- Ask questions to estimate free-ridership and spillover
- Assess satisfaction and feedback regarding their program experience
- Identify participation drivers and barriers
- Verify the installation of measures included in the program tracking database

1.1.4 On-site Inspections

On-site verification visits were conducted for a sample of commercial projects that exhibit a high degree of savings uncertainty. The uncertainty can come from lack of project documentation or the nature of a project. Lighting projects and one-for-one equipment retrofits tend to be more straight forward to review, with fewer parameters to verify. Therefore, most of the information can be gleaned from lighting specifications, invoices, and operational hours. Projects that tend to be more holistic in scope (such as controls projects or new construction, which looks at the whole building for system interactions) can benefit greatly from on-site verification. Speaking with a facilities manager and conducting an on-site assessment to learn how the equipment is operated is a more accurate metric of energy consumption than referring to a building plan sequence of operations that may or may not have been implemented. There were several purposes for these on-sites, 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
- Conduct metering activities if greater uncertainty in operating parameters is expected

1.1.5 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 across the entire portfolio.

For FY2018 programs that did not undergo a gross savings verification, the NMR team assigned a default gross savings realization rate based on either (1) FY2018 realization rates for similar programs or measures or (2) previous realization rates for the same program.

1.2 NET SAVINGS ESTIMATION AND PROCESS EVALUATION

In this section, we provide a description of the activities undertaken to estimate net savings and to conduct a process evaluation. The participant surveys were leveraged to estimate the net-to-gross ratio (NTG) and to collect data for the process evaluation. The participant surveys also assist with gross savings verification for the residential smart thermostat survey.

The following programs were selected for NTG estimation and process evaluation for FY2018:

- CI RX - Equipment Replacement
- Retrofit – Custom
- New Construction – Custom
- Solar PV Market Rate
- Retail Smart Thermostats

1.2.1 Net Savings Estimation

The NMR team calculated net energy and demand savings that are attributable to each evaluated program by multiplying the gross verified energy and demand savings by the NTG ratio. This equation and general methodology are used for estimating both the net energy and demand savings. The NTG ratio is based on measurement of free-ridership and participant spillover rates. The NTG ratio is defined as follows:

NTG = 1 – Free-Ridership + Participant Spillover

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

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 scope, and (c) in the absence of the program. The survey instrument for each of the evaluated programs estimated free-ridership based on two key components:

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

Where appropriate, we estimated partial free-ridership. Partial free-ridership refers to any measure that, in the absence of the program, would have been adopted later, at a lower level of efficiency (but still efficient), or in smaller quantities.

The participant survey asked a series of questions related to the influence of program elements on their decision to purchase and install the energy-efficient measure. For commercial survey participants, we asked the free-ridership questions about the largest savings measure from their largest savings project.

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 or technical assistance from the program. Participant spillover can manifest in participants who take actions beyond the program.

The participant survey instrument estimated participant spillover for each respondent through questions about installations of energy-efficient equipment or upgrades that were done outside the program. In these situations, the survey asked about the installed equipment and the impact the program had on the decision to implement the project. Depending on the program, these non-program installations may include lighting, lighting controls, air conditioning, motors and motor drives, HVAC equipment, or appliances. For each measure installed, the survey obtained details that facilitated quantifying the energy savings that the upgrade produced.

Default NTG Values

For the programs that we did not estimate NTG for FY2018, the default NTG values are based on the most recent SEU NTG estimates (from FY2014 or FY2013), supplemented by a review of more recent NTG values for similar programs from other mid-Atlantic and northeastern states. See Section 4.2 for further details.

1.2.2 Process Evaluation

The NMR team completed the following activities to inform the process evaluation:

- In-depth telephone interviews with program staff to update the NMR team's understanding of the program and identify any current issues for consideration in interviews with participating vendors and surveys of participants.
- In-depth telephone interviews with participating vendors to learn about topics such as the following:
  - Experience with and perception of the program and its equipment or service offerings
  - Program knowledge and attitudes toward energy efficiency
  - Opportunities for program improvement
  - Questions specific to program issues that may have been identified by program staff
- Telephone surveys of a sample of participating customers to collect information about their program experience, including questions on topics such as the following:
  - How they learned of the program
  - Satisfaction with the program overall and particular elements
  - Decision-making process
  - Opportunities for program improvement
  - Questions specific to program issues that may have been identified by program staff

1.3 PROGRAM SAVINGS OVERVIEW

In this section, we provide an overview of the FY2018 tracked savings by sector, program, and measure type. Table 6 displays the percent of FY2018 tracked overall energy, electric, gas, and

peak demand savings by sector. The commercial sector programs contributed the large majority of savings across each savings category. Note that the retail programs yielded negative gas savings due to the heating penalty associated with efficient lighting.

Table 6: FY2018 Tracked Gross Savings Summary by Sector

Sector	Percent of FY2018 Tracked Savings			
	Total Energy Savings (MMbtu)	Electric Savings (MWh)	Gas Savings (MMbtu)	Peak Demand Savings (MW)
Commercial	80.9%	72.7%	100.4%	72.5%
Efficient Products	11.5%	17.3%	-2.0%	12.7%
Multifamily	6.0%	7.9%	1.6%	11.5%
Single-family Residential	0.0%	0.0%	0.0%	0.0%
Solar	1.5%	2.1%	0.0%	3.3%
Total	**609,449**	**125,420**	**181,517**	**19.2**

Table 7 displays the percent of FY2018 tracked overall energy, electric, gas, and peak demand savings by program track. Three commercial programs contributed the largest share of savings to the portfolio: the Retrofit Custom program, the New Construction Custom program, and the Commercial Rx Equipment Replacement program. The largest non-residential programs included the Retail Lighting program and the Retail Smart Thermostat program.

Table 7: FY2018 Tracked Gross Savings Summary by Program

Sector	Program Name	Percent of FY2018 Tracked Savings			
		Total Energy Savings (MMbtu)	Electric Savings (MWh)	Gas Savings (MMbtu)	Peak Demand Savings (MW)
Solar	Solar PV Market Rate	1.5%	2.1%	0.0%	3.3%
Single-family Residential	Low-income Emergency Equipment Replacement	0.0%	0.0%	0.0%	0.0%
Commercial	C& I RX - Equipment Replacement	13.2%	20.4%	-3.9%	13.8%
	Market Transformation Value	1.3%	2.0%	-0.3%	0.8%
	Commercial Upstream (Lighting)	4.2%	6.6%	-1.5%	6.0%
	Retrofit – Custom	44.3%	31.1%	75.6%	29.8%
	Market Opportunities - Custom	1.4%	0.8%	2.9%	1.1%
	New Construction - Custom	16.5%	11.8%	27.6%	21.1%
Multifamily	Implementation Contractor Direct Install	0.9%	1.4%	-0.1%	1.1%
	Income Qualified Efficiency Fund	0.7%	1.1%	0.0%	0.6%
	LI Custom Projects	0.0%	0.0%	0.0%	0.0%
	Low-income Multifamily Comprehensive	2.4%	2.4%	2.4%	2.7%
	Low-income Prescriptive Rebate	2.0%	3.1%	-0.7%	7.1%
Efficient Products	Retail Efficient Appliances	0.1%	0.1%	0.1%	0.1%
	Home Energy Conservation Kit - Market Rate	0.0%	0.0%	0.0%	0.0%
	Retail Heating and Cooling	0.1%	0.0%	0.3%	0.1%
	Retail Lighting	7.6%	15.3%	-10.6%	11.2%
	Retail Smart Thermostats	3.5%	1.4%	8.6%	1.1%
	Retail Lighting Food Bank	0.0%	0.1%	-0.1%	0.0%
	Home Energy Conservation Kit - Low-income	0.2%	0.3%	-0.2%	0.1%
	Residential Upstream	0.0%	0.1%	-0.1%	0.0%
Total		**609,449**	**125,420**	**181,517**	**19.2**

Table 8 displays the percent of FY2018 tracked overall energy, electric, gas, and peak demand savings by measure type. Lighting represented 43% of all energy savings, almost three-quarters of electric savings, and about two-thirds of demand savings. It also resulted in negative gas savings due to the heating penalty associated with efficient lighting. Heating measures represented about one-third of total energy savings and most of the gas savings.

Table 8: FY2018 Tracked Gross Savings Summary by Measure Type

Measure Type	Percent of FY2018 Tracked Savings			
	Total Energy Savings (MMbtu)	Electric Savings (MWh)	Gas Savings (MMbtu)	Peak Demand Savings (MW)
Lighting	42.7%	72.2%	-26.7%	64.6%
Heating	31.6%	-1.1%	108.8%	1.0%
Cooling	7.1%	10.1%	0.0%	18.9%
Comprehensive	4.6%	4.8%	4.1%	1.9%
Hot Water	2.7%	0.5%	7.9%	0.1%
Motors	2.7%	3.4%	1.0%	3.5%
Other HVAC	3.4%	4.9%	0.1%	5.5%
Solar	1.5%	2.2%	0.0%	3.3%
Other	2.3%	2.8%	1.2%	1.0%
Building Shell	1.3%	0.4%	3.6%	0.3%
Total	**609,449**	**125,420**	**181,517**	**19.2**

1.4 Program Sampling Plan

In this section, we outline our sampling plan for the FY2018 evaluation activities.

1.4.1 Gross Savings Verification Sampling Plan

In this section, we outline our sampling plan for the gross savings verification. We apply a staggered impact evaluation approach, in which some programs will be evaluated annually and others biannually, with default realization rates being used in years without evaluation activities. Additionally, for the commercial programs, we allocate 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. For each commercial program strata, we drew a certainty and random sample of individual projects to review based on total energy savings.

1.4.1.1 Commercial and Renewable Programs

Because HVAC measures represent 42% of electric savings and 68% of overall energy savings from the commercial and renewable sectors in FY2018, it was selected as the deep dive measure of interest. Therefore, we targeted programs for the evaluation that feature HVAC as a key measure, but also included programs with large savings contributions such as C&I RX Equipment Replacement.

Table 9 lists the number of projects and 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 also received an on-site visit for the Retrofit Custom, New Construction Custom, and Solar PV Market Rate programs.

Table 9: Commercial Gross Savings Impact Evaluation Sampling Plan

Program	FY2018 Participation (# Projects)	Number Sampled		
		Desk Reviews	Onsites (incl. Desk Review)	Total
C&I RX - Equipment Replacement	259	11	0	11
Market Transformation Value	7	5	0	5
Retrofit - Custom	133	24	8	32
Market Opportunities - Custom	16	7	0	7
New Construction - Custom	49	11	3	14
Solar PV Market Rate	9	3	2	5
All Evaluated Programs	**473**	**61**	**13**	**74**

Each program was stratified based on key measure types split into the categories of HVAC and other, 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.

1.4.1.2 Residential, Retail, and Low-income Multifamily Programs

Table 10 provides the number of FY2018 projects and our recommended sample size for each residential program selected for evaluation. Further details of the sampling plan for each program are provided in the individual program sections.

Table 10: Residential Gross Savings Impact Evaluation Sampling Plan

Program	FY2018 Participation (# Projects)	Number Sampled for Desk Reviews
Retail Lighting	254,710*	n/a**
Retail Smart Thermostats	2,268***	70
Low-income Multifamily Comprehensive	25	10
Low-income Prescriptive Rebate	55	10
Income Qualified Efficiency Fund	24	8
All Evaluated Programs	**269,223**	**98**

* Number of measures rather than projects for the Retail Lighting program.
** A sample of invoice records from each of the seven manufacturers were reviewed.
*** Sites rather than projects.

1.4.2 Net Savings Estimation and Process Evaluation Sampling Plan

In this section, we describe our sampling plan for the in-depth telephone interviews and the participant surveys that serve both the process evaluation and the NTG estimation efforts.

We conducted in-depth telephone interviews (IDIs) with SEU program managers to improve our understanding of the programs, markets, and issues and to identify key research questions for subsequent research activities. We also completed interviews with key program partners (contractors, distributors, architects, engineers, etc.) who are active in the targeted programs. These interviews assessed their experience partnering with the programs and obtained feedback on aspects of the programs that work well and those aspects that offer opportunities for improvement.

Table 11: In-depth Interview Sampling Plan

Program	DCSEU Staff Interviews	Program Partner Interviews
C& I RX - Equipment Replacement	1	2
Retrofit - Custom	1	4
New Construction - Custom	1	3
Retail Smart Thermostats	1	0
Solar PV Market Rate	1	1
All Evaluated Programs	**5**	**10**

We selected programs for the participant surveys because they represent a large share of portfolio savings, and thus would have the largest impact on portfolio savings and cost-effectiveness testing. Therefore, most of the surveys were assigned to commercial programs, although surveys were also assigned to the residential smart thermostat program (Table 12). At the 80% confidence level, the estimated sample precision varies between ±8% and ±37% for each program. Although we completed surveys with two of the three eligible Solar PV Market Rate participants, the wide confidence interval of ±37% is an artifact of the small sample size.

Given the small participant population for the commercial programs, the response rate for the surveys was relatively high, ranging from 16% for the Smart Thermostats program to 31% for the Retrofit-Custom program.

Table 12: FY2018 Participant Survey Sampling Plan

Program	Number of Unique Participating Customers	Number of Customers Sampled*	Number of Completed Surveys	Response Rate	Estimated Sample Precision
C& I RX - Equipment Replacement	134	134	39	29%	80% ± 9%
Retrofit - Custom	88	80	25	31%	80% ± 11%
New Construction - Custom	29	24	6	25%	80% ± 25%
Retail Smart Thermostats	2,268	450	70	16%	80% ± 8%
Solar PV Market Rate	6	3	2	67%	80% ± 37%
All Evaluated Programs	**2,525**	**691**	**142**	**21%**	**90% ± 9%**

*In order to limit the evaluation burden on customers, we excluded 16 commercial program participants from the survey sample who were targeted for on-site visits. In addition, we sampled enough smart thermostats participants (450) to complete 70 surveys.

For each respondent to the commercial participant surveys, we asked questions about their single largest savings project. Certain survey questions asked about the single largest savings measure from that project.

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 six Commercial and Solar programs selected for the FY2018 evaluation:

- Market Transformation Value
- Market Opportunities – Custom
- CI RX - Equipment Replacement
- Retrofit – Custom
- New Construction – Custom
- Solar PV Market Rate

2.1 Market Transformation Value (7512MTV)

The Market Transformation Value (MTV) program provides rebates to large businesses and institutions for lighting upgrades. The program offers prescriptive incentives for lighting. 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, and $10-$20 per sensor for installation of lighting controls. The program completed seven unique projects during FY2018.

For the FY2018 MTV program, we completed the following evaluation activity:

- Gross Savings Verification

2.1.1 Gross Savings Verification

Table 13 displays the tracked savings, realization rate, and evaluated savings for the MTV program. Overall, actual installed lamp wattages were lower than the values that were used in the analyses done by the DCSEU, which relied on lamp measure codes. This garnered an electric realization rate of 108%. The demand realization rate was 139%. This rate also stemmed from the generally lower wattages we encountered in site-specific documentation over the deemed TRM efficient case wattages, as well as fixtures with a higher calculated coincidence factor (CF) than deemed CF. The natural gas realization rate was 107%, also due to the increased electrical (kWh) savings, which correlate directly to an increase in the natural gas heating penalty. The NMR team had the following findings:

- Electrical energy and demand savings were understated.
- Increased electrical savings also lead to a natural gas heating penalty that was understated.

Table 13: Market Transformation Value Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2018 Electric Savings (MWh)	2,542	108%	2,746
FY2018 Peak Demand Savings (MW)	0.15	139%	0.21
FY2018 Gas Savings (MMBtu)	-586	107%	-627

2.1.1.1 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 five 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 (certainty and probability projects) based on each stratum's contribution to the program savings. The NMR team put all projects with more than 3,000 MMBtu of ex ante savings in the certainty stratum. The remaining sample points were randomly selected from projects under the 3,000 MMBtu threshold. Table 14 presents the final sample for the MTV Program.

Table 14: Market Transformation Value Sampling Plan

Substratum	MMbtu Savings	Percent of Energy Savings	FY2018 Participation (Projects)	Number of Sampled Projects
Certainty	3,590	44%	1	1
Probability	4,498	56%	6	4

The selected sample included five total projects. The sample encompassed 6,071 MMbtu, or 75% of the total tracked FY2018 energy savings from the program.

2.1.1.2 Methodology

The NMR team conducted a desk review for each of the selected sample projects to determine the verified savings. No custom analyses were reviewed for the program as all the projects were prescriptive. The desk reviews relied on algorithms and assumptions presented in the TRM. When project files supported deviations in the TRM, the NMR team overwrote TRM assumptions with site-specific data.

The TRM-based algorithms and assumptions for prescriptive lighting measures are detailed in Appendix B.

To facilitate the prescriptive lighting savings calculations, we employed 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 judgement based on available project documentation. For example, the TRM assumes that all sites will utilize gas heat. An engineer from the NMR team adjusted this assumption to show no heat in the case of exterior or parking garage fixtures. The calculator was then used to map site-specific inputs to

the appropriate TRM baseline and installed wattages, CFs, waste heat factors, and controls savings factors.

During the desk review process, our engineers created a calculator for each project within the sample. The engineer reviewed the automatically loaded data for correctness and completeness. Then the NMR team reviewed project files and adjusted the deemed values if site-specific information was supported by enough project documentation, such as invoices, specifications, or email correspondence. These adjustments often included changes to installed fixture wattage values, which we checked against the provided cut-sheets. Likewise, when enough documentation was present to confirm that the actual hours of operation differed from the TRM HOU assumptions, the NMR team created a custom schedule and applied it to corresponding spaces.

2.1.1.3 Results

The program-wide impact results of the program are shown in Table 15.

Table 15: Market Transformation Value Impact Results

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2018 Energy Savings (MWh)	2,542	108%	2,746	±1% @ 80%
FY2018 Peak Demand Savings (MW)	0.15	139%	0.21	±4% @ 80%
FY2018 Gas Savings (MWh)	-586	107%	-627	±1% @ 80%

The program-level electric realization rate was 108%, while the sampled project-specific realization rates ranged from 100% to 117%. The program-level demand realization rate was 139%, while the sampled project-specific demand realization rates ranged from 105% to 201%. The program-level gas savings realization rate was 107%, while the sampled project-specific realization rates ranged from 100% to 116%. The selected sample achieved a ±1% precision at 80% confidence for electric savings.

The largest contributor to the project-level 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. While the actual efficient case wattages were entered into the DCSEU implementation calculator, the delta watts used in the ex ante energy savings calculation was taken from the TRM.

Additionally, the evaluation team observed that the DCSEU lighting calculators relied on 2017 TRM assumptions rather than the 2018 TRM assumptions. Figure 1 shows a screenshot of the DCSEU lighting calculator, which indicates that the lighting assumptions are based on the TRM from May 10, 2017.

Figure 1: TRM assumptions from 5/10/2017

ENERGY SAVINGS CALCULATIONS (based on TRM from 5/10/2017)		
TRM Category	Assumed proposed watt	Assumed Base Watts
Solid State Lighting (LED) Lighting Systems	10.9	70.1
Solid State Lighting (LED) Lighting Systems	10.9	70.1
Solid State Lighting (LED) Lighting Systems	10.9	70.1
Solid State Lighting (LED) Lighting Systems	10.9	70.1
Solid State Lighting (LED) Lighting Systems	11.9	51.4
Solid State Lighting (LED) Lighting Systems	4.6	38
Solid State Lighting (LED) Lighting Systems	10.9	20
Solid State Lighting (LED) Lighting Systems	17.6	54.3
Solid State Lighting (LED) Lighting Systems	12.2	60.4
Solid State Lighting (LED) Lighting Systems	7.1	36.2
Solid State Lighting (LED) Lighting Systems	7.1	36.2
Solid State Lighting (LED) Lighting Systems	160.2	295
Solid State Lighting (LED) Lighting Systems	9.7	16

The assumptions for the baseline wattage and efficient case wattages often remained the same between the 2017 and 2018 TRM. However, for some projects the lamps had a higher TRM baseline wattage assumption in the 2018 TRM. This, combined with the lower site-specific efficient case wattages, led to an increase in the electric realization rates.

The largest contributor to the demand realization rate was an incongruence between hours of use (HOU) and CFs. A CF describes the likelihood that the change in load resulting from the project occurs within DCSEU's peak demand window of 2:00 PM to 6:00 PM from June through August.

The most commonly observed prescriptive lighting CF was the blended indoor commercial rate of 57.82% per the load-shape in the TRM. However, the HOU is an open variable that can be adjusted. The CF and HOU terms are typically proportional (unless a facility is seasonal) and need to be kept as such for savings to be appropriately estimated. For example, if a customer inputs an HOU value of 8,760, the appropriate CF is 100% as the lights are guaranteed to be on during the peak window. The DCSEU, using the current methodology, reports a CF of 57.82% for the majority of lighting projects, which understates the demand savings due to fixtures that operate continuously. This finding increased the reported demand savings in four of the five reviewed projects.

The largest contributor to the natural gas realization rate was the increased heating penalty associated with higher electrical savings as the two values are related. The higher the electrical (kWh) savings are for a lighting project, the larger the associated gas heating penalty will be as the heating system must produce more heat to compensate for the reduced heat emanating from more efficient lights.

2.1.2 Recommendations

Based on the findings of our analysis, the evaluation team offers the following recommendations:

- The lighting calculator used for the program should be updated to reflect the current year TRM lighting assumptions.
- Instead of relying on the assumptions generated by the detailed measure names (LED-101, LED-102, LED-103, etc.) for the efficient lamp wattage, the recorded site-specific efficient case lamp wattage should be used to calculate the wattage difference.
- 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 discrepancies stem from the blended CF being used for lighting that operates continuously. If possible, the DCSEU should work to assign a CF of 100% to any lighting that continuously operates.

2.2 MARKET OPPORTUNITIES – CUSTOM (7520MARO)

The Market Opportunities Custom 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 FY2018, the program provided incentives for 16 projects. Table 16 provides the breakdown of tracked savings by measure type. The bulk of total energy (MMBtu) and total electrical savings (MWh) reside with HVAC measures, which included heat pumps, boilers, whole-building insulation, window improvements, unitary air conditioners, and chillers.

Table 16: Market Opportunities Program Savings Contributions

Measure Type	Percent of FY2018 Combined Energy Savings	Percent of FY2018 Electric Savings	Percent of FY2018 Gas Savings	Percent of FY2018 Peak Demand Savings
HVAC	84%	67%	95%	82%
Lighting	1%	3%	<-1%[6]	2%
Motors & Drives	<1%	2%	N/A	1%
Water Heating	3%	<1%	5%	N/A
Refrigeration & Appliances	<1%	N/A	<1%	N/A
Efficient Transformers	11%	28%	<N/A	15%

For the FY2018 Market Opportunities program, we completed the following evaluation activity:

- Gross Savings Verification

2.2.1 Gross Savings Verification

Table 17 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. The electric realization rate was 102%, the demand realization rate was 106%, and the gas realization rate was 101%.

Table 17: Market Opportunities Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2018 Electric Savings (MWh)	958	102%	974
FY2018 Peak Demand Savings (MW)	0.20	106%	0.22
FY2018 Gas Savings (MMBtu)	5,243	101%	5,290

2.2.1.1 Sampling

Due to the heterogeneous makeup of the program, the sample design employed stratified random sampling. The NMR team designed the sampling plan to ensure the evaluation included a diverse mix of measure types – encompassing both lighting and non-lighting measures. We created a certainty stratum, which ensured that we reviewed the largest project. Projects that had more than 2,900 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 18 presents the final sample.

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

Table 18: Market Opportunities Sampling Plan

Stratum	Percent of Program Energy Savings	FY2018 Participation	Number of Sampled Sites
Certainty	34%	1	1
Probability	66%	15	6

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. 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 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 equations or assumptions were deemed unsuitable, the NMR team overrode them with more appropriate inputs.

The NMR team used a custom savings calculator to facilitate the savings calculations. Similar to the lighting calculator, 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 an industrial boiler project.

Figure 2: Example of Custom Savings Calculation

Measure 1

Measure: INDPBOIL
Description: Industrial Process Efficient Boiler
TRM: No
TRM Reference Page:
Algorithms
Energy (kWh):
Demand (kW):
Gas (MMBTU): ΔMMBtu= (FLH × (BTUh/ AFUE - BTUh/ AFUE)) /1,000,000

Inputs	TRM	Reported	Verified
Nominal Output Capacity for TYP1 (Btu/hr)		496,000	496,000
Nominal Output Capacity for TYP2 (Btu/hr)		496,000	496,000
Nominal Output Capacity for TYP3 (Btu/hr)		496,000	496,000
Nominal Output Capacity for TYP4 (Btu/hr)		496,000	496,000
Annual Fuel Utilization Efficiency (Base) Factor for TYP1		0.80	0.80
Annual Fuel Utilization Efficiency (Base) Factor for TYP2		0.80	0.80
Annual Fuel Utilization Efficiency (Base) Factor for TYP3		0.80	0.80
Annual Fuel Utilization Efficiency (Base) Factor for TYP4		0.80	0.80
Annual Fuel Utilization Efficiency (Energy Efficient) Factor for TYP1		0.94	0.94
Annual Fuel Utilization Efficiency (Energy Efficient) Factor for TYP2		0.94	0.94
Annual Fuel Utilization Efficiency (Energy Efficient) Factor for TYP3		0.94	0.94
Annual Fuel Utilization Efficiency (Energy Efficient) Factor for TYP4		0.94	0.94
Full Load Heating Hours (FLH)		528.00	528.00
Indoor Heating Setpoint for TYP4		70.00	70.00
Outdoor Design Temp for TYP4		17.00	17.00
Heating Degree Days for TYP4		2,247	2,247
Annual Fossil Fuel Savings (MMBtu) for TYP1			47.27
Annual Fossil Fuel Savings (MMBtu) for TYP2			47.27
Annual Fossil Fuel Savings (MMBtu) for TYP3			47.27
Annual Fossil Fuel Savings (MMBtu) for TYP4			47.27

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)
		189	189

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.

2.2.1.3 Results

The program-wide impact evaluation results for the Market Opportunities Program are shown in Table 19. The findings that contributed to the realization rates are described in the text that follows.

Table 19: Market Opportunities Program Impact Results

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2018 Electric Savings (MWh)	958	102%	974	±1% @ 80%
FY2018 Peak Demand Savings (MW)	0.20	106%	0.22	±1% @ 80%
FY2018 Gas Savings (MMBtu)	5,243	101%	5,290	±1% @ 80%

The program-level realization rates are 102% for electric (MWh) savings, 106% for demand savings (MW), and 101% for natural gas savings. The selected sample ultimately achieved a ±1% precision at 80% confidence for electric, demand, and gas savings.

The evaluation team concluded that significant review went into the 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.

Out of seven sampled projects, six had a total energy (MMBtu) realization rate that was between 95% and 105%. There were only two projects that had deviations outside this range. One project had a demand realization rate of 126%. The other project had an electric, demand, and gas realization rate of 121%, 118%, and 125%, respectively. These deviations are discussed below.

- The source of the demand discrepancy in the first project could not be resolved. The NMR team used the site-specific equivalent full load hours (EFLH) multiplied by the deemed CF listed in the project documentation for a commercial AC system. The deemed CF was used in absence of information on the distribution of the actual hours of operation. The evaluation team was not able to find the ex ante calculation for peak demand, or recreate the calculation by using deemed or site-specific variables.
- The other project was a lighting project that assumed efficient case wattages from the TRM for lighting fixtures. The NMR team used the actual installed wattages that were found from lighting specifications. This accounted for the increased electric, demand, and gas realization rates associated with this project.

2.2.2 Recommendations

Based on the findings of our analysis, the evaluation team offers the following recommendations:

- Detail the methodology of calculating peak demand savings in the overview sections of the DCSEU calculators, so that these calculations and the variables they use can be referenced when noting differences.
- When specifications are available, rely on site-specific wattages from lighting specifications rather than TRM deemed efficient case wattages.

2.3 CI RX - EQUIPMENT REPLACEMENT (7511CIRX)

The C&I RX Equipment Replacement program, also known as Business Energy Rebates, 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 electrical 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.

Customers notify DCSEU of their intended purchases and installations and receive a preapproval letter for the rebate. After installation, the required paperwork and invoices are submitted and rebates are issued within 90 days. Due to the quantity of projects submitted, DCSEU does not inspect all installations. Program staff inspect all projects receiving rebates of $5,000 or more and inspect 25% of projects receiving rebates under $5,000. If a project is not inspected by program staff, the customer must submit a signed inspection form attesting to the measure installation.

The CI RX team is small, making it difficult to undertake direct customer engagement, so outreach primarily occurs through digital campaigns, e-blasts, and coordination with contractors. Customers are directed to the program by account managers, engineers, and contractors. An internal trade ally manager works with contractors to highlight the rebates available and explain the application process. The program launches market specific campaigns that target certain building areas or installations that have a large potential for energy savings. DCSEU staff are also considering offering training and engaging more frequently with market stakeholders who could market the rebates to customers.

Savings were accrued and incentives were provided for 259 unique projects in FY2018. For our selected sample, lighting measures provided around two-thirds of the total energy savings, while one project with a building operator certification measure solely accounted for the remaining one-third of total energy savings. The evaluation team sampled all available HVAC projects from the program population, of which there were only two. Table 20 shows the measure type contributing savings to the program during FY2018.

Table 20: C&I RX Equipment Replacement Sample Savings Contributions

Measure Type	Percent of FY2018 Combined Energy Savings (MMBtu)	Percent of FY2018 Electric Savings (MWh)	Percent of FY2018 Gas Savings (MMBtu)	Percent of FY2018 Peak Demand Savings (MW)
Lighting	63%	67%	-250%[7]	100%
Building Operator Certification	37%	33%	147%	0%
HVAC (Furnace)	<1%	<1%	4%	<1%

For the FY2018 CI RX Equipment Replacement program, we completed the following evaluation activities:

- Gross Savings Verification
- Net Savings Estimation
- Process Evaluation

2.3.1 Gross Savings Verification

Table 21 displays the tracked savings, realization rate, and evaluated savings for the CIRX Equipment Replacement program. For the lighting measures from the certainty strata projects, the actual installed lamp wattages were lower than the values in the TRM. However, for the lighting measures from the probability strata projects the realization rate was less than 100% because the installed wattages were higher than the TRM values. The probability strata was more heavily weighted for this program which leads to an overall electric realization rate of 99%.

The demand realization rate was 132%. This rate also stemmed from the generally lower wattages we encountered in site-specific documentation compared to the TRM efficient case wattages. In addition, we calculated higher CFs for fixtures than the deemed CF from the TRM due to a large portion of fixtures operating 24/7. The natural gas realization rate was 121% due to a large portion of lighting projects showing increased electric savings, and applied waste heat factors being higher than the claimed values which results in an increased heating penalty. Overall, the NMR team had the following findings:

- Electric savings were understated for certainty strata lighting projects.
- Electric savings were overstated for probability strata lighting projects.
- Demand savings were understated.
- Increased electric savings for certainty strata lighting projects led to a natural gas heating penalty that was understated.

[7] These gas savings are negative due heating penalties associated with more efficient lighting. The overall gas savings for the program are negative as the actual gas savings from the building operator certification and furnace measures are countered by the heating penalties from the lighting measures.

- The single furnace project benefitted from a slightly higher gas realization rate due to a higher efficiency than the TRM accounted for.
- The building operator certification project also yielded a slightly increased gas realization rate due to utilizing the actual building area instead of the bins from the TRM.

Table 21: CIRX Equipment Replacement Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2018 Electric Savings (MWh)	25,640	99%	25,505
FY2018 Peak Demand Savings (MW)	2.65	132%	3.48
FY2018 Gas Savings (MMBtu)	-7,084	121%	-8,597

2.3.1.1 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 substrata (certainty and probability projects) based on each substratum's contribution to the program savings. We set our certainty strata cut off 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 3,000 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 22 presents the final sample for the CIRX Equipment Replacement Program.

Table 22: CIRX Equipment Replacement Sampling Plan

Substratum	MMbtu Savings	Percent of Energy Savings	FY2018 Participation (Projects)	Number of Sampled Projects
Certainty	14,960	18.6%	4	4
Probability	65,440	81.4%	255	7

The selected sample included nine lighting projects, one building operator certification project, and one furnace project. These 11 projects encompassed 17,217 MMbtu, or 21% of the total tracked energy savings from the CIRX Equipment Replacement program.

2.3.1.2 Methodology

The NMR team conducted a desk review for each of the sampled projects to determine the verified savings. No custom analyses were reviewed for this program as all the projects were prescriptive. The desk reviews relied on algorithms and assumptions presented in the TRM. When project files supported deviations in the TRM, the NMR team overwrote TRM assumptions with site-specific data.

The TRM-based algorithms and assumptions for prescriptive lighting measures are detailed in Appendix A.

To facilitate the prescriptive lighting savings calculations, we employed 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 judgement based on available project documentation. For example, the TRM assumes that all sites will utilize gas heat. An engineer from the NMR team adjusted this assumption to show no heat in the case of exterior or parking garage fixtures. The calculator was then used to map site-specific inputs to the appropriate TRM baseline and installed wattages, CFs, waste heat factors, and controls savings factors.

During the desk review process, our engineers created a calculator for each project within the sample. The engineer reviewed the automatically loaded data for correctness and completeness. Then the NMR team reviewed project files and adjusted the deemed values if site-specific information was supported by enough project documentation, such as invoices, specifications, or email correspondence. These adjustments often included changes to installed fixture wattage values, which we checked against the provided cut-sheets. Likewise, when enough documentation was present to confirm that the actual hours of operation differed from the TRM HOU assumptions, the NMR team created a custom schedule and applied it to corresponding spaces. Where installed fixtures were controlled by a photocell, the calculator analyzed historical sunrise and sunset times to more accurately portray the hours these fixtures were in use.

In addition to the nine lighting projects reviewed, the evaluation team reviewed one building operator certification project. The TRM-based algorithms and assumptions for the building operator certification measure are presented in Appendix B. Similar to the methodology of the lighting projects, the evaluation team used a custom calculator to evaluate the building operator certification savings. The calculator auto-populated as much information as could be mined from the reported savings database. An NMR team engineer reviewed project documentation to make changes where values differed from TRM assumptions.

The final CIRX project reviewed by the evaluation team was a furnace project. The database listed the measure code for a high efficiency gas furnace (SHRFNGAS). This measure code applies to residential applications and therefore was not appropriate for the installed furnace. Instead, the DCSEU calculations and the evaluation team applied the measure code for a condensing gas furnace from the commercial and institutional sector. This measure code is SHRDCFRN and uses different equations to quantify electrical and natural gas savings. The TRM-based algorithms and assumptions for the condensing gas furnace are presented in Appendix B.

The evaluation team created a custom calculator, which was used to evaluate the condensing furnace savings. The calculator auto-populated as much information as could be mined from the reported savings database, and an engineer reviewed project documentation to make changes where site-specific values differed from TRM assumptions.

2.3.1.3 Results

The program-wide impact results of the CIRX Equipment Replacement Program are shown in Table 23. The findings that contribute to the realization rates are discussed in the text that follows.

Table 23: CIRX Equipment Replacement Impact Results

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2018 Energy Savings (MWh)	25,640	99%	25,505	±7% @ 80%
FY2018 Peak Demand Savings (MW)	2.65	132%	3.48	±11% @ 80%
FY2018 Gas Savings (MMBtu)	-7,084	121%	-8,597	±7% @ 80%

The program-level electric realization rate is 99%, while the sampled project-specific realization rates ranged from 86% to 114%. The program-level demand realization rate is 132%, while the sampled project-specific demand realization rates ranged from 107% to 186%. The program-level gas savings realization rate is 121%, while the sampled project-specific realization rates ranged from 40% to 133%. The selected sample ultimately achieved a ±7% precision at the 80% confidence level for electric savings.

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. While the actual efficient case wattages were provided in the DCSEU implementation calculators, the delta watts used in the ex ante energy savings calculation was taken from the TRM.

Additionally, the evaluation team observed that the DCSEU lighting calculators relied on 2017 TRM assumptions rather than the 2018 TRM assumptions. A screenshot of the DCSEU lighting calculator shows the lighting assumptions are based on the TRM from May 10, 2017, as seen in Figure 3.

Figure 3: TRM Assumptions from 5/10/2017

ENERGY SAVINGS CALCULATIONS (based on TRM from 5/10/2017)		
TRM Category	Assumed proposed watt	Assumed Base Watts
Solid State Lighting (LED) Lighting Systems	10.9	70.1
Solid State Lighting (LED) Lighting Systems	10.9	70.1
Solid State Lighting (LED) Lighting Systems	10.9	70.1
Solid State Lighting (LED) Lighting Systems	10.9	70.1
Solid State Lighting (LED) Lighting Systems	11.9	51.4
Solid State Lighting (LED) Lighting Systems	4.6	38
Solid State Lighting (LED) Lighting Systems	10.9	20
Solid State Lighting (LED) Lighting Systems	17.6	54.3
Solid State Lighting (LED) Lighting Systems	12.2	60.4
Solid State Lighting (LED) Lighting Systems	7.1	36.2
Solid State Lighting (LED) Lighting Systems	7.1	36.2
Solid State Lighting (LED) Lighting Systems	160.2	295
Solid State Lighting (LED) Lighting Systems	9.7	16

The assumptions for the baseline wattage and efficient case wattages often remained the same between the 2017 and 2018 TRM. However, for some projects, the lamps had a higher TRM baseline assumption in the 2018 TRM than in the 2017 TRM. Combined with site-specific efficient

case wattages lower than deemed TRM efficient case wattages, this led to an increase in the electric realization rates.

The largest contributor to the demand realization rate was an incongruence between HOU and CFs. A CF describes the likelihood that the change in load resulting from the project occurs within DCSEU's peak demand window of 2:00 PM to 6:00 PM from June through August.

The most commonly observed prescriptive lighting CF was the blended indoor commercial rate of 57.82% per the load-shape in the TRM. However, the HOU is an open variable that can be adjusted. The CF and HOU terms are typically proportional (unless a facility is seasonal) and need to be kept as such for savings to be appropriately estimated. For example, if a customer inputs an HOU value of 8,760, the appropriate CF is 100% as the lights are guaranteed to be on during the peak window. The DCSEU, using the current methodology, reports a CF of 57.82% for the majority of lighting projects, which understates the demand savings due to fixtures that operate 24/7. This finding increased the reported demand savings in four of the nine reviewed lighting projects.

The largest contributor to the natural gas realization rate was the increased heating penalty associated with higher electrical savings for the certainty strata lighting projects, as the two values are related. The higher the electrical 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. Even for the probability strata lighting projects that showed electric realization rates lower than 100%, their gas realization rates were still higher due to a higher applied waste heat factor. For one project there was a smaller gas penalty claimed because DCSEU uses a standard WHF on all lighting projects that assumes 26% of all bulbs are installed in exterior spaces or unconditioned interior spaces. Our calculations claim zero gas penalties for lighting measures installed in exterior or unconditioned spaces.

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 39 telephone surveys completed with participating CI RX customers.

2.3.2.1 Free-ridership

Free-ridership was estimated 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

About one-quarter (26%) of the 39 CI RX participants reported they would have delayed the measure installation by one year or canceled the installation in the absence of the program (Table 25). These respondents were assigned a low free-ridership intention score (0%).

About another one-quarter (23%) said they would have installed the measure but scaled back the scope or efficiency in the absence of the program, or didn't know. These respondents were assigned a moderate free-ridership intention score (25%).

About one-half of the 39 CI RX respondents (51%) reported they would have installed the measure with the exact same scope and efficiency in the absence of the program (Table 24). Most of these respondents (38%) indicated they would have had the funds to cover the entire cost of the measure and were therefore assigned a high free-ridership intention score (50%). Ten percent of respondents said they might have had the funds available and were therefore assigned a moderate-high free-ridership intention score (37.5%). Another 3% of respondents said they would not have had the funds available and were therefore assigned a moderate free-ridership intention score (25%).

Table 24: Free-ridership Intention Scoring for CI RX Program

Intention in the Absence of the Program	Funds Available to Cover the Entire Cost	Assigned Free-ridership Intention Score (%)	Percent of Respondents
• Delayed the installation of the measure for at least one year OR • Cancelled the installation of the measure altogether	• Not Asked	0%	26%
• Installed the measure but scaled back the scope or efficiency OR • Don't know OR • I'd rather not answer	• Not Asked	25%	23%
• 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%	3%
	• Might have had the funds	37.5%	10%
	• Definitely would have had the funds	50%	38%
Number of Respondents			**39**

Influence

Table 25 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 features with the highest average ratings include the rebate, information from contractors/suppliers, and prior program experience.

Table 25: Influence of DCSEU program features for CI RX Program

Features	Number of Respondents*	1 Played no role at all	2	3	4	5 Played a great role	Average Rating
The financial incentive/rebate	39	5%	0%	15%	23%	56%	4.3
Information provided by a DCSEU representative	30	17%	3%	20%	20%	40%	3.6
Results of DCSEU audits or technical studies	20	15%	5%	5%	40%	35%	3.8
Information from contractors or suppliers associated with the program	31	13%	0%	3%	26%	58%	4.2
DCSEU program marketing materials	29	28%	7%	17%	17%	31%	3.2
Previous experience with a DCSEU program	28	15%	7%	0%	4%	74%	4.2

* The total number of respondents excludes those who said "Not applicable" or "I'm not sure."

Each respondent was assigned a free-ridership influence score based on the *highest* rating they provided for *any* of the above program features. Seventy-two percent of the 39 respondents indicated that at least one program feature played a great role in their decision and were assigned a free-ridership influence score of 0% (Table 26). Another 18% of respondents provided a maximum rating of 4.0 and were assigned a free-ridership influence score of 12.5%. Eight percent gave a maximum rating of 3.0 and were assigned a free-ridership influence score of 25%.

Table 26: Free-ridership Influence Scoring for CI RX Program

Maximum Influence Rating	Assigned Free-ridership Influence Score (%)	Percent of Respondents
5 - program feature played a great role	0%	72%
4	12.5%	18%
3	25%	8%
2	37.5%	0%
1 - program feature played no role OR Not Applicable	50%	2%
Don't know OR Refused	25%	0%
Number of Respondents		**39**

For each respondent, the free-ridership intention score and the free-ridership influence score were summed 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 greatest tracked energy savings (MMBtu) associated with the project. The average unweighted and weighted free-ridership rate was 35% (Table 27). Because lighting was the primary measure for 38 of the 39 sampled projects, the free-ridership rate almost entirely reflects lighting measures.

Table 27: Free-ridership Rate for CI RX Program

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

2.3.2.2 Participant Spillover

Four respondents reported installing energy-efficient or renewable energy equipment at a DC location after the CI RX project. These installations did not receive an incentive, according to the respondent. All four respondents reported installing LEDs and indicated their earlier involvement with the DCSEU program had a great influence on their decision to install the LEDs, based on a 1 to 5 scale, where 1 means "no influence at all" and 5 means "great influence" (Table 28).

These four respondents each installed between two and 200 LEDs. The most common type of LED installed through the CI RX program in FY2018 was a TLED, with average total energy savings of 0.26 MMBtu.

In order to calculate the spillover rate for each participant, the energy savings per LED was multiplied by the quantity of LEDs installed. This figure was then multiplied by the spillover influence score for each respondent and summed across all four spillover respondents to calculate the total spillover savings.

Table 28: Spillover Influence Scores for CI RX Program

Program Influence Rating	Assigned Influence Score (%)	Spillover Measures	Count of Respondents
Rating of 2 (some influence)	25%		0
Rating of 3	50%		0
Rating of 4	75%		0
Rating of 5 (great influence)	100%	LEDs	4
Respondent does not know how much influence	50%		0

The total spillover savings for the four respondents was then divided by the cumulative tracked savings across all 39 survey respondents to calculate the spillover rate for the program. Table 29 displays the estimated spillover rate for the CI RX program (1%).

Table 29: Spillover Rate for CI RX Program

	Average	Minimum	Maximum
Spillover Rate	1%	0%	20%

2.3.2.3 NTG Ratio

The savings-weighted NTG ratio for the CI RX program equals 66% (Table 30).

Table 30: NTG Ratio for CI RX Program

	Free-ridership	Spillover	NTG (1 – FR +SO)
Net-to-Gross Ratio	35%	1%	66%

2.3.3 Process Evaluation

The process evaluation of the CI RX program included in-depth telephone interviews with program staff and two program partners (Table 31). The NMR team also conducted telephone surveys with 39 participating customers.

Table 31: CI RX Equipment Replacement Process Evaluation Activities

Stakeholder	Completed
Program staff interviews	1
Program partner interviews	2
Participant surveys	39

2.3.3.1 Key Findings

Key findings from the process evaluation include the following:

- Overall, staff and partners describe the program as highly efficient and straightforward.
- Due to a lack of resources, customer engagement is limited and outreach is primarily digital. However, digital communication is effective at keeping partners and customers up to date.

- Both program partners interviewed were satisfied with the program and thought the administrative requirements were not burdensome. On average, participants gave a satisfaction rating of 4.5 on a scale of 1 to 5, where 5 means "very satisfied."
- Participants were satisfied with the program, and 67% of participants reported that they would not make any changes to the program.
- The Net Promoter Score (NPS) for the CI RX program was 77. Overall, 82% of respondents were *promoters* – that is, these customers may actively promote the program to other potential participants.
- More than three-fourths of the 39 participants (77%) indicated that they have plans for energy-efficient or renewable energy improvements in the next two years. In addition, the majority (90%) revealed they will consider involving DCSEU in their future plans.
- Most respondents (85%) indicated that they did not face any barriers or hurdles when deciding whether to participate in the program.

2.3.3.2 Program Staff Interview Results

Program Strengths. Program staff reported that the CI RX Program is DCSEU's most cost-effective, straightforward program with eligibility requirements clearly laid out on the website. Through dialogue and through its technical expertise, the DCSEU has established itself as a trusted technical resource in the District and believe many customers do not feel comfortable moving forward with a project until DCSEU has reviewed and approved it.

Challenges and Opportunities for Improvement. Program staff indicated that the program is challenged by its lack of resources to engage small business customers face-to-face. According to program staff, these projects collectively represent significant savings, but the program does not have the capacity to consistently engage with this segment of the market. Offering trainings and increasing stakeholder engagement may help reach some of these small-scale savings projects. The DCSEU has recently created a planning tool to forecast market demand for different measures. This will help the program as it works to meet increasing savings goals.

Program staff also noted that the program requires a substantial amount of paperwork and documentation, which is a barrier to participation. Additionally, most of the outreach and updates are accomplished through digital means, so the process is not user-friendly for customers who are not technologically savvy.

2.3.3.3 Partner Interview Results

Program Strengths. The NMR team interviewed one electrical distributor and one lighting manufacturer for the process evaluation. Overall, the program partners reported that the CI RX program is straightforward and easy to understand. The partners noted that the program excels at providing status updates on applications, paying customer reimbursements promptly, and communicating overall program updates.

Challenges and Opportunities for Improvement. Program partners cited the level of the incentives as one drawback to the program. The partners noted that customers expect rebates to be comparable to Maryland's because both are served by Pepco and are in close proximity.

Partners additionally noted that there can be some inertia in the industry among contractors who are resistant to new technologies.

In addition to increasing program incentive amounts, partners recommended improving marketing and outreach efforts to raise customer awareness and knowledge of the program. The partners also suggested that the program improve the application by using simpler language.

2.3.3.4 Participant Survey Results

Program Awareness

- More than one-third of the 39 participants (39%) learned about the DCSEU financial incentives or technical assistance through a contractor or through the DCSEU. Finding out through a lighting distributor was the third most common source, at 11%.
- Of the 39 respondents, 80% were informed they could receive a DCSEU rebate for the energy-efficient equipment and roughly two-thirds of participants (66%) knew about the DCSEU rebate before it was mentioned by the individuals who helped them implement the project.
- Almost two-thirds of the 39 respondents (64%) have visited the DCSEU website to look for information on DCSEU financial or technical assistance for an energy-efficiency or renewable energy project. Of the 25 respondents who had visited the DCSEU website, 52% rated the information on the website as “very useful.”

Program Experience and Satisfaction

- Participants listed saving money on energy costs (17%), reducing operating or maintenance costs (14%), and saving money on equipment installation/purchase (13%) as their main reasons for installing the measures through the program.
- The most realized program benefit was increased savings on energy costs (23%), followed by increased savings on equipment installation/purchase (16%) and reduced operating or maintenance costs (15%).
- Participants were asked to rate various aspects of their experience with the CI RX program. On a scale of 1 to 5, where 1 equals “not at all satisfied” and 5 equals “very satisfied,” respondents’ average ratings were relatively high, falling between 4.2 and 4.9 (Table 32).

Table 32: Participant Experience with the CI RX Program

Features	Sample size*	1 Not at all satisfied	2	3	4	5 Very satisfied	Average Rating
Your experience overall	39	3%	0%	3%	14%	80%	4.7
The type of eligible equipment	36	0%	3%	6%	30%	61%	4.5
The rebate or incentive amount	37	5%	5%	8%	29%	51%	4.2
The application process	32	3%	3%	6%	25%	63%	4.4
The preapproval process	30	0%	0%	3%	43%	54%	4.2
Time to receive the rebate or incentive	34	3%	3%	18%	29%	47%	4.2
Assistance from contractor	24	0%	0%	0%	29%	71%	4.7
The performance of the new equipment	37	0%	0%	0%	8%	92%	4.9
Energy savings from new equipment	34	0%	0%	0%	18%	82%	4.8
Information about DCSEU offerings	34	0%	3%	9%	27%	61%	4.5
Technical assistance from DCSEU	27	4%	0%	0%	26%	70%	4.6

* The total number of respondents excludes those who said “Not applicable” or “I’m not sure.”

- On average, participants rated the ease of completing the application as a 4.2 out of 5, where 5 means “very easy.”
- While roughly two-thirds of the 39 participants (65%) revealed they would not change any aspects of the program, 14% mentioned they would like to see the rebate level increase.
- The majority of the 39 respondents (85%) indicated that they did not face any barriers or hurdles when deciding whether to implement the measure through the DCSEU program. Just 5% cited equipment availability as a hurdle.
- Participants were also asked to rate the likelihood of recommending the CI RX program to others. For this question, respondents used a scale of 0 to 10, where 0 means “extremely unlikely” and 10 means “extremely likely.” This rating, or NPS, is a well-established measure of customer loyalty. With the NPS, 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 CI RX program was 77. Overall, 82% of respondents were *promoters* – that is, these customers may actively promote the program to other potential participants by word of mouth.

Future Plans

- More than three-fourths of the 39 participants (77%) indicated that they have plans for energy-efficient or renewable energy improvements in the next two years. Of these respondents, the majority (90%) revealed they will consider involving DCSEU in their future plans.
- While 31% of the 39 participants stated that current DCSEU support levels were sufficient to assist in meeting their future energy needs, 15% mentioned they would like an updated list of program offerings.

2.3.4 Recommendations

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

- The lighting calculator used for the CI RX program should be updated to reflect the current year TRM lighting assumptions.
- Use site-specific information where available, 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.
- To help resolve the issue of incorrectly applying WHF for interior and exterior lights, we recommend using a lookup table where the WHF is based on the field detailing the location of the fixture rather than the measure code. The current lookup table in the pre-approval application is based on measure code, whereas the TRM assigns WHFs based on whether a fixture is located inside or outside. Exterior is one of the available selections in the location drop-down menu and also translates into the reported savings database, and, as such, could be used to determine an appropriate WHF. Our evaluation found the *location* field to be accurate based on available project details and submitted lamp specification sheets.
- 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 discrepancies stem from the blended CF being used for lighting that operates 24/7. At a minimum, it is recommended that a flag be used 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%.

- Consider streamlining the application and use simpler, more accessible language for potential applicants. The results from the program staff and partner interviews indicated that application requirements may be burdensome for some commercial customers. Partners, in particular, noted that some commercial customers may not understand the technical language included on the application.
- Maintain existing digital marketing and outreach efforts as they are successful at reaching participants, but consider additional options for face-to-face engagement. Nearly two-thirds of survey respondents reported that they have visited the DCSEU website for information on financial or technical assistance, indicating that the website is known and accessible to the majority of customers. However, face-to-face engagement may help foster personal relationships and develop other connections with specific market segments, such as small businesses and contractor networks.

2.4 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 per unit of energy saved, 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 and 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. This year, the program also 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 bags to introduce and vet new energy-efficiency technologies.

In FY2018, the program provided incentives for 133 projects. Table 33 provides the breakdown of tracked savings by measure type. The bulk of total energy (MMBtu) and total electrical savings (kWh) come from 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 33: Custom Retrofit Program Savings Contributions

Measure Type	Percent of FY2018 Combined Energy Savings	Percent of FY2018 Electric Savings	Percent of FY2018 Gas Savings	Percent of FY2018 Peak Demand Savings
HVAC	69%	30%	108%	23%
Lighting	24%	59%	-10%[8]	65%
Motors & Drives	5%	10%	N/A	11%
Water Heating	1%	<1%	2%	<1%
Refrigeration & Appliances	<1%	<1%	<1%	<-1%[9]
Efficient Transformers	<1%	1%	<1%	1%

For the FY2018 Custom Retrofit program, we completed the following evaluation activities:

- Gross Savings Verification
- Net Savings Estimation
- Process Evaluation

2.4.1 Gross Savings Verification

Table 34 shows the tracked savings, realization rate, and evaluated savings for the Custom Retrofit program. Overall, the evaluation found the tracked savings to be calculated with a high degree of accuracy, with all three realization rates falling within ±3% of 100%.

Table 34: Custom Retrofit Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2018 Electric Savings (MWh)	38,992	97%	37,896
FY2018 Peak Demand Savings (MW)	5.72	99%	5.63
FY2018 Gas Savings (MMBtu)	137,196	102%	140,145

2.4.1.1 Sampling

Due to the heterogeneous makeup of the program, the sample design employed stratified random sampling. The NMR team designed the sampling plan to ensure the evaluation included a diverse mix of measure types – encompassing both lighting and non-lighting measures. We created a certainty stratum, which ensured that we reviewed the largest projects from the program. Projects with more than 3,000 MMBtu of total energy savings were assigned to the certainty stratum. We

[8] Tracked percent of gas savings are actually negative due to the heating penalties associated with more efficient lighting.
[9] Tracked percent of peak demand savings was negative.

also created a probability stratum, from which we randomly sampled projects. Table 35 presents the final sample for the Custom Retrofit program.

Table 35: Custom Retrofit Sampling Plan

Stratum	Percent of Program Energy Savings	FY2018 Participation	Number of Sampled Sites
Certainty	73%	19	19
Probability	27%	114	13
Total	100%	133	32

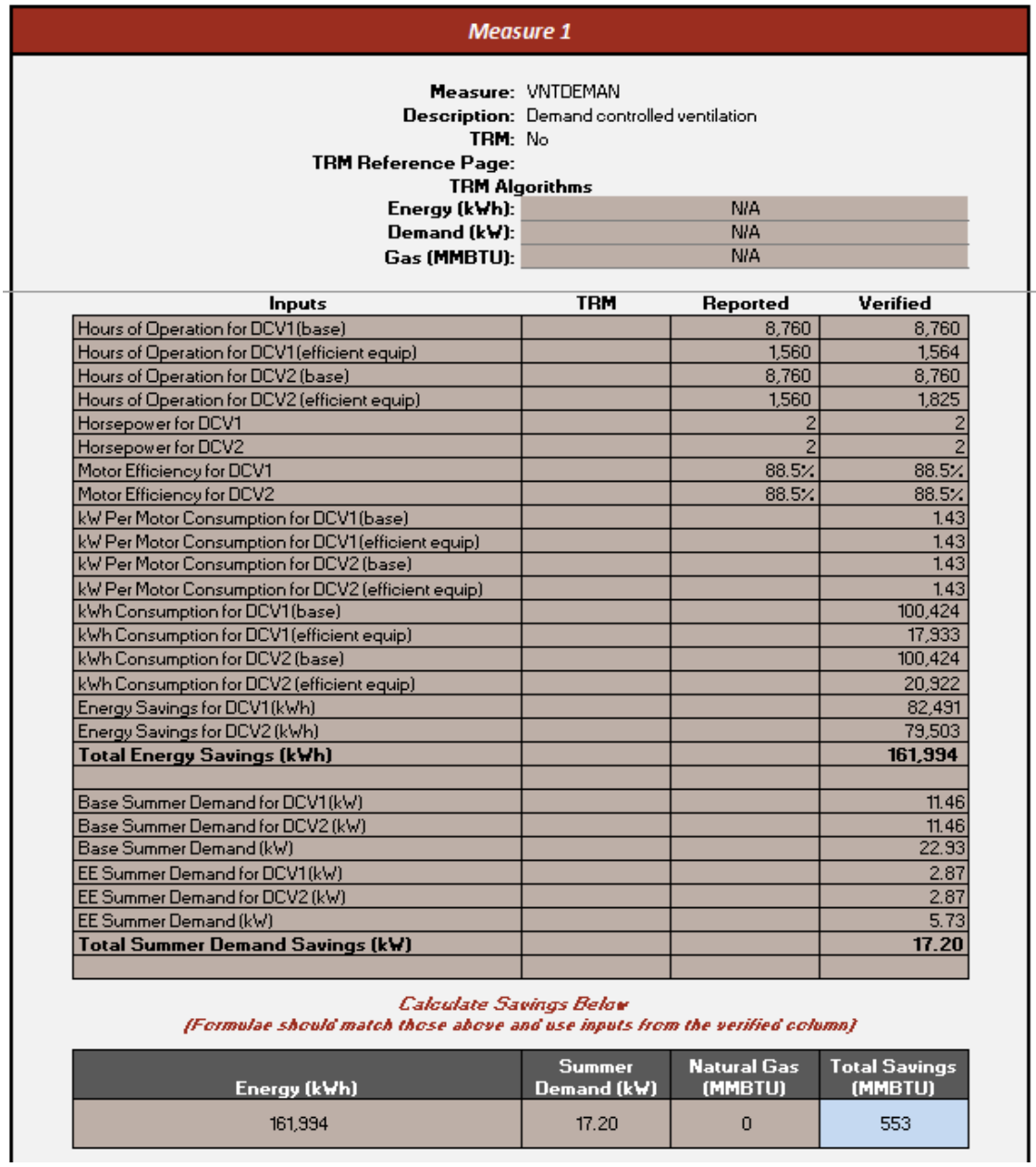
2.4.1.2 Methodology

The NMR team conducted a desk review for each of the 32 sampled sites, through which we calculated the evaluated savings. Eight of the 32 desk reviews used additional information gathered from onsite verifications. Each project was analyzed using one of three evaluation methodologies:

- For measures that exist in the TRM, desk reviews used algorithms and assumptions presented in the TRM as a reference for our analysis, making methodological adjustments as appropriate given the site-specific information provided. TRM assumptions were overwritten 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 equations or assumptions were deemed unsuitable, the NMR team overrode them with more appropriate inputs.
- Two custom projects were reviewed using a regression analysis of energy consumption data to quantify savings based on typical meteorological year data, with energy consumption as the dependent variable and applicable variables such as heating degree days (HDD) and cooling degree days (CDD) as independent variables.

The NMR team used a custom savings calculator to facilitate the savings calculations. Similar to the lighting calculator, 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 comparing inputs between those used in the tracked savings, those used in the TRM (if applicable), and those deemed appropriate by the evaluating engineer. Figure 4 shows an example of the calculator used for a demand-controlled ventilation project.

Figure 4: Example of Custom Savings Calculation



Measure 1

Measure: VNTDEMAN
Description: Demand controlled ventilation
TRM: No
TRM Reference Page:

TRM Algorithms

Energy (kWh):	N/A
Demand (kW):	N/A
Gas (MMBTU):	N/A

Inputs	TRM	Reported	Verified
Hours of Operation for DCV1 (base)		8,760	8,760
Hours of Operation for DCV1 (efficient equip)		1,560	1,564
Hours of Operation for DCV2 (base)		8,760	8,760
Hours of Operation for DCV2 (efficient equip)		1,560	1,825
Horsepower for DCV1		2	2
Horsepower for DCV2		2	2
Motor Efficiency for DCV1		88.5%	88.5%
Motor Efficiency for DCV2		88.5%	88.5%
kW Per Motor Consumption for DCV1 (base)			1.43
kW Per Motor Consumption for DCV1 (efficient equip)			1.43
kW Per Motor Consumption for DCV2 (base)			1.43
kW Per Motor Consumption for DCV2 (efficient equip)			1.43
kWh Consumption for DCV1 (base)			100,424
kWh Consumption for DCV1 (efficient equip)			17,933
kWh Consumption for DCV2 (base)			100,424
kWh Consumption for DCV2 (efficient equip)			20,922
Energy Savings for DCV1 (kWh)			82,491
Energy Savings for DCV2 (kWh)			79,503
Total Energy Savings (kWh)			**161,994**
Base Summer Demand for DCV1 (kW)			11.46
Base Summer Demand for DCV2 (kW)			11.46
Base Summer Demand (kW)			22.93
EE Summer Demand for DCV1 (kW)			2.87
EE Summer Demand for DCV2 (kW)			2.87
EE Summer Demand (kW)			5.73
Total Summer Demand Savings (kW)			**17.20**

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)
161,994	17.20	0	553

During the desk review process, our engineers created a calculator for each project within the sample. The engineer reviewed all available project documentation and looked at 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 and made adjustments, such as setting the baseline to be code compliant; adjusting the variables, such as HOU; or adjusting the efficiencies that we identified throughout the project documentation. Savings calculations ultimately relied on the verified values.

A sub-set of eight sampled projects also received onsite verification. The NMR team only completed site visits at certainty stratum sites. These projects were selected for onsites because

they were larger and more complex projects that would benefit from clarification and additional data gathering. The eight projects that received site visits included a variety of measures, such as lighting, boilers, chillers, motor replacements, comprehensive building commissioning, and steam trap replacements. While onsite, the NMR team verified the installation of the measures and collected information on key input variables for the savings analysis. Some examples of information collected during the site visits included nameplate information from equipment, HOU for HVAC and lighting, and data on the equipment schedules and operation. The evaluation team used this data to confirm the ex ante assumptions or to modify the calculation with site-specific information.

2.4.1.3 Results

The program-wide impact evaluation results for the Custom Retrofit Program are shown in Table 19. The findings that contributed to the realization rates are detailed in the text that follows.

Table 36: Custom Retrofit Program Impact Results

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2018 Electric Savings (MWh)	38,992	97%	37,896	±5% @ 80%
FY2018 Peak Demand Savings (MW)	5.72	99%	5.63	±5% @ 80%
FY2018 Gas Savings (MMBtu)	137,196	102%	140,145	±1% @ 80%

The program-level realization rates are 97% for electric (kWh) savings, 99% for demand savings (kW), and 102% for natural gas savings. The selected sample ultimately achieved ±5% precision at 80% confidence for electric savings, ±5% precision for demand savings, and ±1% precision 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. The evaluation 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.

Of the 32 sampled custom projects, 27 had a total energy (MMBtu) realization rate that was between 90% and 110%. Several project specific deviations are noted below, as well as an observation made for a good number of custom projects that involved modeled lighting savings.

The evaluation team noted one recurring issue in the calculation of gas heating penalties for custom lighting projects. The DCSEU included modeled lighting interactive effects when calculating custom lighting savings. In general, the DCSEU's modeled gas heating penalties were quite large.

For one project where the evaluation team made an adjustment to the gas heating penalty, the claimed penalty would have negated over one-half of the electric savings from the lighting upgrade. In that project, when we converted the electric savings into MMbtu to compare the gas heating penalty as a function of total energy savings, 67% of the energy savings from the lighting measures were negated by the gas heating penalty. In contrast, the evaluation team calculated that 12% of the lighting energy was negated by the gas heating penalty.

The evaluation team did not find this to be a reasonable assumption. The NMR team had all the variables necessary to independently calculate energy savings for these lighting measures and we assigned a significantly smaller gas penalty for this one project, and additional projects that showed similar overstated gas heating penalties for lighting measures. These adjusted projects yielded lower gas heating penalties, which resulted in overall higher program-level gas savings and by extension energy savings.

Additionally, a driving factor for the high realization rate for demand savings was the discrepancy between the DCSEU methodology and our methodology of calculating demand savings. The custom lighting projects included a CF that was appropriate to the building type where the fixtures were installed. However, given that fixture-level information was available, including the HOU and lighting type, we calculated demand savings on a per fixture basis. In contrast, the DCSEU divided the building-level electrical savings from lighting by the deemed HOU and applied a load shape CF that was appropriate at a building level. This led to slightly higher evaluated demand savings values. In addition, several lighting projects contained fixtures that operated 24/7 and therefore should have a CF of 1.0. The DCSEU's assumed CF ranged from 11% to 100%, which was usually too low for these 24/7 fixtures.

The NMR team's verification uncovered five additional project-level errors that resulted in realization rates less than or greater than 100%, as described below.

- The NMR team adjusted the baseline efficiency for a chilled water project. The International Energy Conservation Code (IECC 2012) Path B was deemed more appropriate to use than Path A as this chiller was primarily used for partly loaded conditions and would not have met code minimum under Path A.
- A waste heat factor of 1.107 was applied for a custom lighting project, when the ex ante analysis did not appear to include a WHF. Including the additional savings from interactive effects resulted in a realization rate that exceeded 100%.
- The NMR team found that nominal tonnages were used for four projects rather than AHRI certified tonnages. The evaluation team used the certified tonnage in the ex post calculations, which, on average, reduced the realization rates by a small amount.
- A utility bill regression for one project aligned well for electrical savings, but showed an increase in electric consumption during the peak summer period, which lead to a negative realization rate for demand savings.

2.4.2 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 25 telephone surveys completed with participating Custom Retrofit customers.

2.4.2.1 Free-ridership

Free-ridership was estimated 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

Eight percent of the 25 Custom Retrofit participants reported they would have delayed the measure installation by one year or canceled the installation in the absence of the program (Table 37). These respondents were assigned a low free-ridership intention score (0%).

Another 20% said they would have installed the measure but scaled back the scope or efficiency in the absence of the program, or didn't know. These respondents were assigned a moderate free-ridership intention score (25%).

Seventy-two percent of the 25 respondents reported they would have installed the measure with the exact same scope and efficiency in the absence of the program (Table 37). Most of these respondents (60%) indicated they would have had the funds to cover the entire cost of the measure and were therefore assigned a high free-ridership intention score (50%). Eight percent of respondents said they might have had the funds available and were therefore assigned a moderate-high free-ridership intention score (37.5%). Another 4% of respondents said they would not have had the funds available and were therefore assigned a moderate free-ridership intention score (25%).

Table 37: 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 (%)	Percent of Respondents
• Delayed the installation of the measure for at least one year OR • Cancelled the installation of the measure altogether	• Not Asked	0%	8%
• Installed the measure but scaled back the scope or efficiency OR • Don't know OR • I'd rather not answer	• Not Asked	25%	20%
• 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%	4%
	• Might have had the funds	37.5%	8%
	• Definitely would have had the funds	50%	60%
Number of Respondents			**25**

Influence

Table 38 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 features with the highest average ratings include prior program experience, results of DCSEU audits/studies, and information from DCSEU representatives.

Table 38: Influence of DCSEU program features for Custom Retrofit Program

Features	Number of Respondents*	1 Played no role at all	2	3	4	5 Played a great role	Average Rating
The financial incentive/rebate	25	32%	4%	18%	23%	23%	3.0
Information provided by a DCSEU representative	22	29%	6%	12%	12%	41%	3.3
Results of DCSEU audits or technical studies	15	26%	7%	13%	7%	47%	3.4
Information from contractors or suppliers associated with the program	18	44%	0%	28%	11%	17%	2.6
DCSEU program marketing materials	17	41%	6%	29%	6%	18%	2.5
Previous experience with a DCSEU program	18	22%	0%	11%	22%	45%	3.7

* The total number of respondents excludes those who said “Not applicable” or “I’m not sure.”

Each respondent was assigned a free-ridership influence score based on the *highest* rating they provided for *any* of the above program features. Forty-eight percent of the 25 respondents indicated that at least one program feature played a great role in their decision and were assigned a free-ridership influence score of 0% (Table 39). Another 12% of respondents provided a maximum rating of 4.0 and were assigned a free-ridership influence score of 12.5%. Similarly, 12% gave a maximum rating of 3.0 and were assigned a free-ridership influence score of 25% (Table 39). Twenty-eight percent said all the program features played no role and were assigned a free-ridership influence score of 50%.

Table 39: Free-ridership Influence Scoring for Custom Retrofit Program

Maximum Influence Rating	Assigned Free-ridership Influence Score (%)	Percent of Respondents
5 - program feature played a great role	0%	48%
4	12.5%	12%
3	25%	12%
2	37.5%	0%
1 - program feature played no role OR Not Applicable	50%	28%
Don't know OR Refused	25%	0%
Number of Respondents		**25**

For each respondent, the free-ridership intention score and the free-ridership influence score were summed 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 greatest tracked total energy savings (MMBtu) associated with the project. The average unweighted free-ridership rate was 58%, while the average weighted rate was 56% (Table 40). We also calculated free-ridership rates based on whether the primary measure associated with the project was lighting or non-lighting. Lighting projects had an average weighted free-ridership rate of 71% (based on 11 surveys) while the average weighted rate for non-lighting projects was 52% (based on 14 surveys).

Table 40: Free-ridership Rate for Custom Retrofit Program

	Average	Minimum	Maximum
Free-ridership (unweighted)	58%	0%	100%
Free-ridership (savings-weighted)	56%	0%	100%

2.4.2.2 Participant Spillover

Two participants reported installing energy-efficient or renewable energy equipment at a DC location after their Custom Retrofit project. These installations did not receive an incentive, according to the respondent (Table 41). These respondents indicated their earlier involvement with the DCSEU program had some influence on their decision to install the measures, based on a 1 to 5 scale, where 1 means "no influence at all" and 5 means "great influence."

The respondents reported installing air conditioning controls, an air conditioning system, and an ENERGY STAR refrigerator. In order to calculate the spillover rate for each participant, the average FY2018 energy savings for each measure was multiplied by the reported quantity installed. This figure was then multiplied by the spillover influence score for each respondent and summed across both spillover respondents to calculate the total spillover savings.

Table 41: Spillover Influence Scores for Custom Retrofit Program

Influence Rating	Assigned Influence Score (%)	Spillover Measures	Count of Respondents
Rating of 2 (some influence)	25%	Air conditioning controls	1
Rating of 3	50%	ENERGY STAR Refrigerator; Air conditioning system	1
Rating of 4	75%		0
Rating of 5 (great influence)	100%		0
Respondent does not know how much influence	50%		0

The total spillover savings for the two respondents was then divided by the cumulative tracked savings across all 25 survey respondents to calculate the spillover rate for the program. Table 42 displays the estimated spillover rate for the Custom Retrofit program (1%).

Table 42: Spillover Rate for Custom Retrofit Program

	Average	Minimum	Maximum
Spillover Rate	1%	0%	37%

2.4.2.3 NTG Ratio

The savings-weighted NTG ratio for the Custom Retrofit program equals 45% (Table 43).

Table 43: NTG Ratio for Custom Retrofit Program

	Free-ridership	Spillover	NTG (1 – FR +SO)
Net-to-Gross Ratio	56%	1%	45%

2.4.3 Process Evaluation

For the process evaluation of the Custom Retrofit program, the NMR team sought input from various program stakeholders, including in-depth telephone interviews with program staff and partners, and telephone surveys with program participants (Table 44). The results from these evaluation activities are presented below.

Table 44: Custom Retrofit Process Evaluation Activities

Stakeholder	Completed
Program staff interviews	1
Program partner interviews	4
Participant surveys	25

2.4.3.1 Key Findings

A summary of findings from program staff, partners, and participants is presented below:

- Program partners and participants reported overall satisfaction with the program. Program partners gave an average satisfaction of 4 (on a 5-point scale where 5 is “very satisfied”)

and rated administrative requirements as not difficult. Program participants gave an average satisfaction rating of 4.6 on a scale of 1 to 5, where 5 means "very satisfied."

- Partners reported that program incentives are not high enough to match other programs in the area and serve as a bonus rather than a selling point. However, the majority of participants reported positive satisfaction with the rebate or incentive amount. On a five-point scale, where 1 is "not at all satisfied" and 5 is "very satisfied," participants' average rating was 4.2.
- DCSEU hopes to expand a pay-for-performance pilot to incentivize more complex measures.
- The NPS for the program was 78. Overall, 82% of respondents were *promoters* -- that is, these customers may actively promote the program to other potential participants.
- More than one-half of the 25 participants (56%) said they have plans for energy-efficient or renewable energy improvements in the next two years.

2.4.3.2 Program Staff Interview Results

Program Strengths. Under the Custom Retrofit program, the energy design incentives encourage customers to implement measures that yield more energy savings than they may otherwise. Incentive amounts can also be finetuned to meet the customer's needs. However, the funding amounts are not always substantial enough for customers to engage with DCSEU. To mitigate the effects of this limitation and provide additional value, DCSEU provides non-financial assistance, such as leading customers through best practices in optimization, retro-commissioning, or continuous improvement.

Challenges and Opportunities for Improvement. Challenges include a relatively lengthy approval process; limited staffing capacity relative to the workload; and cost-effectiveness barriers, especially with new technologies. To mitigate the issues related to cost-effectiveness, the DCSEU piloted a pay-for-performance project, which it hopes to expand, to incentivize more complex measures, such as building control systems. It also hopes to increase the number of measures included in the prescriptive tracks.

2.4.3.3 Partner Interview Results

Program Strengths. For the Custom Retrofit program, we interviewed four program partners, including two engineering firms, an energy consultant, and an installer. These partners appreciated the program's ease of use, its flexible approach to energy efficiency, and the ability to work with cutting edge technologies. All four partners anticipated that their program involvement will increase over the next year.

Challenges and Opportunities for Improvement. Drawbacks highlighted by program partners include a lack of customer awareness and incentive amounts that are not considered significant enough to warrant the effort required. Partners noted that with the uncertainty in awarded incentive amounts and the below average incentive levels in general, the incentives serve as a bonus, but not a selling point. This makes it harder to implement projects such as control upgrades, fuel switching, or co-generation. Additionally, program partners pointed out that not all

customers can afford the upfront costs required as the incentives are awarded after project completion.

Program Partners recommended the following actions moving forward:

- Provide a point of contact for program partners. Act as a consultant for them and as someone they can direct customers to.
- Reach out to construction companies about the program rather than building owners.
- Assist in marketing the program to customers and in gathering application form data and filling out application forms.
- Increase incentive levels to at least double the current amounts.
- Offer an upfront incentive for energy savings analysis or modeling to help defray initial scoping costs.

2.4.3.4 Participant Survey Results

Program Awareness

- Roughly one-third of the 25 respondents (32%) learned about the financial incentives or technical assistance available through DCSEU via the DCSEU website. The next most common sources were DCSEU staff or Account Managers (21%) and contractors (18%).
- For 84% of the 25 participants, the individuals they worked with to implement the project informed them that they could receive a DCSEU rebate. Of these respondents, one-half indicated having prior knowledge of the DCSEU rebate before it was mentioned by the individuals they worked with.
- At the time of the survey, 56% of the 25 participants had visited the DCSEU website to look for information on DCSEU financial or technical assistance for an energy-efficiency or renewable energy project. Sixty-three percent of these participants rated the information on the website as “very useful,” with an average rating of 4.4 out of 5.

Program Experience and Satisfaction

- Participants indicated that saving money on energy costs (19%) was their main reason for installing the measures. Reducing operating or maintenance costs (15%), installing more reliable equipment (14%), and saving money on equipment installation/purchase (14%) also drove the installation of measures.
- The most commonly reported benefit was money saved on energy costs (23%), followed by reduced operating or maintenance costs (20%) and money saved on equipment installation/purchase (15%).
- Participants were asked to rate various aspects of their experience with the program (Table 45). On a scale of 1 to 5, where 1 equals “not at all satisfied” and 5 equals “very satisfied,” respondents’ average ratings were all relatively high, ranging between 4.2 and 4.8.

Table 45: Participant Experience with the Custom Retrofit Program

Features	Sample size*	1 Not at all satisfied	2	3	4	5 Very satisfied	Average Rating
The performance of the new equipment	24	0%	0%	0%	12%	88%	4.8
Energy savings from new equipment	24	0%	0%	0%	24%	76%	4.8
The preapproval process	18	0%	0%	6%	11%	83%	4.8
Technical assistance from DCSEU	18	0%	0%	0%	22%	78%	4.8
The type of eligible equipment	21	0%	5%	0%	19%	76%	4.7
Your experience overall	25	4%	0%	0%	20%	76%	4.6
Assistance from contractor	18	0%	0%	11%	28%	61%	4.5
Time to receive the rebate or incentive	24	4%	0%	4%	25%	67%	4.5
The application process	24	5%	0%	0%	41%	54%	4.4
Information about DCSEU offerings	24	5%	0%	0%	43%	52%	4.4
The rebate or incentive amount	25	8%	4%	8%	20%	60%	4.2

* The total number of respondents excludes those who said “Not applicable” or “I’m not sure.”

- Participants rated the ease of completing the application with an average rating of 4.6 out of 5, where 5 means “very easy.”
- Most of the 25 participants (62%) indicated they would not change any aspects of the program. Of those who would like to change the program, the largest portion (10%) would like to increase the rebate level.
- Eighty-one percent of the 25 participants did not face any barriers or hurdles when deciding whether or not to implement the measures through the DCSEU program.
- Participants were also asked to rate the likelihood of recommending the program to others. For this question, respondents used a scale of 0 to 10, where 0 means “extremely unlikely” and 10 means “extremely likely.” This rating, or NPS, is a well-established measure of customer loyalty. With the NPS, 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 program was 78. Overall, 82% of respondents were *promoter*s – that is, these customers may actively promote the program to other potential participants via word of mouth recommendations.

Future Plans

- More than one-half of the 25 participants (56%) said they have plans for energy-efficient or renewable energy improvements in the next two years. Of the 25 participants, 88% indicated they will consider involving DCSEU in their future plans.
- Roughly one-fourth of the 25 respondents (24%) indicated that DCSEU could provide additional input or guidance to assist in meeting their future energy needs, while 20% revealed that current program support levels, including financial incentives, site visits, and technical assistance, are adequate.

2.4.4 Recommendations

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

- The calculation of demand savings was often oversimplified. When sufficient detail is provided in a useable format (i.e. spreadsheet), demand savings should be calculated independently of energy savings for projects that operate 8760 hours per year. Calculating demand requires additional inputs, which the evaluation team understands may not be available and usable for every project.
- As has been noted in previous sections, greater care should be taken to more accurately represent waste heat factor calculations associated with lighting retrofits.
- Code minimums must be met at standard conditions, and adjustments should only be made if the equipment physically cannot be tested at standard conditions, which was not found to be the case for the chiller project.
- Use AHRI values for HVAC efficiency and tonnage rather than nominal tonnages and efficiencies from mechanical plans.
- Adjust the interactive effects for modeled lighting projects. The NMR team believes that the claimed gas heating penalties are too severe and should be reduced.
- Continue promoting the value of the technical assistance offered by the program. Program staff and partners noted that the limited incentives for this program may pose a barrier to participation. However, technical assistance and sharing of best practices provide additional non-financial value to engaging with the DCSEU.

2.5 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, marketing 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 bags 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 FY2018, the program provided incentives for 49 projects. Table 46 provides the breakdown of tracked savings by measure type. The bulk of total energy (MMBtu) and total electrical savings (kWh) 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 46: New Construction Custom Program Savings Contributions

Measure Type	Percent of FY2018 Combined Energy Savings	Percent of FY2018 Electric Savings	Percent of FY2018 Gas Savings	Percent of FY2018 Peak Demand Savings
HVAC	69%	58%	81%	79%
Lighting	17%	35%	<-1%[10]	20%
Motors & Drives	2%	3%	N/A	<1%
Water Heating	11%	2%	20%	<1%
Refrigeration & Appliances	1%	1%	<1%	1%

For the FY2018 New Construction Custom program, we completed the following evaluation activities:

- Gross Savings Verification
- Net Savings Estimation
- Process Evaluation

[10] Tracked percent of gas savings are negative due to the gas heating penalties associated with more efficient lighting. The percentage value is small because the majority of buildings were modeled such that lighting interactive effects were grouped with the HVAC model outputs.

2.5.1 Gross Savings Verification

Table 47 shows the tracked savings, realization rate, and evaluated savings for the program. Overall, the evaluation found the tracked savings to be calculated with a high degree of accuracy. The electric savings realization rate was 100%, the demand savings realization rate was 97%, and the natural gas savings realization rate was 102%.

Table 47: New Construction Custom Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2018 Electric Savings (MWh)	14,743	100%	14,780
FY2018 Peak Demand Savings (MW)	4.04	97%	3.91
FY2018 Gas Savings (MMBtu)	50,130	102%	51,225

2.5.1.1 Sampling

Due to the heterogeneous makeup of the program, the program sample design employed stratified random sampling. The NMR team designed the sampling plan to ensure the evaluation included a diverse mix of measure types – encompassing both lighting and non-lighting measures. We created a certainty stratum, which ensured that we reviewed the largest projects from the program. Projects that had more than 3,000 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 48 presents the final sample for the program.

Table 48: New Construction Custom Sampling Plan

Stratum	Percent of Program Energy Savings	FY2018 Participation	Number of Sampled Sites
Certainty	70%	10	10
Probability	30%	39	4

2.5.1.2 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 majority of new construction projects were modeled using a building simulation software, such as EQuest or OpenStudio. For these types of projects, the NMR team reviewed the model inputs and building systems against available construction and design documents. The HVAC and lighting systems were compared to provided project documentation and were also checked against applicable building codes to confirm that the building systems were more efficient than code minimums by the claimed amount.
- The NMR team used a custom savings calculator to aggregate the savings pulled from building models. For lighting measures that provided detail on individual lighting fixtures, such as HOU, location, and wattages, the savings calculations were created using the calculator. A custom lighting calculator was relied on that used site-specific information on efficient case lighting and code baselines for baseline parameters.

A sub-set of sampled projects also received onsite verification. For the FY2018 evaluation, three projects were selected 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 date of the building construction documents was also confirmed to ensure that the correct code baselines were applied.

The measures for these projects included lighting, space heating, air conditioning, motor efficiency, ventilation, comprehensive hot water conservation, refrigeration, and water flow fixtures.

2.5.1.3 Results

The program-wide impact evaluation results for the program are shown in Table 49. The findings that contributed to deviations in the realization rates are described in the text that follows.

Table 49: New Construction Custom Program Impact Results

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2018 Electric Savings (MWh)	14,743	100%	14,780	±1% @ 80%
FY2018 Peak Demand Savings (MW)	4.04	97%	3.91	±2% @ 80%
FY2018 Gas Savings (MMBtu)	50,130	102%	51,225	±1% @ 80%

The program-level realization rates are 100% for electric (MWh) savings, 97% for demand savings (kW), and 102% for natural gas savings. The selected sample ultimately achieved a ±1% precision at 80% confidence for electric savings, ±2% precision for demand savings, and ±1% 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.

Several scaling adjustments were made by the DCSEU 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 building codes commission in DC deemed it acceptable for the project to be grandfathered on the older building codes. The evaluation 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.

However, the evaluation team found one error regarding the scaling between the 2007 and 2010 versions of the code. Scaling based on total estimated building energy use accounts for increases in required efficiency and the general reduction in energy use due to improved controls. However, it does not properly account for specific measures that were not required in 2007 but were required in 2010.

For example, one of the new construction measures was garage carbon monoxide (CO) monitoring controls. Underground parking garages were not required to have CO sensors installed and used to control the garage ventilation system under ASHRAE 90.1 2007. However, that changed in the 2010 version. Applying the scaling tool reduced the claimed savings slightly for ventilation, but did not completely negate the savings modeled for the garage CO sensors. The evaluation team manually excluded these CO savings after the scaling was done.

All 14 sampled new construction projects had a total energy (MMBtu) realization rate that was between 90% and 110%. 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%, which are detailed below.

- One project appeared to incorrectly record the natural gas savings, which yielded an increased gas savings realization rate. This same project assumed CFs of 1.0 when calculating the demand savings, which led to a reduced realization rate for the peak demand savings when accounting for actual hours of use.
- The NMR team found that the installed wattages used for the new lights in one building model were too high. The savings for this lighting measure were re-calculated using the installed wattages from lighting specifications, which led to an increase in the electric realization rate. This same project used an inflated boiler capacity, which overestimated gas savings. Adjusting the boiler capacity to reflect the mechanical plans yielded a lower natural gas savings realization rate. These two findings mostly negated each other, resulting in a total energy realization rate of 97%.
- One additional project applied a CF of 1.0 to the demand savings, leading to a low demand realization rate once the appropriate standard TRM load shape was applied.

2.5.2 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 six telephone surveys completed with participating New Construction Custom customers.

2.5.2.1 Free-ridership

Free-ridership was estimated 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

One of the six New Construction Custom participants reported they would have delayed the measure installation by one year or canceled the installation in the absence of the program. This respondent was assigned a low free-ridership intention score (0%).

Another respondent said they would have installed the measure but scaled back the scope or efficiency in the absence of the program, or didn't know. This respondent was assigned a moderate free-ridership intention score (25%).

Four of the six respondents reported they would have installed the measure with the exact same scope and efficiency in the absence of the program (Table 50). Three of these four respondents indicated they would have had the funds to cover the entire cost of the measure and were therefore assigned a high free-ridership intention score (50%). One respondent said they might have had the funds available and were therefore assigned a moderate-high free-ridership intention score (37.5%).

Table 50: Free-ridership Intention Scoring for New Construction Custom Program

Intention in the Absence of the Program	Funds Available to Cover the Entire Cost	Assigned Free-ridership Intention Score (%)	Percent 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%	1
• 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%	0
	• Might have had the funds	37.5%	1
	• Definitely would have had the funds	50%	3
Number of Respondents			**6**

Influence

Table 51 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 features with the highest average ratings include the financial incentive, information from DCSEU representatives, and the results of DCSEU audits/studies.

Table 51: Influence of DCSEU program features for New Construction Custom Program

Features	1 Played no role at all	2	3	4	5 Played a great role	Average Rating
The financial incentive/rebate	0	0	1	0	4	4.6
Information provided by a DCSEU representative	1	0	1	1	2	3.6
Results of DCSEU audits or technical studies	1	0	0	0	1	3.0
Information from contractors or suppliers associated with the program	2	0	0	0	1	2.3
DCSEU program marketing materials	2	1	1	0	0	1.8
Previous experience with a DCSEU program	2	0	0	1	0	2.0

Each respondent was assigned a free-ridership influence score based on the *highest* rating they provided for *any* of the above program features. Four of the six respondents indicated that at least one program feature played a great role in their decision and were assigned a free-ridership influence score of 0% (Table 52). Another respondent gave a maximum rating of three and was assigned a free-ridership influence score of 25%. One respondent said all the program features played no role and was assigned a free-ridership influence score of 50%.

Table 52: Free-ridership Influence Scoring for New Construction Custom Program

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

For each respondent, the free-ridership intention score and the free-ridership influence score were summed 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 greatest tracked total energy savings (MMBtu) associated with the project. The average unweighted free-ridership rate was 48%, while the average weighted rate was 61% (Table 53).

Table 53: Free-ridership Rate for New Construction Custom Program

	Average	Minimum	Maximum
Free-ridership (unweighted)	48%	25%	75%
Free-ridership (savings-weighted)	61%	25%	75%

2.5.2.2 Spillover

One participant reported installing energy-efficient or renewable energy equipment at a DC location after their New Construction Custom project. This installation did not receive an incentive according to the respondent (Table 54). This respondent indicated their earlier involvement with the DCSEU program had great influence on their decision to install the measures, based on a 1 to 5 scale, where 1 means "no influence at all" and 5 means "great influence."

This respondent reported installing a solar PV system, which we verified did not receive a DCSEU incentive during FY2018 or so far in FY2019. In order to calculate the spillover rate, we applied the average tracked energy savings for solar PV systems in FY2018. This figure was then multiplied by the spillover influence score to calculate the total spillover savings.

Table 54: Spillover Influence Scores for New Construction Custom Program

Influence Rating	Assigned Influence Score (%)	Spillover Measures	Count of Respondents
Rating of 2 (some influence)	25%		0
Rating of 3	50%		0
Rating of 4	75%		0
Rating of 5 (great influence)	100%	Solar PV System	1
Respondent does not know how much influence	50%		0

The spillover savings for this respondent was then divided by the cumulative tracked savings across all six survey respondents to calculate the spillover rate for the program. Table 55 displays the estimated spillover rate for the New Construction program (7%).

Table 55: Spillover Rate for New Construction Custom Program

	Average	Minimum	Maximum
Spillover Rate	7%	0%	220%

2.5.2.3 NTG Ratio

The savings-weighted NTG ratio for the New Construction program equals 46% (Table 56).

Table 56: NTG Ratio for New Construction Custom Program

	Free-ridership	Spillover	NTG (1 – FR +SO)
Net-to-Gross Ratio	61%	7%	46%

2.5.3 Process Evaluation

The process evaluation for the Commercial New Construction Program included one program staff interview, three program partner interviews, and telephone surveys with six participants. The small number of responses reported below should be interpreted with caution.

Table 57: New Construction Process Evaluation Activities

Stakeholder	Completed
Program staff interviews	1
Program partner interviews	3
Participant surveys	6

2.5.3.1 Key Findings

Below are the key process evaluation results from program staff, partners, and participants:

- The Commercial New Construction Program focuses on cultivating customer relationships and providing support over the long-term.
- Program participants gave an average program satisfaction rating of 4.5 on a scale of 1 to 5, where 1 means “very dissatisfied” and 5 means “very satisfied.”
- Program partners gave the administrative requirements an average rating of 3.0 out of 5 and rated their overall satisfaction with the program as a 3.75 on a scale of 1 to 5, where 5 means “very satisfied.”
- The main program drawback, according to program partners, is low incentive levels relative to other energy-efficiency programs.

2.5.3.2 Program Staff Interview Results

Program Strengths. The Commercial New Construction Program focuses on cultivating relationships and experiences with customers over the long-term. Most projects participating in this program are pursuing LEED certification. DCSEU encourages them to pursue LEED

certification at the gold level rather than silver as the program achieves lower savings levels with LEED silver projects; the minimal effort required is worth the additional savings.

Challenges and Opportunities for Improvement. Program staff noted that the incentives available are not always worth the customer's effort to engage with DCSEU. To supplement the financial incentive, DCSEU provides technical assistance with best practices in optimization and continuous improvement. It may also finetune the financial incentive based on the customer's needs. Moving forward, DCSEU would like to better identify cutting edge technologies in the new construction field and raise program awareness through increased marketing.

2.5.3.3 Partner Interview Results

Program Strengths. For the Commercial New Construction Program, we interviewed three program partners, including two building consultants and a representative from a DC government agency. These partners noted how early involvement in projects by DCSEU can influence design and budget. Partners commented that the program can be innovative and nimble with quality staff who are willing to try new things. They also commented on its popularity with customers who have completed multiple projects because the customers know what to provide DCSEU and the approximate incentive level they will receive.

Challenges and Opportunities for Improvement. Program partners mentioned the following drawbacks to the program:

- Documentation requirements can be cumbersome, and payment is often delayed.
- A lack of up-front funding makes it difficult for low-income projects to participate.
- Customers reported contacting DCSEU and being unable to reach the right contact or never hearing back.

Partner recommendations include offering incentives for energy modeling at the beginning of projects, and for a specific level of commissioning; responding to inquiries within 48 hours; and a prompt review of submitted documentation so that if additional information is needed, the project team has time to collect it. Program partners also stated that providing information on the level of incentive awarded for specific measures or projects would also be beneficial. This can be achieved by alerting energy consultants regarding the level of incentives awarded to projects they contribute to; providing example buildings with sample incentive amounts; and offering a savings range up front, or identifying eligible systems and assemblies, and efficiency tiers to target. Partners noted that a list of required documentation, instead of requesting paperwork on a project by project basis, would also provide clarity for customers.

2.5.3.4 Participant Survey Results

With only six completed participant surveys, we report counts here rather than percentages.

Program Awareness

- Three of six participants indicated learning about the financial incentives or technical assistance available through DCSEU staff or Account Managers. Other options, such as a DCSEU mailing or email; the DCSEU website; DCSEU social media; or a home show, conference, trade show, or fair were each mentioned by only one participant.

- Of the six respondents, three had visited the DCSEU website to look for information on DCSEU financial or technical assistance for an energy-efficiency or renewable energy project at the time of the survey. Using a scale of 1 to 5, where 5 means "very useful," the three participants who had visited the DCSEU website gave the information available on the DCSEU website an average rating of 4.7.

Program Experience and Satisfaction

- For the Commercial New Construction program, four participants identified saving money on energy costs as their main reason for installing the measure through the program. Saving money on equipment installation/purchase and improving the work environment were mentioned by three of the six participants.
- Five of the six participants identified money saved on energy costs as the most realized program benefit. Four of the six participants also noted money saved on equipment installation/purchase, reduced operating or maintenance costs, and the installation of more reliable equipment as additional benefits.
- The survey asked participants to rate different aspects of their experience with the Commercial New Construction Program. Using a scale of 1 to 5, where 1 equals "not at all satisfied" and 5 equals "very satisfied," the six respondents' average ratings ranged between 4.2 and 4.8 (Table 58).

Table 58: Commercial New Construction Participant Experience

Features	1 Not at all satisfied	2	3	4	5 Very satisfied	Average Rating
The preapproval process	0	0	0	1	3	4.8
The performance of the new equipment	0	0	0	1	4	4.8
The application process	0	0	0	1	3	4.8
The type of eligible equipment	0	0	0	2	3	4.6
The rebate or incentive amount	0	0	0	2	3	4.6
Time to receive the rebate or incentive	0	0	1	0	3	4.5
Technical assistance from DCSEU	0	0	0	1	1	4.5
Your experience overall	0	0	0	3	2	4.4
Information about DCSEU offerings	0	0	1	2	2	4.2
Assistance from contractor	0	0	1	2	2	4.2
Energy savings from new equipment	0	0	0	1	3	4.8

- New construction program participants gave the ease of completing the application an average rating of 3.75 out of 5, with 5 being "very easy."
- Five of the six respondents indicated they would not change any aspects of the program.
- Five of the six respondents also noted that they did not face any barriers or hurdles when deciding whether or not to implement the measure through the DCSEU program.
- Participants were also asked to rate the likelihood of recommending the new construction program to others. For this question, respondents used a scale of 0 to 10, where 0 means

"extremely unlikely" and 10 means "extremely likely." This rating, or NPS, is a well-established measure of customer loyalty. With the NPS, 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 program was 50. Overall, 67% of respondents were *promoters* -- that is, these customers may actively promote the program to other potential participants via word of mouth recommendations.

Future Plans

- Three of the six respondents indicated they have plans for energy-efficient or renewable energy improvements in the next two years. One respondent reported not being sure of their future plans.
- Regardless of whether or not they have future plans in place, five of the six respondents revealed they 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 New Construction Custom program:

- Verify that appropriate building specific load shapes are applied to each new construction project.
- Verify the savings claimed in the tracking database match the final version of savings from the building models.
- Cross-check the individual measures claimed within the models to ensure that specific pieces of equipment, such as variable speed drives, controls, or garage CO sensors, so that savings for code required measures are removed after any baseline scaling calculations.
- Improve the communication about projected incentive amounts. Program partners expressed concern regarding lack of information about anticipated incentives. Partners suggested sharing examples of historic incentive awards, offering example buildings with sample incentive amounts, or offering an anticipated savings range. Providing greater clarity regarding anticipated incentives will help reduce confusion about incentive estimates and will garner buy-in early in the process.
- Increase the transparency of DCSEU staff roles and responsibilities. Because partners voiced confusion regarding appropriate staff contacts to answer questions or clarify issues, they would likely benefit from an explanation of staffing structures, including whom to contact for which issues. A solution as simple as an organizational chart would likely assist partners in making appropriate connections with staff. Providing partners with accurate information on which staff to contact for certain issues may also improve response times and partners' experiences with the approval process.

2.6 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 the DCSEU recently signed a contract amendment with DOEE to support. Solar for All 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 nine months 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; it 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 FY2018, the program provided incentives for nine projects and claimed 2,606 MWh of electric savings and 0.62 MW of peak demand reduction.

For the FY2018 Solar PV Market Rate program, we completed the following evaluation activities:

- Gross Savings Verification

- Net Savings Estimation
- Process Evaluation

2.6.1 Gross Savings Verification

Table 59 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. Overall, the evaluation found the tracked savings to be calculated accurately. The electric savings program-level realization rate was found to be 100%, while the demand savings realization rate was 100%.

Table 59: PV Market Rate Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2018 Electric Savings (MWh)	2,606	100%	2,606
FY2018 Peak Demand Savings (MW)	0.62	100%	0.62

2.6.1.1 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 projects from the program. Projects with more than 3,000 MMBtu of total energy savings were assigned to the certainty stratum. The remaining projects were assigned to the probability stratum, from which we drew a random sample (Table 60). Five of the nine projects were selected for review in the FY2018 evaluation.

Table 60: PV Market Rate Sampling Plan

Stratum	Percent of Program Energy Savings	FY2018 Participation	Number of Sampled Sites
Certainty	39%	1	1
Probability	61%	8	4

2.6.1.2 Methodology

The NMR team conducted a desk review for five 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, system losses, and invertor efficiency. Also confirmed the capacity factors matched the project documentation.
- Confirmed the installation date of the solar panels

The NMR team re-created the ex ante calculations using the PV Watts tool developed by NREL[11]. The PV Watts tool relies on several key inputs including:

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

During the site visits, field engineers visually confirmed the estimates for the key inputs to the PV Watts calculation. Additionally, the customer was interviewed regarding planned maintenance or other scheduled periods where the array would be disabled. After completing the onsite visit, engineers developed updated models using PV Watts with information obtained during the site visit.

During the desk review process, our engineers reviewed all available project documentation for consistency. The PV Watts models used by the DCSEU were recreated to ensure they were accurate and consistent with the project documentation.

2.6.1.3 Results

The program-wide impact evaluation results for the program are shown in Table 61. The findings that contributed to the realization rates are detailed in the text that follows.

Table 61: PV Market Rate Program Impact Results

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2018 Electric Savings (MWh)	2,606	100%	2,606	±0% @ 80%
FY2018 Peak Demand Savings (MW)	0.62	100%	0.62	±0% @ 80%

The program-level realization rates are 100% for electric savings and 100% for demand savings. The selected sample ultimately achieved a ±0% precision at 80% confidence for electric savings and ±0% precision for demand savings.

The evaluation team concluded that significant review went into the solar savings calculations. The documentation provided was thorough, and the methods and assumptions used were reliable. The evaluation team has leveraged the PV Watts solar calculation for evaluations in other

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

jurisdictions, and vetted its accuracy and reliability. The tool also projects estimated energy production relative to typical meteorological year (TMY3) data[12], providing the DCSEU with a weather normalized generation estimate.

2.6.2 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 the two telephone surveys completed with participating Solar PV Market Rate customers.

2.6.2.1 Free-ridership

Free-ridership was estimated 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

Both of the Solar PV Market Rate respondents reported they would have delayed the measure installation by one year or canceled the installation in the absence of the program (Table 62). These two respondents were assigned a low free-ridership intention score (0%).

Table 62: 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%	2
• Installed the measure but scaled back the scope or efficiency OR • Don't know OR • I'd rather not answer	• Not Asked	25%	0
• 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%	0
	• Might have had the funds	37.5%	0
	• Definitely would have had the funds	50%	0

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

Influence

Table 63 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. All features received a rating of either 4 or 5.

Table 63: Influence of DCSEU program features for Solar PV Market Rate Program

Features	1 Played no role at all	2	3	4	5 Played a great role	Average Rating
The financial incentive/rebate	0	0	0	0	2	5.00
Information provided by a DCSEU representative	0	0	0	0	2	5.00
Results of DCSEU audits or technical studies	0	0	0	1	1	4.00
Information from contractors or suppliers associated with the program	0	0	0	0	2	5.00
DCSEU program marketing materials	0	0	0	0	2	5.00
Previous experience with a DCSEU program	n/a	n/a	n/a	n/a	n/a	n/a

Each respondent was assigned a free-ridership influence score based on the *highest* rating they provided for *any* of the above program features. Because both respondents indicated that at least one program feature played a great role in their decision, they were each assigned a free-ridership influence score of 0% (Table 64).

Table 64: 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%	2
4	12.5%	0
3	25%	0
2	37.5%	0
1 - program feature played no role OR Not Applicable	50%	0
Don't know OR Refused	25%	0

Both Solar PV Market Rate participants received a free-ridership rate of 0%.

2.6.2.2 NTG Ratio

There was no spillover reported for either of the two Solar PV Market Rate program participants. The savings-weighted NTG ratio for the CI RX program equals 100% (Table 65).

Table 65: NTG Ratio for Solar PV Market Rate Program

	Free-ridership	Spillover	NTG (1 – FR +SO)
Net-to-Gross Ratio	0%	0%	100%

2.6.3 Process Evaluation

The process evaluation for the Solar PV Market Rate program included one program staff interview, one program partner interview, and telephone surveys with two participants. The small number of responses reported below should be interpreted with caution.

Table 66: Solar PV Market Rate Process Evaluation Activities

Stakeholder	Completed
Program staff interviews	1
Program partner interviews	1
Participant surveys	2

2.6.3.1 Key Findings

The NMR team's key process evaluation findings include the following:

- The Solar PV Market Rate program enables partners to work with customers who wouldn't be eligible in a traditional market.
- The typical timeline for a solar project is 12-18 months, which makes it difficult to fit within a given fiscal year.
- The program partner interviewed for this evaluation reported that DCSEU staff are easy to reach and work with.
- The program partner stated that the main challenge with the program is the delay and difficulty in obtaining a formal contract. However, this process has improved over the past six months.
- Both program participants were very satisfied with the program and were likely to recommend the program to others.

2.6.3.2 Program Staff Interview Results

Program Strengths. Thus far, the program has focused on meeting its capacity goals. As custom projects which may contain solar enroll, they are referred to the PVMR program. An initial $/Watt incentive amount is set, which can be tweaked if necessary.

The project pipeline for solar installations builds up roughly nine months in advance, making it difficult to determine which projects that come in will finish during a given fiscal year. With a focus on account management and engagement, the DCSEU often ends up managing projects to meet customers' deadlines rather than internal deadlines.

Challenges and Opportunities for Improvement. Moving forward, the program is expanding its focus with the advent of the Solar for All program. This initiative will enable the solar program to include low-income single-family and community solar work. Through these efforts and its

technical expertise, the Solar PV Market Rate program hopes to establish itself as a one-stop shop for all aspects of solar installations within the District.

2.6.3.3 Partner Interview Results

Program Strengths. The Solar PV Market Rate program enables partners to work with customers who wouldn't be eligible in a traditional market, such as low-income residents and multifamily and residential buildings that don't have grade A credit facilities. The one partner interviewed stated that DCSEU staff are easy to reach and work with.

Challenges and Opportunities for Improvement. The primary drawback mentioned by the program partner was the delay and difficulty in getting a formal contract established. However, they noted this has improved over the last six months as DCSEU has better defined the program, the guidelines, and begun to sign contracts before money is spent on the installation. Another challenge noted by the partner is that caps for the incentive levels seem to be arbitrary and can prohibit the development of more innovative projects.

Solar projects typically take 12-18 months from start to finish. This makes it difficult to fit projects into DCSEU's fiscal year constraints, according to the interviewed program partner. The partner suggested that multi-year programs would remedy this constraint and allow businesses to plan and scale up their team and company. If programs remain annual, the partner stated that the solar program should be up and running at the start of the fiscal year or DCSEU should find a way to remove the risk from subcontractors so they can still get paid if they miss a fiscal year deadline. Now that the DCSEU has a five-year contract, this respondent's perspective may reflect the annual renewals from their previous contract.

Finally, the program partner mentioned that transparency with DCSEU's goals, their progress and their plans for achieving them would enable contractors to plan for potential changes.

2.6.3.4 Participant Survey Results

With only two completed participant surveys, we report counts here rather than percentages.

Program Awareness

- One of the two respondents learned about the program financial incentives and technical assistance via the DCSEU website. The other respondent was not able to recall how they learned about the program.
- On a scale of 1 to 5, where 5 means "very useful," the two participants gave the available information on the DCSEU website an average rating of 4.5.

Program Experience and Satisfaction

- Both participants indicated that saving money on equipment installation/purchase was their main reason for participating in the program.
- Both participants identified money saved on energy costs as a realized program benefit. One of the participants also mentioned the advancement of their long-term strategic energy management plan too.

- Table 67 shows results from a series of questions that asked respondents to rate their satisfaction with various aspects of the program. For all areas, respondents reported that they were "very satisfied."

Table 67: Participant Experience with the Solar PV Market Rate Program

Features	1 Not at all satisfied	2	3	4	5 Very satisfied	Average Rating
Your experience overall	0	0	0	0	2	5.00
The type of eligible equipment	0	0	0	0	2	5.00
The rebate or incentive amount	0	0	0	0	1	5.00
The application process	0	0	0	0	1	5.00
The preapproval process	0	0	0	0	1	5.00
Time to receive the rebate or incentive	0	0	0	0	2	5.00
Assistance from contractor	0	0	0	0	1	5.00
The performance of the new equipment	0	0	0	0	2	5.00
Energy savings from new equipment	0	0	0	0	2	5.00
Information about DCSEU offerings	0	0	0	0	2	5.00
Technical assistance from DCSEU	0	0	0	0	1	5.00

- For the one participant who completed the application, the ease of completing the application was rated as a 5 ("very easy").
- Both respondents revealed that there are no aspects of the program that they would change.
- Neither respondent faced hurdles or barriers when deciding whether or not to implement the measure through the DCSEU program.
- Neither of the respondents encountered any problems with the installation or performance of their solar system or with the contractor who installed it.

Future Plans

- At the time of the survey, one of the two respondents indicated plans for energy-efficient or renewable energy improvements in the next two years. This same respondent reported that they would consider involving DCSEU in their future plans.

2.6.4 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.
- With the expansion of the solar programs, the DCSEU should emphasize its technical expertise and assistance. As an offering within the Commercial Custom and New Construction programs, the Solar program offers distinct technical expertise and

assistance. While financial incentives may be limited, the DCSEU should promote the value of non-financial contributions like technical assistance.

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, Multifamily, and Single-family Residential programs selected for the FY2018 evaluation:

- Retail Lighting
- Retail Smart Thermostats
- 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 FY2018, the Retail Lighting initiative offered rebates for qualifying ENERGY STAR LED lightbulb purchases, including recessed surface or pendant downlights, screw base lamps, and lighting fixtures. 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 FY2018 Retail Lighting program, we completed the following evaluation activity:

- Gross Savings Verification

3.1.1 Gross Savings Verification

Table 68 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 68: Retail Lighting Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2018 Electric Savings (MWh)	19,180	100%	19,197
FY2018 Peak Demand Savings (MW)	2.2	100%	2.2
FY2018 Gas Savings (MMBtu)	-19,266	100%	-19,299

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 254,726 measures that represent 100% of FY2018 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. The slight variations between tracked and evaluated savings estimates in Table 69 are due to rounding errors.

Table 69: Retail Efficient Lighting Savings and Realization Rates by Measure Type

Measure Category	FY2018 Electric Savings (MWh)			FY2018 Peak Demand Savings (MW)			FY2018 Gas Savings (MMBtu)		
	Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated
LED Screw-Base Bulbs	16,908	100%	16,922	1.9	100%	2.0	-17,394	100%	-17,430
LED Lighting Fixtures	945	100%	945	0.1	100%	0.1	-574	100%	-574
LED Recessed Downlights	1,327	100%	1,329	0.1	100%	0.1	-1,298	100%	-1,295
Total	**19,180**	**100%**	**19,197**	**2.2**	**100%**	**2.2**	**-19,266**	**100%**	**-19,299**

3.2 RETAIL SMART THERMOSTATS (7710STAT)

The Retail Smart Thermostats program works to increase sales of advanced thermostats in the District of Columbia. Partnering with retailers and Nest, the DCSEU offers rebates for these technologies installed in DC homes. Smart thermostats expand the benefits of a programmable thermostat, including the ability to regulate HVAC schedules using results from sensors, software algorithms, and/or occupancy sensors.

In FY2018, the Retail Smart Thermostats program worked with retailers to offer residents a $50 rebate on qualifying smart thermostat purchases. The Retail Smart Thermostats rebate program 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.

DCSEU collaborated with Nest to offer instant rebates on thermostats purchased through the Nest website and assisted customers with enrollment in the Seasonal Savings program. This program automatically optimizes temperature controls through Nest thermostats.

For the FY2018 Retail Smart Thermostats program, we completed the following evaluation activities:

- Gross Savings Verification
- Net Savings Estimation
- Process Evaluation

3.2.1 Gross Savings Verification

Table 70 displays the tracked savings, realization rate, and evaluated savings for the two Retail Smart Thermostats initiatives. The evaluation team calculated realization rates of 97% for electric and gas savings and 95% for peak demand savings for the Smart Thermostats Rebate initiative. We calculated realization rates of 33% for electric savings, 1,123% for peak demand savings, and 0% for gas savings for the Seasonal Savings initiative.

Table 70: Retail Smart Thermostats Savings and Realization Rates by Initiative

Savings Type	Smart Thermostat Rebates			Seasonal Savings		
	Tracked Savings	Realization Rate	Evaluated Savings	Tracked Savings	Realization Rate	Evaluated Savings
FY2018 Electric Savings (MWh)	589	97%	570	1,182	33%	385
FY2018 Peak Demand Savings (MW)	0.19	95%	0.18	0.02	1,123%	0.2
FY2018 Gas Savings (MMBtu)	4,637	97%	4,513	10,934	0%	0

Table 71 displays the tracked savings, realization rate, and evaluated savings for the overall Retail Smart Thermostats program. We calculated overall realization rates of 54% for electric savings, 200% for peak demand savings, and 29% for gas savings.

Table 71: Overall Retail Smart Thermostats Savings and Realization Rates

Savings Type	Overall Program		
	Tracked Savings	Realization Rate	Evaluated Savings
FY2018 Electric Savings (MWh)	1,771	54%	955
FY2018 Peak Demand Savings (MW)	0.2	200%	0.4
FY2018 Gas Savings (MMBtu)	15,571	29%	4,513

3.2.1.1 Smart Thermostat Rebate Initiative

In this section we describe the evaluation of the Smart Thermostats Rebate initiative.

Methodology

For the Smart Thermostats Rebate initiative, we reviewed rebate forms, invoices, and summary files to verify that the quantities, home type (single- or multifamily), and heating and cooling types indicated on these documents matched those listed in the tracking database. In addition, we verified that the savings algorithms from the TRM were applied correctly for 70 sampled measures that represent 3% of FY2018 Smart Thermostat Rebate energy savings.

Sampling Plan

We completed 70 randomly selected desk reviews for the Retail Smart Thermostats Rebate initiative.

Results

- The evaluation team found that the home, heating, and/or cooling types indicated on the rebate forms aligned with the item codes in the tracking database for all but four of 70 thermostats.
- We noticed that the item code labels in the TRM did not align with the item code labels in the program tracking database. Once we verified with DCSEU which labels were correct, we determined that the tracked savings for advanced thermostats were calculated in accordance with the algorithm and inputs presented in the TRM.
- There are two reasons why the realization rates we calculated for the Smart Thermostat Rebate program differ from 100%:
  - Sixty-seven of the 70 surveyed Retail Smart Thermostats program participants reported that their thermostats were installed. Two of these three respondents had never installed the thermostat and, based on their verbatim comments, did not intend to in the future. One respondent reported removing their thermostat. Based on these results, we applied an in-service rate of 96%.[13]

[13] The TRM algorithm for advanced thermostats does not contain an ISR variable.

- We recategorized the home, heating, and/or cooling type for four sites where the types listed on the rebate form did not align with the item codes in the tracking database.

Table 72: Retail Smart Thermostat Rebate Savings and Realization Rates by Measure Type

Measure Category	FY2018 Electric Savings (MWh)			FY2018 Peak Demand Savings (MW)			FY2018 Gas Savings (MMBtu)		
	Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated
SF - Electric Heat, AC	267	96%	256	<0.1	94%	<0.1	-	-	-
SF - Gas Heat, AC	177	97%	172	0.1	95%	0.1	3,822	97%	3,720
SF - Gas Heat, no AC	1	100%	1	-	-	-	59	100%	59
SF - Unknown Heat & Cool	5	105%	6	<0.1	106%	<0.1	44	107%	47
SF - AC Only	5	96%	4	<0.1	94%	<0.1	-	-	-
SF - Electric Heat, no AC	2	100%	2	-	-	-	-	-	-
MF - Electric Heat, AC	102	98%	100	<0.1	95%	<0.1	-	-	-
MF - Gas Heat, AC	21	96%	21	<0.1	99%	<0.1	461	96%	444
MF - Gas Heat, no AC	2	96%	2	-	-	-	214	96%	206
MF - Unknown Heat & Cool	4	96%	4	<0.1	100%	<0.1	38	97%	37
MF - Electric Heat, no AC	1	100%	1	1	100%	1	-	-	-
MF - AC Only	1	100%	1	<0.1	100%	<0.1	-	-	-
Total	**589**	**97%**	**570**	**0.2**	**95%**	**0.2**	**4,637**	**97%**	**4,513**

3.2.1.2 Seasonal Savings Initiative

For the Seasonal Savings initiative, we verified gross savings. The Seasonal Savings initiative is a thermostat optimization measure offered by Nest Labs that delivers energy and peak demand savings by offering existing Nest owners the opportunity to implement more conservative thermostat setpoints for a season. The initiative operates by making small, incremental adjustments to participant's heating or cooling schedules through their Nest thermostats. The initiative provides impacts that are above and beyond the expected savings from the initial installation of the smart thermostat.

For DCSEU, the program was implemented in summer 2017 and summer 2018. For analysis purposes, the program randomly split users into an intention-to-treat (ITT) group and a control group. This randomization allows for "difference in difference" modeling to compare how changes in the ITT group compare to changes in the control group over time. A summary of these results is provided in Table 73.

- The electric energy realization rate is 33% because claimed savings were based on a savings rate from the winter season rather than summer as well as a high connected load assumption.
- The peak demand realization rate is 1,123%, largely due to a faulty air conditioning CF assumption in the DCSEU TRM measure characterization.[14]
- The natural gas realization rate is 0% because the program did not operate during the winter season.

Table 73: FY2018 Seasonal Savings Results Summary

Savings Type	Tracked Savings	Realization Rate	Verified Gross Savings
FY2018 Electric Savings (MWh)	1,182	33%	385
FY2018 Peak Demand Savings (MW)	0.02	1,123%	0.2
FY2018 Gas Savings (MMBtu)	10,934	0%	0

The full description of the seasonal savings analysis is provided in Appendix C.

3.2.2 Net Savings Estimation

The NMR team calculated the NTG ratio, which is composed of free-ridership and participant spillover, for the Smart Thermostat Rebate initiative. We estimated free-ridership and participant spillover based on question responses from the 70 telephone surveys completed with participating customers.

[14] The DCSEU TRM assumes a 66% CF for residential air conditioning. The Seasonal Savings measure uses an annual characterization of 4% rather than a summer specific value. This results in a significant underestimate of the summer Seasonal Savings peak demand.

3.2.2.1 Free-ridership

Free-ridership was estimated 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

Forty-four percent of the 70 Smart Thermostat Rebate respondents reported they would have delayed the purchase of the thermostat by one year or canceled the purchase altogether in the absence of the program rebate (Table 74). These respondents were assigned a low free-ridership intention score of 0%.

Another 7% said they would have purchased a different thermostat in the absence of the program, or didn't know. These respondents were assigned a moderate free-ridership intention score of 25%.

About one-half of the 70 respondents (49%) reported they would have purchased the same thermostat in the absence of the program (Table 74). Most of these respondents (43%) indicated they would have had the funds to cover the entire cost and were therefore assigned a high free-ridership intention score of 50%. Six percent of respondents said they might have had the funds available and were therefore assigned a moderate-high free-ridership intention score of 37.5%.

Table 74: Free-ridership Intention Scoring for Retail Smart Thermostat Rebates

Intention in the Absence of the Program	Funds Available to Cover the Entire Cost	Assigned Free-ridership Intention Score (%)	Percent of Respondents
• Delayed the purchase of the thermostat for at least one year OR • Cancelled the purchase of the thermostat altogether	• Not Asked	0%	44%
• Purchased a different thermostat instead OR • Don't know OR • I'd rather not answer	• Not Asked	25%	7%
• Purchased the same thermostat anyway	• Definitely would not have had the funds OR • Don't know OR • I'd rather not answer	25%	0%
	• Might have had the funds	37.5%	6%
	• Definitely would have had the funds	50%	43%
Number of Respondents			**70**

Influence

Table 75 displays the influence rating of various program features on participants decision to install the smart thermostat, using a 1 to 5 scale, where 1 means it played no role at all and 5 means it played a great role. The feature with the highest average ratings was the rebate.

Table 75: Influence of DCSEU program features for Retail Smart Thermostat Rebates

Features	Number of Respondents*	1 Played no role at all	2	3	4	5 Played a great role	Average Rating
The financial incentive/rebate	69	12%	4%	4%	22%	58%	4.1
Information provided by a DCSEU representative	64	40%	5%	16%	19%	20%	2.7
Previous experience with a DCSEU program	61	70%	3%	5%	7%	15%	1.9

* The total number of respondents excludes those who said "Not applicable" or "I'm not sure."

Each respondent was assigned a free-ridership influence score based on the *highest* rating they provided for *any* of the above program features. Sixty-one percent of the 70 respondents indicated that at least one program feature played a great role in their decision and were assigned a free-ridership influence score of 0% (Table 76). Another 23% of respondents provide a maximum rating of 4.0 and were assigned a free-ridership influence score of 12.5%. Seven percent gave a maximum rating of only 1.0 and were therefore assigned a free-ridership influence score of 50%.

Table 76: Free-ridership Influence Scoring for Retail Smart Thermostat Rebates

Maximum Influence Rating	Assigned Free-ridership Influence Score (%)	Percent of Respondents
5 - program feature played a great role	0%	61%
4	12.5%	23%
3	25%	4%
2	37.5%	3%
1 - program feature played no role OR Not Applicable	50%	7%
Don't know OR Refused	25%	2%
Number of Respondents		**70**

For each respondent, the free-ridership intention score and the free-ridership influence score were summed 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 tracked total energy

savings (MMBtu) for each respondent. The average unweighted free-ridership rate was 34% while the average weighted rate was 33% (Table 77).

Table 77: Free-ridership Rate for Retail Smart Thermostat Rebates

	Average	Minimum	Maximum
Free-ridership (unweighted)	34%	0%	100%
Free-ridership (savings-weighted)	33%	0%	100%

3.2.2.2 Spillover

Four participants reported installing energy-efficient or renewable energy equipment at a DC location that did not receive an incentive after their smart thermostat purchase. These four respondents reported installing LEDs. They indicated their earlier involvement with the Smart Thermostat program had some influence on their decision to install the equipment based on a 1 to 5 scale, where 1 means "no influence at all" and 5 means "great influence" (Table 78).

In order to calculate the spillover rate for each participant, the average FY2018 energy savings for LEDs was multiplied by the quantity purchased. This figure was then multiplied by the spillover influence score for each respondent and summed across all four spillover respondents to calculate the total spillover savings.

Table 78: Spillover Influence Scores for Retail Smart Thermostat Rebates

Influence Rating	Assigned Influence Score (%)	Spillover Measures	Count of Respondents
Rating of 2 (some influence)	25%	LED	1
Rating of 3	50%	LED	1
Rating of 4	75%	LED	2
Rating of 5 (great influence)	100%		0
Respondent does not know how much influence	50%		0

The total spillover savings for the four respondents was then divided by the cumulative tracked savings across all 70 survey respondents to calculate the spillover rate for the program. Table 79 displays the estimated spillover rate for the Smart Thermostat Rebate initiative (2%).

Table 79: Spillover Rate for Retail Smart Thermostat Rebates

	Average	Minimum	Maximum
Spillover Rate	2%	0%	7%

3.2.2.3 NTG Ratio

The savings-weighted NTG ratio for the Smart Thermostat rebate program equals 69% (Table 80).

Table 80: NTG Ratio for Retail Smart Thermostat Rebates

	Free-ridership	Spillover	NTG (1 – FR +SO)
Net-to-Gross Ratio	33%	2%	69%

3.2.3 Process Evaluation

For the Smart Thermostats program process evaluation, the NMR team interviewed DCSEU staff and conducted 70 telephone surveys with program participants in order to assess the strengths, challenges and opportunities for improvement. The NMR team attempted to contact three participating retailers, however none responded to our repeated requests. This section, therefore, does not include a perspective from program partners.

Table 81: Smart Thermostat Process Evaluation Activities

Stakeholder	Completed
Program staff interviews	1
Participant surveys	70

3.2.3.1 Key Findings

Below are the main findings from the process evaluation.

- The largest barrier mentioned by program staff was a lack of awareness by consumers, retailers and contractors.
- The majority of participants (88%) were very satisfied with their overall program experience.
- When asked what, if anything, they would change about the smart thermostat rebate program, respondents most commonly mentioned that the program should increase the rebate amount and enhance advertising.
- Using a scale from 1 to 5, where 5 means “very easy,” participants gave the ease of using the thermostat relatively high average ratings (ranging between 4.1 and 5.0).
- The NPS for the thermostat program was 80. Overall, 86% of 70 respondents were *promoters* -- that is, these customers may actively promote the program to other potential participants.

3.2.3.2 Program Staff Interview Results

The smart thermostat program benefits from its collaboration with manufacturers through the Nest online point of sale rebate and its coordinated promotional campaigns with retail partners, which includes thermostats from other manufacturers. These efforts strive to overcome consumers’, retailers’ and contractors’ lack of awareness regarding the availability and benefits of smart thermostat technology. Moving forward, the program hopes to build upon and expand its

collaborations with manufacturers. Program staff reported that they also are exploring the implementation of a grace period, so that applications received after the fiscal year deadline may still receive a rebate. Currently, funds can only be awarded for installations within the same fiscal year.

3.2.3.3 Participant Survey Results

Program Awareness

- Participants were asked to report how they heard about the smart thermostat rebate, and the respondents most commonly referenced the Nest thermostat website (28%). Other frequently mentioned sources included a colleague, family member or friend (21%) and the DCSEU website (17%).
- Roughly one-half of the 70 respondents (51%) reported that they had visited the DCSEU website at the time of the survey. Most participants who reported visiting the DCSEU's website rated the information on the DCSEU's energy savings programs as useful. On a scale of 1 to 5, where 1 means "not at all useful" and 5 means "very useful," 87% of the 70 respondents gave a 4 or 5 rating, and the average rating was 4.4.[15] Three participants expressed the desire for more relevant and organized information on energy-saving programs when the participants were given an opportunity to offer suggestions.

Installation Verification

- At the time of the survey, the vast majority of the 70 respondents (96%) confirmed that the rebated thermostat was installed. Of the three respondents who did not confirm installation, two mentioned the thermostat was never installed.
- Most respondents installed the thermostat themselves (59%) or had a contractor (24%) or someone else in the household (12%) handle the installation.
- Overall, participants generally found the installation to be an easy process. On a scale of 1 to 5, where 1 means "very difficult" and 5 means "very easy," 69% of the 70 respondents gave a 4 or 5 rating, and the average rating was 4.1.

Program Experience and Satisfaction

- Participants' main reasons for purchasing the thermostat were to use technology to moderate their household temperature (37%), save energy (23%), save money on their bills (15%), and improve their home's comfort (16%).
- Participants reported positive experiences with the smart thermostat. On a scale of 1 to 5, where 1 means "very difficult" and 5 means "very easy," average ratings were relatively high (ranging between 4.1 and 5.0; Table 82). One respondent did note experiencing difficulties downloading and familiarizing with the app.

[15] This excludes 10% of respondents who said "Don't know/I'm not sure."

Table 82: Experience with Thermostat Features

Feature	Number of Respondents*	1 Very Difficult	2	3	4	5 Very Easy	Average Rating
Using the online or app interface	64	0%	2%	3%	19%	77%	4.7
Using the interface on the device itself	65	0%	0%	2%	26%	72%	4.7
Adjusting the temperature	66	0%	0%	0%	5%	96%	5.0
Adjusting the schedule	59	2%	3%	19%	34%	42%	4.1

* The total number of respondents excludes those who said "Not applicable" or "I'm not sure."

- Participants most commonly reported adjusting settings or using features on their thermostat a few times per week (35%). Participants who interacted with their thermostat multiple times each day or about once each day made up the next largest group of respondents (20% and 18%, respectively). About a quarter of those surveyed (24%) stated that they interacted with the thermostat less frequently, and only 3% indicated that they had not adjusted or used any feature on their thermostat.
- Participants were asked to rate the usefulness of various thermostat features using a scale of 1 to 5, where 1 means "not at all useful" and 5 means "very useful." The thermostat feature with the highest average usefulness rating was adjusting settings using a smartphone, at 4.8 out of 5. The auto-schedule feature had the lowest usefulness rating, with an average rating of 3.9 out of 5.

Table 83:Usefulness of Thermostat Features

How useful is the following feature or function of your thermostat?	Number of Respondents*	Not Applicable/ Don't know	1 Not at all Useful	2	3	4	5 Very Useful	Average Rating
Adjusting settings with your smart phone	64	5%	0%	0%	3%	10%	87%	4.8
Using the home/away feature	64	13%	4%	5%	7%	13%	71%	4.4
Adjusting settings online	64	25%	0%	4%	17%	17%	63%	4.4
Viewing your energy history	64	20%	2%	8%	22%	20%	49%	4.1
Programming a custom schedule for every day of the week with as many set points as you want	64	20%	2%	8%	22%	22%	47%	4.0
Using autoschedule	64	23%	6%	10%	16%	25%	43%	3.9

* The total number of respondents excludes those who said "Not applicable" or "I'm not sure."

- Participants were asked to rate various aspects of their experience with the Retail Smart Thermostat program. On a scale of 1 to 5, where 1 equals "not at all satisfied" and 5 equals "very satisfied," respondents' average ratings ranged between 4.1 and 4.8 (Table 84).

Table 84: Participant Experience with the Retail Smart Thermostat Program

Features	Number of Respondents*	1 Not at all satisfied	2	3	4	5 Very satisfied	Average Rating
The rebate or incentive amount	68	1%	2%	4%	6%	87%	4.8
Your experience overall	68	3%	0%	6%	3%	88%	4.7
The information about eligible thermostats on the DCSEU website	43	0%	0%	7%	19%	74%	4.7
The performance of the thermostat	66	0%	2%	6%	20%	72%	4.6
The variety of eligible thermostats	40	5%	2%	13%	5%	75%	4.4
The application process	14	7%	0%	15%	14%	64%	4.3
Time to receive the rebate	15	0%	8%	23%	0%	69%	4.3
The energy savings from the thermostat	50	4%	2%	14%	38%	42%	4.1

* The total number of respondents excludes those who said "Not applicable" or "I'm not sure."

- When asked what, if anything, they would change about the smart thermostat rebate program, respondents most commonly mentioned that the program should increase the rebate amount (16%) and increase advertising (13%).
- Participants were also asked to rate the likelihood of recommending the smart thermostat program to others. For this question, respondents used a scale of 0 to 10, where 0 means "extremely unlikely" and 10 means "extremely likely." This rating, or NPS, is a well-established measure of customer loyalty. With the NPS, 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 thermostat program was 80. Overall, 86% of 70 respondents were *promoters* -- that is, these customers may actively promote the program to other potential participants by word of mouth. As noted above, the fact that one-fifth of respondents reported learning about the program through a colleague, family member or friend suggests that the program is indeed getting considerable free advertising from past participants.

Energy-Saving Behaviors

- The survey asked respondents if they recalled receiving information on how to save energy in their home when they received their smart thermostat. Thirty-eight percent of the 70 respondents reported receiving information and 37% said that they had not. An additional 24% reported they were not sure whether or not they had received any information.
- Of the 27 respondents who could recall receiving the energy saving recommendations, the most commonly noted recommendations included lowering the temperature (8%) and using the eco setting on the thermostat (6%).
- More than one-half of the 27 respondents who recalled the energy saving information (59%) revealed they had adopted some of the energy saving recommendations. Of these 16 respondents who adopted some of the energy saving recommendations, four noted becoming more aware of their energy use.

3.2.4 Recommendations

Based on the findings of our analysis, we offer the following recommendations for the Smart Thermostat Rebate initiative:

- Ensure the item code labels align between the tracking database and the TRM.
- Incorporate an in-service rate of 96% into the TRM algorithm to more accurately represent the savings from installed measures.
- Continue to promote the smart thermostats' distinct characteristics in marketing and educational materials. The majority of participants reported positive experiences with their smart thermostat and provided high ratings for its different features. Marketing and educational materials should provide equal if not more emphasis on addressing concerns related to ease of use as on reducing costs.

We offer the following recommendations for the Seasonal Savings initiative:

- The TRM assumptions for Seasonal Savings are reasonable for the most part, but they need to be applied carefully. The treatment is season specific and summer Seasonal Savings program impacts cannot be applied outside of the summer season. A separate tracking record should be created for each season as the opt-in counts for a summer and winter deployment will not be the same. The year-round TRM characterization was the primary driver of large variance between the reported and verified savings. Season-specific TRM characterizations and participant counts should always be used.
- The allocation of devices to the ITT and control groups was a bit unbalanced (86% ITT and 14% 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.

- The TRM assumption of 3.5% cooling savings was taken from a Massachusetts evaluation of Seasonal Savings during the winter season. Based on the evaluated findings from 2018, the 3.5% assumption appears to be overstated, as the NMR team's estimate is 2.16% savings for the opt-in devices. Other evaluations[16] of Seasonal Savings have found larger percent reductions for winter than summer.
- Model specification is important when the control group and effect are small. If DCSEU plans to continue offering Seasonal Savings, we should consider selecting the model a priori to eliminate any opportunity or perception of cherry picking. With a common model specification and connected load assumptions, we expect the Nest results would be very well-aligned with the evaluated savings.
- The first two weeks of October 2018 were relatively warm so it is likely that many DC homes were still operating a cooling schedule. Nest only provided data through September 30th for analysis so it's possible the evaluated savings exclude a small amount of October energy savings that occurred in FY2019. For future analyses of the summer season, we recommend including data through October 15th if warm weather persists beyond September 30th. While the September 30th cutoff may be a function of the DCSEU fiscal year definition, Seasonal Savings is different from other measures in that program savings are econometrically measured and the program only operates during specific dates. For typical energy-efficiency measures, installation date is irrelevant for annual savings calculations. For example, an LED installed on October 1 is assigned the same kWh savings as an LED installed on September 30, despite the fact that almost none of the savings from the September 30 installation occur within the fiscal year.
- If the Seasonal Savings program will be continued, DCSEU should consider a reporting cadence that makes sense with regards to fiscal years. The summer season is challenging because the fiscal year ends on September 30. If Seasonal Savings is offered in summer 2019, should the savings be recorded in FY2019 or FY2020? We would recommend aligning the savings claims with the same fiscal year the Nest fees are incurred.

3.3 INCOME QUALIFIED EFFICIENCY FUND (7610IQEF)

In FY2018 DCSEU launched a new program to better serve low-to-moderate income residents. 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 24 energy-efficiency projects were funded at DC multifamily properties, shelters, or clinics in FY2018.[17]

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

[17] "2018 Annual Report." DC Sustainable Energy Utility, https://doee.dc.gov/sites/default/files/dc/sites/ddoe/publication/attachments/DCSEU%20Annual%20Report%20%E2%80%93%202018.pdf

For the FY2018 Income Qualified Efficiency Fund program, we completed the following evaluation activity:

- Gross Savings Verification

3.3.1 Gross Savings Verification

Table 85 displays the tracked savings, realization rates, evaluated savings, and sample precisions for the Income Qualified Efficiency Fund program.

Table 85: Income Qualified Efficiency Fund Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2018 Electric Savings (MWh)	1,330	100%	1,330	±1% @ 80%
FY2018 Peak Demand Savings (MW)	0.11	100%	0.11	±1% @ 80%
FY2018 Gas Savings (MMBtu)	-31	100%	-31	±1% @ 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. In addition, we conducted measure reviews 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.

3.3.1.2 Sampling Plan

We conducted desk reviews for the eight projects with the most energy savings. For the Income Qualified Efficiency Fund program, the top eight sites represented about 79% of the tracked energy savings from all 24 projects that participated in the program in FY2018.

3.3.1.3 Results

Lighting

- All of the lighting measures achieved electric, demand, and gas savings realization rates of 100%.

Thermostats

- Advanced thermostats achieved an electric and gas savings realization rate of 100%. The peak demand savings realization rate of 103% is the result of a rounding error amplified by the considerable number of measures installed through this program.
- This program included one sampled project with programmable thermostats, which produced an electric savings realization rate of 100% and a gas savings realization rate of 100%. No demand savings were recorded because the TRM instructs that savings for

this measure are only derived from the reduction in heating load for fossil fuel fired heating systems.

Cooling

- The cooling savings for this program come from a unitary air conditioning system installed at one sampled project. Electric and demand savings realization rates of 100% were achieved.

Boilers/Furnaces

- One sampled project included 38 high efficiency gas furnaces. We calculated savings using project-specific capacity and AFUE values, resulting in a gas savings realization rate of 100%.

Table 86: Income Qualified Efficiency Fund Savings and Realization Rates by Measure Type

Measure Category	FY2018 Electric Savings (MWh)			FY2018 Peak Demand Savings (MW)			FY2018 Gas Savings (MMBtu)		
	Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated
Outdoor LED Fixtures	414	100%	414	<0.1	100%	<0.1	-6	100%	-6
Linear LEDs	290	100%	290	<0.1	100%	<0.1	-134	100%	-134
Downlight LEDs	195	100%	195	<0.1	100%	<0.1	-98	100%	-98
Screw Base LEDs	179	100%	179	<0.1	100%	<0.1	-139	100%	-139
Indoor LED Fixtures	98	100%	98	<0.1	100%	<0.1	-26	100%	-26
LED Pin-based CFL Replacements	92	100%	92	<0.1	100%	<0.1	-46	100%	-46
Thermostats	53	100%	53	<0.1	103%	<0.1	62	100%	62
Cooling	4	100%	4	<0.1	100%	<0.1	-	-	-
LED HID Replacements	4	100%	4	<0.1	100%	<0.1	-	-	-
Occupancy Sensors	2	100%	2	<0.1	100%	<0.1	-	-	-
Furnaces	-	-	-	-	-	-	287	100%	287
Water Heating	-	-	-	-	-	-	70	100%	70
Total	**1,330**	**100%**	**1,330**	**0.1**	**100%**	**0.1**	**-31**	**100%**	**-31**

3.4 LOW-INCOME MULTIFAMILY COMPREHENSIVE (7612LICP)

The Low-Income Multifamily Comprehensive (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. The NMR team evaluated a sample of projects and chose specific energy conservation measures (ECM) for review. In FY2018, 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.

For the FY2018 Low-income Multifamily Comprehensive program, we completed the following evaluation activity:

- Gross Savings Verification

3.4.1 Gross Savings Verification

Table 87 displays the tracked savings, realization rates, evaluated savings and sample precisions for the Low-Income Multifamily Comprehensive program.

Table 87: Low-income Multifamily Comprehensive Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2018 Electric Savings (MWh)	2,968	98%	2,902	±11% @ 80%
FY2018 Peak Demand Savings (MW)	0.53	102%	0.54	±3% @ 80%
FY2018 Gas Savings (MMBtu)	4,307	108%	4,668	±10% @ 80%

3.4.1.1 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. In addition, we conducted measure reviews for ten 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.

3.4.1.2 Sampling Plan

We conducted desk reviews for the ten projects with the most energy savings. For the Low-Income Multifamily Comprehensive program, the top ten sites represented about 86% of the tracked energy savings from all 25 projects that participated in the program in FY2018.

3.4.1.3 Results

Lighting

For the lighting measures as a whole, the electric realization rate equals 96%, the demand realization rate equals 100%, and the gas realization rate equals 38%.

- We calculated electric, demand, and gas realization rates of 100% for most lighting measures, including the following:
  - custom lighting efficiency
  - LED wall-mount area fixtures
  - surface and suspended linear led fixtures
  - parking garage/canopy LED fixtures
  - exterior lighting power density reduction
  - outdoor bollard LEDs
  - wall wash LED fixtures
- Screw base LEDs were installed in three sampled projects. The peak demand realization rate among these three projects is 100%. We calculated an electric savings realization rate of 67% based on 1) the application of a waste heat factor to account for reduced waste heat for two projects with electric heat pump heating and 2) the reduction in HOU for LEDs installed in residents' closets from 3.2 hours per day to 0.6 hours per day at one project. The 0.6 hours per day estimate comes from the Pennsylvania TRM.[18] We reviewed TRMs for areas near DC and selected the Pennsylvania TRM estimate because it is the only one we found specifically for residential closets. We calculated a gas savings realization rate of 19% because 1) there is no gas heating penalty at the two projects with electric heat pump heating and 2) we reduced the HOU for LEDs installed in residents' closets at the third sampled project.
- The electric realization rate for LED surface or pendant downlights is 91% because we applied a waste heat factor to account for reduced waste heat for two projects with electric heat pump heating. We calculated a demand realization rate of 101%, which we attribute to a slight underestimate of demand savings in the tracking database. The gas realization rate is 100%.
- The recessed LED surface or pendant downlight measure achieved a demand realization rate of 100%. One project in which recessed downlight LEDs were installed had been coded as having gas heat when in fact it has electric heat pump heat. The electric realization rate is 87% because we applied a waste heat factor to account for reduced electric waste heat. Similarly, the gas realization rate is 53% because we removed the gas heating penalty from this project.
- We sampled one project with interior lighting power density reduction. The electric and demand savings realization rates are 100%. The gas realization rate is 0% because we removed the gas heating penalty upon verifying that the project has electric heating rather than gas heating.
- The occupancy sensor achieved a demand realization rate of 100%. The electric realization rate is 92% because we applied a waste heat factor to account for reduced

[18] Pennsylvania Public Utility Commission. Technical Reference Manual. June 2016. Available online: http://www.puc.state.pa.us/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx

lighting waste heat for a project that had been coded as having gas heat when in fact it has electric heat pump heat. Similarly, the gas realization rate is 0% because we removed the gas heating penalty from this project.

Solar PV

- Solar PV was installed at one project. The DCSEU calculated demand savings for this measure but did not record any peak demand savings in the tracking database. The addition of the peak demand savings from this measure explains why the program-level peak demand realization rate is greater than 100%.

Other Measures

- We reviewed a number of other measures and found realization rates of 100% in all instances. These measure categories include the following:
  - Heating
  - Cooling
  - Low flow water fixtures
  - Heat pumps
  - Appliances
  - Variable frequency drives
  - Water heating
  - Ventilation
  - Thermostats
  - Others

Table 88: Low-income Multifamily Comprehensive Savings and Realization Rates by Measure Type

Measure Category	FY2018 Electric Savings (MWh)			FY2018 Peak Demand Savings (MW)			FY2018 Gas Savings (MMBtu)		
	Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated
Lighting	1,463	96%	1,408	0.1	100%	0.1	-585	38%	-224
Heating	-145	100%	-145	-	-	-	3,320	100%	3,321
Cooling	678	100%	678	0.3	100%	0.3	6	100%	6
Low Flow Water Fixtures	124	100%	124	<0.1	100%	<0.1	1,275	100%	1,274
Heat Pumps	414	100%	413	0.1	100%	0.1	-	-	-
Solar PV	145	100%	145	-	n/a[19]	<0.1	-	-	-
Appliances	125	100%	125	<0.1	100%	<0.1	-2	100%	-2
Variable Frequency Drive	124	100%	124	<0.1	100%	<0.1	-	-	-
Water Heating	30	100%	30	<0.1	100%	<0.1	262	100%	262
Ventilation	42	100%	42	<0.1	100%	<0.1	-28	100%	-28
Thermostats	1	100%	1	-	-	-	58	100%	58
Others	-32	100%	-32	-	-	-	-	100%	-
Total	**2,968**	**98%**	**2,913**	**0.5**	**102%**	**0.5**	**4,307**	**108%**	**4,668**

[19] Zero peak demand savings were recorded in the tracking database for this solar PV measure. However, eight kilowatts of peak demand savings can be attributed to it. No realization rate is presented because seven is not divisible by zero.

3.4.1.4 Recommendations

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

- Confirm that heating fuel types are coded correctly so that the appropriate waste heat factors are applied.
- Apply site-specific fossil fuel heating system efficiency values in lighting savings calculations when available. The prescriptive values are 0.75 for commercial gas heating systems and 0.78 for residential gas heating systems. Because program sponsored heating systems are typically more efficient than the prescriptive efficiency values, the gas heating penalty associated with lighting measures will be smaller, thereby increasing overall lighting savings.

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 Low-Income Prescriptive Rebates 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.[20]

For the FY2018 Low-income Prescriptive Rebate program, we completed the following evaluation activity:

- Gross Savings Verification

3.5.1 Gross Savings Verification

Table 89 displays the tracked savings, realization rates, evaluated savings and sample precisions for the Low-Income Prescriptive Rebate program.

Table 89: Low-income Prescriptive Rebate Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2018 Electric Savings (MWh)	3,936	100%	3,935	±1% @ 80%
FY2018 Peak Demand Savings (MW)	1.4	100%	1.4	±1% @ 80%
FY2018 Gas Savings (MMBtu)	-1,256	100%	-1,268	±1% @ 80%

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

3.5.1.1 Methodology

We performed measure reviews to verify that tracked savings were reasonable and to determine which measures merited further review. The NMR team identified five measures within the LIRX program for closer analysis. 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.

3.5.1.2 Sampling Plan

We conducted desk reviews of supporting documentation for the ten projects with the most energy savings. For the Low-Income Prescriptive Rebate program, the top ten sites represented about 56% of the tracked energy savings from all 55 projects that participated in the program in FY2018.

3.5.1.3 Results

We summarize the evaluation findings for each measure below.

- We calculated electric, peak demand, and gas realization rates of 100% for the linear LEDs, LED downlights, indoor LED fixtures, and outdoor LED fixtures.
- We calculated electric and peak demand realization rates for screw base LEDs of 100%. The 101% gas realization rate for screw base LEDs is due to rounding errors.

Table 90: Low-income Prescriptive Rebate Savings and Realization Rates by Measure Type

Measure Category	FY2018 Electric Savings (MWh)			FY2018 Peak Demand Savings (MW)			FY2018 Gas Savings (MMBtu)		
	Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated
Screw Base LEDs	3,329	100%	3,328	1.3	100%	1.3	-1,062	101%	-1,074
Linear LEDs	325	100%	325	0.1	100%	0.1	-106	100%	-106
LED Downlights	250	100%	250	<0.1	100%	<0.1	-81	100%	-81
Indoor LED Fixtures	22	100%	22	<0.1	100%	<0.1	-7	100%	-7
Outdoor LED Fixtures	11	100%	11	<0.1	100%	<0.1	-	100%	-
Total	**3,936**	**100%**	**3,935**	**1.4**	**100%**	**1.4**	**-1,256**	**100%**	**-1,268**

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 were not selected for the FY2018 evaluation.

4.1 Default Realization Rates

As described in Section 1.4, the FY2018 evaluation verified the gross savings for 12 programs. In order to assign default realization rates for the ten programs that were not evaluated for FY2018, we reviewed previous realization rates for these SEU programs, as well as the calculated FY2018 realization rates for other programs. Because realization rates can change over time as measure offerings and markets evolve, we opted to apply the FY2017 realization rate for the same program or the FY2018 realization rate from similar programs or similar measures if they exist. If neither FY2017 results nor similar programs exist, then we apply the average realization rates from the FY2013 to FY2015 period for the same program as it represents a typical realization rate value.

Table 91 lists each of the ten programs that did not undergo an evaluation in FY2018, the source of the realization rate, and the default realization rate values.

Table 91: FY2018 Default Realization Rates

Sector	Program Name	Source for Default Realization Rate	Default Realization Rates		
			Electric Savings	Peak Demand Savings	Gas Savings
Single-family Residential	Low-income Emergency Equipment Replacement	FY2017 Evaluation for Retail Heating & Cooling	100%	100%	100%
Commercial	Commercial Upstream (Lighting)	FY2017 Evaluation	109%	108%	192%
Multifamily	Implementation Contractor Direct Install	FY2017 Evaluation	100%	99%	100%
	LI Custom Projects	FY2018 Evaluation for LIMF Comprehensive program	98%	102%	108%
Efficient Products	Retail Efficient Appliances	FY2017 Evaluation	100%	100%	100%
	Home Energy Conservation Kit - Market Rate	FY2017 Evaluation	100%	100%	99%
	Retail Heating and Cooling	FY2017 Evaluation	100%	100%	100%
	Retail Lighting Food Bank	FY2018 Evaluation for Retail Lighting	100%	100%	100%
	Home Energy Conservation Kit - Low-income	FY2017 Evaluation	100%	100%	99%
	Residential Upstream	FY2018 Evaluation for Retail Lighting	100%	100%	100%

4.2 NET-TO-GROSS REVIEW

The NMR team estimated NTG values for five FY2018 programs. For the 16 programs where a NTG value was not estimated, we primarily based the FY2018 NTG values on the most recently available DCSEU NTG estimates from FY2014. If the NTG for a particular initiative was not measured in FY2014, we used the FY2013 estimates. For programs where NTG was not assessed in either FY2013 or FY2014 (and for new programs launched since FY2014), the NMR team derived NTG values from similar programs from other jurisdictions or applied assumed values. Table 92 presents the recommended NTG estimates for these FY2018 programs.

Table 92. Recommended Default FY2018 NTG Estimates

Sector	Program Name	NTG Value	Source
Single-family Residential	Low-income Emergency Equipment Replacement	100%	Assumed
Commercial	Market Transformation Value	90%	FY2014
	Commercial Upstream (Lighting)	85%	Lit review
	Market Opportunities - Custom	60%	FY2014
Multifamily	Implementation Contractor Direct Install	100%	FY2013
	Income Qualified Efficiency Fund	100%	Assumed
	LI Custom Projects	100%	Assumed
	Low-income Multifamily Comprehensive	83%	FY2013
	Low-income Prescriptive Rebate	100%	Assumed
Efficient Products	Retail Efficient Appliances	65%	FY2014
	Home Energy Conservation Kit - Market Rate	80%	Lit Review
	Retail Heating and Cooling	HVAC: 70% Gas: 80%	FY2014 Lit Review
	Retail Lighting	51%	FY2013
	Retail Lighting Food Bank	100%	Assumed
	Home Energy Conservation Kit - Low-income	100%	Assumed
	Residential Upstream	60%	Lit Review

To inform the derived FY2018 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. These include the following:

- **Home Energy Conservation Kit - Market Rate (7710HEKT):** This initiative was new in FY2018. The NMR team compared NTG estimates for similar programs to derive the FY2018 value.
- **Home Energy Conservation Kit – Low-income (7717HEKT), Income Qualified Efficiency Fund (7610QEF), and Low-income Prescriptive Rebate (7613LIRX):** These initiatives were new in FY2018. We assume the NTG equals 100%, which is frequently assumed for low-income programs.
- **Low-income Custom Projects (7610LICP) and Retail Lighting Food Bank (7717FBNK):** The NTG for these programs was not measured in either FY2013 or FY2014. We assume the NTG equals 100%, which is regularly assumed for low-income programs.
- **Residential Upstream (7725RSUP):** The derived NTG value (60%) is based on comparable estimates for peer programs.

Table 93 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 were 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 92 are reasonable values for FY2018.

Table 93: 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	100%	FY2018	--	--
Single-family Residential	7413LIER	Low-income Emergency Equipment Replacement	100%	Assumed	100% 100% 100%	PA PPL (2017-2018) PA First Energy Companies (2017-2018) PA Duquesne (2017-2018)
Commercial	7511CIRX	C& I RX - Equipment Replacement	66%	FY2018	Non-Lighting=56% Lighting=69% 41-100% 75%	PA PPL (2017-2018)[a] PA PPL (2017-2018) PA First Energy Companies (2016-2017)[b] EMPOWER Maryland (2017)[c]
	7512MTV	Market Transformation Value	≥90%	FY2014	63%-84%	PA First Energy Companies (2016-2017)
	7513UPLT	Commercial Upstream Lighting	85%	FY2018 Lit Review	85% 88% 85%	PA PPL (2017-2018)[1] PA Duquesne (2016-2017)[2, d] EMPOWER Maryland (2017)[3]
	7520CUST	Retrofit - Custom	45%	FY2018	73%	PA PPL (2017-2018)
	7520MARO	Market Opportunities - Custom	≥60%	FY2014	39%-52% 31% 75%	PA First Energy Companies (2016-2017)[b] PA Duquesne (2017-2018)[d] EMPOWER Maryland (2017)
	7520NEWC	New Construction - Custom	46%	FY2018	Small C&I=27% Large C&I=41% 76%	PA PECO (2017-2018)[e] EMPOWER Maryland (2017)
Multifamily	7610ICDI	Implementation Contractor Direct Install	Elec=93% Gas=132%	FY2013 FY2013	100%	Efficiency Maine (2012-2013, assumed)[g]
	7610IQEF		100%	Assumed	45%	PA Duquesne (2017-2018)

Sector	Track	Initiative	DCSEU NTG	Year Assessed	Benchmark NTG	Benchmark Source Program Administrator (Program Year)
		Income Qualified Efficiency Fund			86%	PA PECO (2016-2017)
	7610LICP	LI Custom Projects	100%	Assumed	--	--
	7612LICP	Low-income Multifamily Comprehensive	83%	FY2013	65%	PA PECO (2017-2018)
	7613LIRX	Low-income Prescriptive Rebate	100%	Assumed	45%	PA Duquesne (2017-2018)
Efficient Products	7710APPL	Retail Efficient Appliances	Appliances: ~60-70%	FY2014	77%	PA PPL (2016-2017)[a]
					47%-52%	PA First Energy Companies (2016-2017)
					66%	PA PECO (2016-2017)[e]
					59%	PA Duquesne (2015-2016)[d]
					62%	EMPOWER Maryland (2017)
			HVAC: ~70-125%	FY2014	45%-56%	PA First Energy Companies (2016-2017)
					56%	PA PECO (2016-2017)
					54%	EMPOWER Maryland (2017)
	7710HEKT	Home Energy Conservation Kit - Market Rate	80%	FY2018 Lit Review	82%-83%	PA First Energy Companies (2017-2018)[b]
					75%	PA Duquesne (2017-2018)
	7710HTCL	Retail Heating and Cooling	HVAC: 70% Gas: 80%	FY2014, FY2017 Lit Review	45%-56%	PA First Energy Companies (2016-2017)
					56%	PA PECO (2016-2017)
					54%	EMPOWER Maryland (2017)
	7710LITE	Retail Lighting	51%	FY2013	LEDs=83%	PA PPL (2016-2017)
					Std LEDs=51%	PA PECO (2016-2017)
					Spec LEDs=46%	PA PECO (2016-2017)
					CFLs, LEDs=65%	EmPOWER Maryland (2017)f
	7710STAT	Retail Smart Thermostats	69%	FY2018	--	--

Sector	Track	Initiative	DCSEU NTG	Year Assessed	Benchmark NTG	Benchmark Source Program Administrator (Program Year)
	7717FBNK	Retail Lighting Food Bank	100%	Assumed	--	--
	7717HEKT	Home Energy Conservation Kit - Low-income	100%	Assumed	100%	PA PPL (2017-2018)
					100%	PA First Energy Companies (2017-2018)
					100%	PA Duquesne (2017-2018)
	7725RSUP	Residential Upstream	60%	FY2018 Lit Review	LEDs=83%	PA PPL (2016-2017)
					Std LEDs=51%	PA PECO (2016-2017)
					Spec LEDs=46%	PA PECO (2016-2017)
					CFLs, LEDs=65%	EmPOWER Maryland (2017)[f]
					86%	PA PECO (2016-2017)

Notes:

[1] Represents NTG value from the Midstream Lighting component of PPA's Non-Residential Energy Efficiency Program.
[2] Represents NTG value from Duquesne Light's Nonresidential Midstream Lighting Program.
[3] Two of the four EmPOWER Maryland Utilities, Baltimore Gas and Electric (BGE) and Southern Maryland Electric Company's (SMECO), offer a C&I Midstream Lighting program.

Sources:

[a] The Cadmus Group. November 15, 2018. Annual Report to the Pennsylvania Public Utility Commission Phase III of Act 129 Program Year 8 (June 1, 2017-May 31, 2018) for Pennsylvania Act 129 of 2008 Energy Efficiency and Conservation Plan. Prepared for PPL Electric Utilities.
[b] ADM Associates and Tetra Tech. November 15, 2018. Final Annual Report to the Pennsylvania Public Utility Commission, Phase III of Act 129 Program Year 8 (June 1, 2017-May 31, 2018). Prepared for Metropolitan Edison Company, Pennsylvania Electric Company, Pennsylvania Power Company, West Penn Power.
[c] Itron. 2018. V*erification of the 2017 EmPOWER Maryland Energy Efficiency Program Impact Evaluation*. Submitted to: Maryland Public Service Commission Staff.
[d] Navigant Consulting. November 15, 2018. *Final Annual Report to the Pennsylvania Public Utility Commission, Phase III of Act 129 Program Year 7 (June 1, 2017-May 31, 2018)*. Prepared for Duquesne Light Company.
[e] Navigant Consulting. November 15, 2018. Final Annual Report to the Pennsylvania Public Utility Commission, Phase III of Act 129 Program Year 8 (June 1, 2017-May 31, 2018). Prepared for PECO.
[f] Apex Analytics and Demand Side Analytics. July 18, 2017. *EmPOWER Maryland Lighting Sales Data Modeling.*
[g] 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

Appendix A Program Descriptions

This appendix provides a description for each of the program tracks offered by DCSEU in FY2018.

A.1 Commercial Sector

C&I RX - Equipment Replacement (7511CIRX)

The C&I RX Equipment Replacement initiative 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 electrical 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 installation of lighting controls, $350 for an efficient reach-in refrigerated case, and $750 for installation of qualifying 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.

Market Transformation Value (7512MTV)

The MTV program provides rebates to large businesses and institutions for lighting upgrades. The program offers prescriptive incentives for lighting. 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 installation of lighting controls. The program completed seven unique projects during FY2018.

Commercial Upstream (7513UPLT)

The Commercial Midstream/Upstream program provides instant rebates to customers purchasing lighting equipment through qualified distributors. Through this program, customers can purchase light bulbs from any one of nine participating distributors including ENERGY STAR 2.0 certified LED directional, omnidirectional, and decorative bulbs, as well as DLC certified linear LED tubes.

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 per unit of energy saved, but also through partnerships with lenders in the District who may finance up to 100% of a project's cost.

Market Opportunities - Custom (7520MARO)

The Market Opportunities Custom 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.

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, refrigerator and freezers.

A.2 Solar Sector

Solar PV Market Rate (7101PVMR)

The PVMR Program provides incentives to buildings that install solar panels that produce local electric energy to reduce their consumption from the electric grid. The program is looking to 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. This effort will supplement the Solar for All program, which DCSEU recently signed a contract amendment with DOEE to support.

A.3 Multifamily Sector

Implementation Contractor Direct Install (7610ICDI)

The Low-Income Multifamily (LIMF) Implementation Contractor Direct Install (ICDI) initiative supports low-income multifamily communities in the District of Columbia. Under this program DCSEU hires implementation contractors to install energy-efficient equipment in eligible buildings and covers 100% of the product and installation costs. Measures covered can be in-unit or common area measures and may include the installation of heating and cooling systems, domestic hot water systems, in-unit and common area lighting, refrigeration, and controls. While this track is aimed at low-income residences, multifamily residential buildings that do not meet the low-income requirements are eligible to install common space fixtures under this track. DCSEU promotes this opportunity to property owners, property managers, developers, architects and engineers.

Income Qualified Efficiency Fund (7610IQEF)

The Income Qualified Efficiency fund is an initiative designed to serve low-income, multifamily housing, shelters, and approved clinics. DCSEU approved contractors are awarded funding to

implement energy-efficiency projects, which will provide energy and financial savings benefits for 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. Measures eligible for funding include domestic hot water systems, lighting, appliances, controls, and measures improving the thermal envelope.

Low-income Custom Projects (7610LICP)

The Low-Income Custom Project initiative is designed to serve low-income multifamily housing – specifically, new construction, substantial renovation, and redevelopment housing. This program works with developers and owners of low-income multifamily projects to provide custom technical services and incentives for energy-efficiency improvements. Each project is independently evaluated and specific energy conservation measures (ECM) are chosen depending on the project's needs. Projects are generally focused on specific end uses and may include thermal envelope (air and thermal barriers, doors, and windows) improvements, domestic hot water systems, in-unit and common area lighting, appliances, and controls.

Low-income Multifamily Comprehensive (7612LICP)

The Low-Income Multifamily Comprehensive program supports energy-efficiency measures in gut-rehab or new construction projects of low-income multifamily buildings. Each project is evaluated independently and energy-efficiency measures are selected to best meet the project's needs. Supported measures include domestic hot water systems, lighting, appliances, controls and thermal envelope measures. The program enables DCSEU to provide technical expertise and funding to comprehensive energy-efficiency upgrades or installations in low-income multifamily housing.

Low-income Prescriptive Rebate (7613LIRX)

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 Design Lighting Consortium qualified. This initiative enables DCSEU to provide incentives and custom technical services for lighting improvements to low-income multifamily establishments.

A.4 Efficient Products Sector

Retail Efficient Appliances (7710APPL)

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.

Retail Lighting (7710LITE)

DCSEU supports the installation of LED lighting in the District through its Retail Efficient Lighting Program. This initiative coordinates with lighting retailers and manufacturers to increase the availability of LEDs and offer them at lower prices in the District of Columbia. The initiative also

aims to increase awareness of LED technology through educational materials as LEDs are less familiar to residents than CFLs or incandescent bulbs.

Home Energy Conservation Kit - Market Rate (7710HEKT)

The Home Energy Conservation Kit – Market Rate track was developed to track non-low-income installs for energy-efficiency kits sent to residents of the District. Measures in this track are only home energy conservation kits, which include an advanced power strip, a faucet aerator, and six LEDs. These kits offer District residents a free, easy way to implement energy savings measures.

Retail Heating and Cooling (7710HTCL)

The Retail Heating & Cooling project track works with participating contractors in the District to install heating and cooling equipment in residential applications. Measures found in this track include central air conditioners, ductless heat pumps, domestic hot water, programmable thermostats, boilers, furnaces, and air-source heat pumps.

Retail Smart Thermostats (7710STAT)

The Retail Smart Thermostats program aims to reduce HVAC energy use by offering rebates for the installation of smart thermostats in DC homes. 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.

Retail Lighting Food Bank (7717FBNK)

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

Home Energy Conservation Kit - Low-income (7717HEKT)

The Home Energy Conservation Kit – Low-income track was developed to track low-income installs for energy-efficiency kits sent to residents of the District. Measures in this track are only home energy conservation kits, which include an advanced power strip, a faucet aerator, and six LEDs. These kits offer low-income District residents a free, easy way to implement energy savings measures.

Residential Upstream (7725RSUP)

The Residential Upstream project track is used to track the upstream program of residential, efficient lighting projects purchased through electrical distributors. Participating electrical distributors buy down the price of the lighting products, offering a point-of-sale rebate to their customers. Eligible products include TLEDs, directional LEDs, and omnidirectional LEDs. After sale, the distributors submit rebate documentation to DCSEU for reimbursement.

A.5 SINGLE-FAMILY RESIDENTIAL SECTOR

Low-income Emergency Equipment Replacement (7413LIER)

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). The approved specific energy conservation measures include furnaces, boilers, domestic hot water systems, appliances, and controls. Each project utilizes the TRM to determine energy savings.

Appendix B Detailed Savings Formulas

In this section, we provide the detailed savings formulas applied in the evaluation.

B.1 Market Transformation Value

- Electric Demand Savings (ΔkW):
  - Lighting: $\Delta\text{kW} = ((Watts_{BASE} - Watts_{EE})/1000) * ISR * WHF_d$
  - Controls: $\Delta\text{kW} = kW_{connected} * SVG * OTF * ISR * WHF_d$
- Electric Energy Savings (ΔkWh)
  - Lighting: $\Delta\text{kWh} = ((Watts_{BASE} - Watts_{EE})/1000) * HOURS * ISR * WHF_e$
  - Controls: $\Delta\text{kWh} = kW_{connected} * HOURS * SVG * OTF * ISR * WHF_e$
- Natural Savings (ΔMMBtu)
  - All Lighting:

$$\Delta\text{MMBtu} = \left(\frac{-\Delta kWh}{WHF_e}\right) \times Aspect\ Ratio \times 0.003412 \times Heating\ Fraction/\eta_{Heat}$$

Where:

ΔkW	=	Demand Savings
ΔkWh	=	Electrical energy savings for the measure
ΔMMBtu	=	Natural gas savings for the measure
HOURS	=	Annual lighting HOU; collected from prescriptive application form. If operating hours are not available, the value will be selected from the table "Operating Hours by Building Type" in the reference tables section of the TRM.
ISR	=	In service rate, or the percentage of units rebated that actually get installed (98%)
$Watts_{base}$	=	Baseline connected kW from table located in DC LED New and Baseline Assumptions document
$Watts_{EE}$	=	Energy-efficient connected kW from table located in DC LED New and Baseline Assumptions document
WHF_d	=	Waste heat factor for demand to account for cooling savings from efficient lighting (1.00 exterior / 1.290 case fixtures / 1.203 all other LED categories)
WHF_e	=	Waste heat factor for energy to account for cooling savings from efficient lighting (1.00 exterior / 1.290 case fixtures / 1.107 for all other LED categories)
OTF	=	Operational testing factor (1.0 for all occupancy sensors and daylighting controls when the project undergoes operational testing or commissioning services, 0.80 for daylight dimming controls otherwise)

SVG	=	Savings factor to account for percentage of annual lighting energy savings by lighting controls; determined on a site-specific basis or refer to SVG table by control type
Aspect Ratio	=	Aspect ratio to account for the difference in lighting intensity and therefore heating needs at different heights within the space (0.70)
Heating Fraction	=	Amount of lighting heat that contributes to space heating (0.23)
η_{Heat}	=	Heating system efficiency (75%)

B.2 CI RX Equipment Replacement Program

Lighting Energy Savings Equations:

- Electric Demand Savings (ΔkW):
  - Lighting: $\Delta kW = ((Watts_{BASE} - Watts_{EE})/1000) * ISR * WHF_d$
  - Controls: $\Delta kW = kW_{connected} * SVG * OTF * ISR * WHF_d$
- Electric Energy Savings (ΔkWh)
  - Lighting: $\Delta kWh = ((Watts_{BASE} - Watts_{EE})/1000) * HOURS * ISR * WHF_e$
  - Controls: $\Delta kWh = kW_{connected} * HOURS * SVG * OTF * ISR * WHF_e$
- Natural Gas Savings (ΔMMBtu)
  - All Lighting:

$$\Delta MMBtu = \left(\frac{-\Delta kWh}{WHF_e}\right) \times Aspect\ Ratio \times 0.003412 \times Heating\ Fraction/\eta_{Heat}$$

Where:

ΔkW	=	Demand Savings
ΔkWh	=	Electrical energy savings for the measure
ΔMMBtu	=	Natural gas savings for the measure
HOURS	=	Annual lighting HOU; collected from prescriptive application form. If operating hours are not available, the value will be selected from the table "Operating Hours by Building Type" in the reference tables section of the TRM.
ISR	=	In service rate, or the percentage of units rebated that actually get installed (97%)
$Watts_{base}$	=	Baseline connected kW from table located in DC LED New and Baseline Assumptions document
$Watts_{EE}$	=	Energy-efficient connected kW from table located in DC LED New and Baseline Assumptions document
WHF_d	=	Waste heat factor for demand to account for cooling savings from efficient lighting (1.203 interior / 1.00 exterior / 1.290 refrigerated cases / 1.5 freezer cases)
WHF_e	=	Waste heat factor for energy to account for cooling savings from efficient lighting (1.107 interior / 1.00 exterior / 1.290 refrigerated cases / 1.5 freezer cases)

OTF	=	Operational testing factor (1.0 for all occupancy sensors and daylighting controls when the project undergoes operational testing or commissioning services, 0.80 for daylight dimming controls otherwise)
SVG	=	Savings factor to account for percentage of annual lighting energy savings by lighting controls; determined on a site-specific basis or refer to SVG table by control type
Aspect Ratio	=	Aspect ratio to account for the difference in lighting intensity and therefore heating needs at different heights within the space (0.70)
Heating Fraction	=	Amount of lighting heat that contributes to space heating (0.23)
η_{Heat}	=	Heating system efficiency (75%)

Building Operation Certification Energy Savings Equations:

- Electric Demand Savings (ΔkW):
  - $\Delta\text{kW} = None$
- Electric Energy Savings (ΔkWh)
  - $\Delta\text{kWh} = SQFT * BOC_{elec}$
- Natural Gas Savings (ΔMMBtu)
  - $\Delta\text{MMBtu} = SQFT * BOC_{MMBtu}$

Where:

ΔkW	=	Demand Savings
ΔkWh	=	Electrical energy savings for the measure
ΔMMBtu	=	Natural gas savings for the measure
SQFT	=	Square footage input representing total facility area that the operator may influence
BOC_{elec}	=	Building operator certification savings factor for electricity, expressed as kWh savings per square foot of building area
BOC_{MMBtu}	=	Building operator certification savings factor for natural gas, expressed as kWh savings per square foot of building area

Condensing Gas Furnace Energy Savings Equation:

- Electric Demand Savings (ΔkW):
  - $\Delta\text{kW} = 0.189\ kW$
- Electric Energy Savings (ΔkWh)
  - $\Delta\text{kWh} = 924\ kWh$
- Natural Gas Savings (ΔMMBtu)
  - $\Delta\text{MMBtu} = \left(CAP * HDD * \frac{24}{\Delta T}\right) * \left(\frac{1}{AFUE_{BASE}} - \frac{1}{AFUE_{EFFICIENT}}\right)$ / 1,000,000

Where:

ΔkW	=	Demand Savings
ΔkWh	=	Electrical energy savings for the measure
ΔMMBtu	=	Natural gas savings for the measure
CAP	=	Equipment Capacity in Btu/hr (Actual installed)
HDD	=	Heating Degree Days (2,247)
ΔT	=	Temperature difference at design conditions (Indoor heating setpoint – design temperature / 70◦F-17◦F)
$AFUE_{BASE}$	=	Annual Fuel Utilization Efficiency of minimally code-compliant equipment (80%)
$AFUE_{EFFICIENT}$	=	Annual Fuel Utilization Efficiency of efficient equipment (Actual installed, 95% if unknown)

Appendix C Seasonal Savings Analysis

Seasonal Savings is a thermostat optimization measure offered by Nest Labs that delivers energy and peak demand savings by offering existing 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 95 summarizes the reported savings for FY2018. Two Seasonal Savings entries were recorded in the FY2018 program tracking data. In discussions with Nest, the evaluation team learned the "Qty." column represents the number of devices that opted into the Seasonal Savings algorithm during summer 2017 and summer 2018. If DCSEU believes this is incorrect and the records shown in Table 95 represent something other than a summer 2017 and summer 2018 deployment, then the NMR team should be notified and provided with supporting documentation.

Table 94: FY2018 Claimed Impacts from Seasonal Savings

Measure ID	Report Date	Qty.	Per-Unit kWh	KWh Total	Per-Unit MMBtu	MMBtu Total	Deployment Period
221629	12/31/2017	5,183	97.3	504,305.9	0.9	4,664.7	Summer 2017
232314	9/30/2018	6,966	97.3	677,791.8	0.9	6,269.4	Summer 2018

The "Report Date" field in the program tracking data determines to which fiscal year each measure accrues for reporting purposes. Impacts from the summer 2018 were recorded earlier in the year than the summer 2017 impacts, which led to two summers of program activity being claimed in one fiscal year. The per-unit kWh and MMBtu assumptions come from a TRM entry that assumes the values shown in Table 95.

Table 95: TRM Basis for Seasonal Savings Per-Unit Assumptions

ΔMMBtu	$\Delta kWh_{heating}$	$\Delta kWh_{cooling}$	ΔkWh_{total}
0.9	61.4	35.9	97.3

Because the deployment periods claimed in FY2018 were for the summer season, the use of winter electric and gas heating assumptions was an improper application of TRM defaults. The NMR team requested daily thermostat operating data for all thermostats in the summer 2018 deployment and performed an independent assessment of the energy and peak demand savings achieved by the offering. These findings were then applied to the summer 2017 savings claims.

The Seasonal Savings program was deployed as a randomized encouragement design (RED). The RED is similar to a randomized controlled trial (RCT) often used with behavioral conservation programs like Home Energy Reports, except that it includes an opt-in component. Figure 6 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. Customers eligible to be included in the RED study (ITT or control group) first had to meet the following criteria:

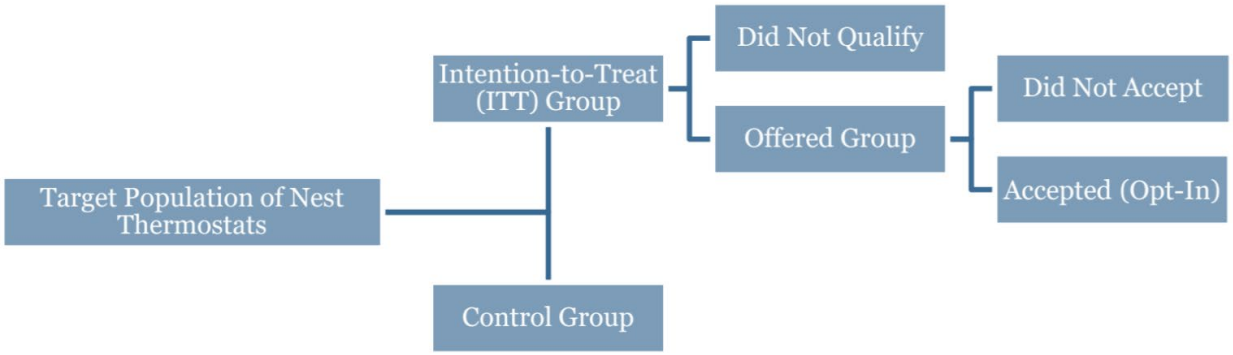
- Have a Nest installed and an online account;
- Have a forced-air cooling system connected to thermostat (e.g., a central air conditioner or ducted heat pump); and
- Are located in a list of DCSEU eligible zip codes.

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

- Thermostat connected to internet;
- Actively operating a cooling 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 5: Randomized Encouragement Design

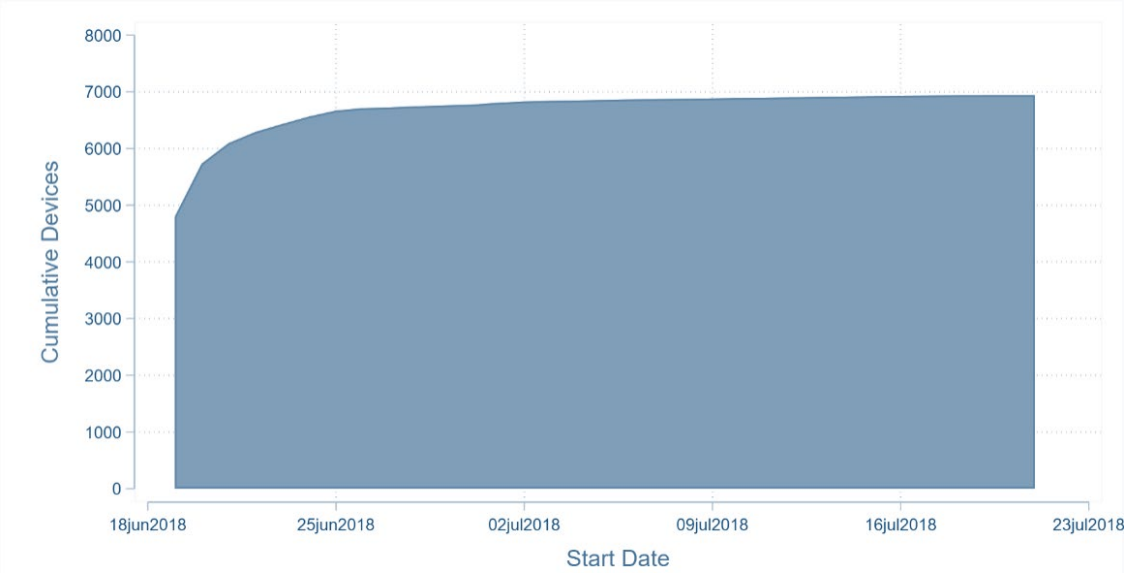


The tracking data shows 6,966 enrolled devices; however, a small fraction of devices did not have the runtime data that is required for the statistical analysis. The evaluation team's analysis and estimates provided here are detailing only those devices in the control and intention-to-treat group that include runtime data. Table 96 shows the differences between the full population and the thermostat counts used for analysis.

The program start date was June 19, 2018, but not all opt-ins were accepted on this date. Figure 7 shows the cumulative number of devices that opted into the Seasonal Savings program during summer 2018. There were 6,961 devices enrolled in the program by July 21, 2018; 4,800 of these devices enrolled on the first day of the offer. 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 summer on July 21, 2018. 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 increase the thermostat's scheduled setpoints. The ramp up period minimizes participant awareness of the change.

Figure 6: Cumulative Opt-In Devices



The group distributions of all devices and those with runtime data are provided in **Table 96**. Specifically focusing on the devices with runtime data, there are 1,900 devices in the control group and 12,117 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 6,961 devices with runtime data that were selected, qualified, and ultimately chose to participate in the program. The savings impact comes from these thermostats, but is diluted since analysis occurs at the ITT grouping.

Table 96: Qualification and Opt-In Rates

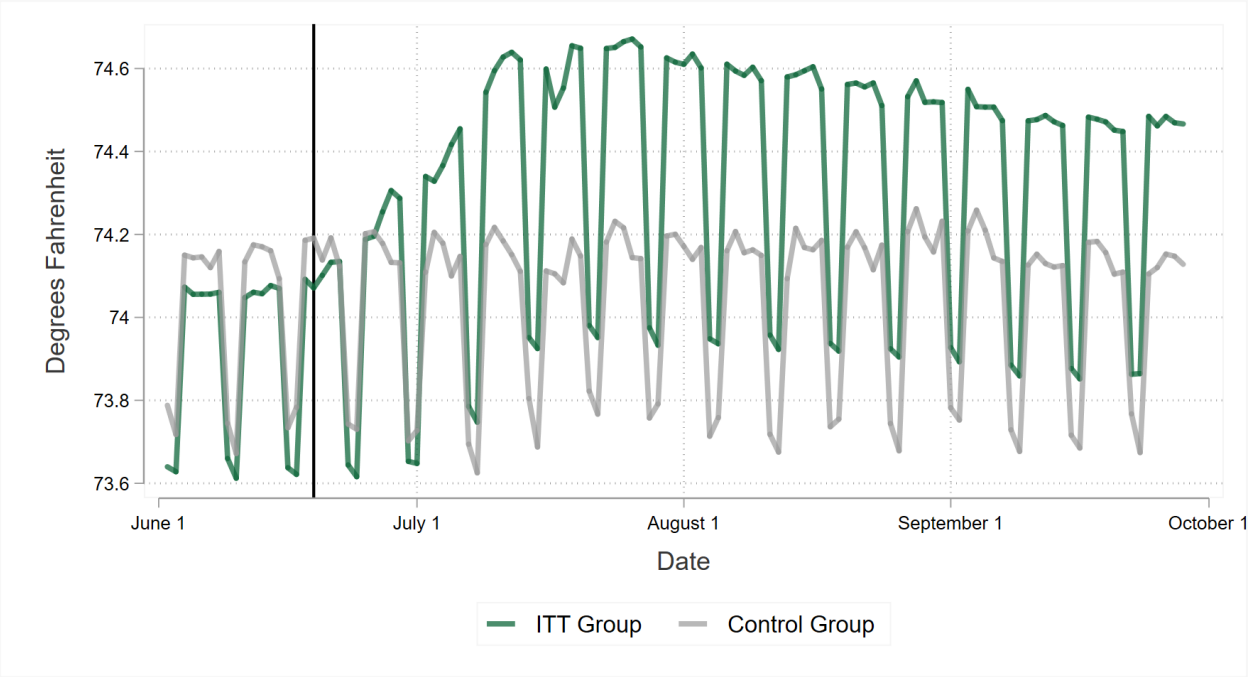
Study Group	All Devices	Devices with Runtime Data
Control	2,000	1,900
ITT Group	12,669	12,117
Did Not Qualify	2,621	2,079
Did Not Accept	3,082	3,077
Opt-In	6,966	6,961
Qualification Rate	79.31%	82.84%
Opt-In Rate Among Offered	69.33%	69.35%
Effective Opt-In Rate	54.98%	57.45%

Any devices that drop out during the summer 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 decreasing average scheduled set point of the ITT group in Figure 8.

C.1 METHODOLOGY

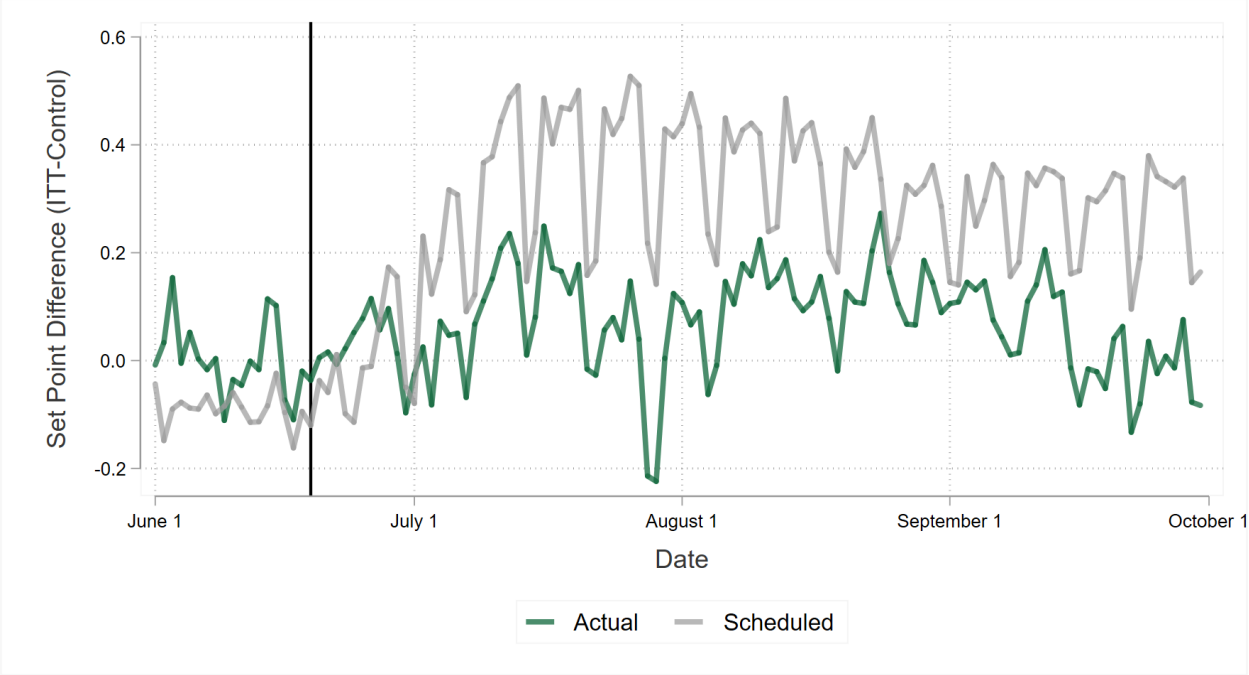
The Seasonal Savings program makes minor adjustments to the scheduled set points for enrolled thermostats. Figure 8 shows the average scheduled set point for both the ITT group and the control group. The black line indicates the program start date of June 19, 2018. Prior to the program start date, the average scheduled set point was slightly lower for the Treatment group. Beginning June 19, 2018, 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 higher average scheduled set points than the control group. The difference between the groups declines slightly over time. This trend could be due to individuals updating the cooling setpoints to a less efficient schedule.

Figure 7: Scheduled Set Point



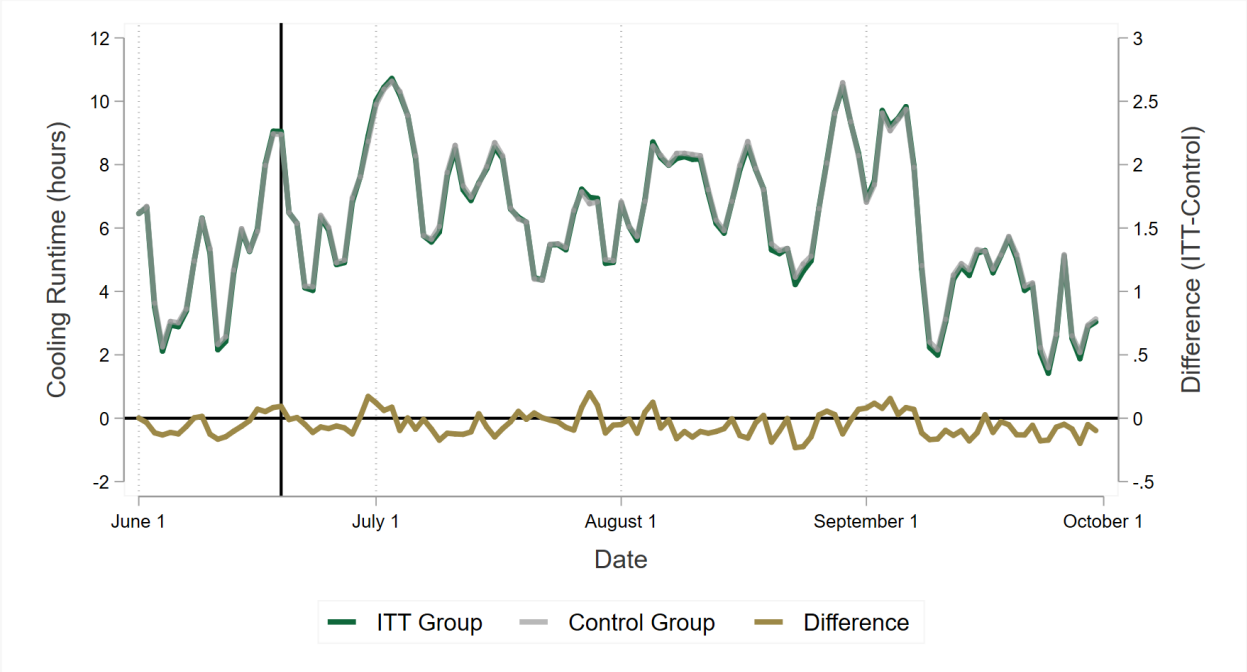
The scheduled set points do not necessarily indicate the actual set points because users can manually adjust the thermostat settings via the smart phone app or directly on the thermostat. Figure 9 shows the difference in the ITT and control group for both the scheduled and actual set points. Following the enrollment period, the average set point of the ITT group is scheduled to be about 0.2°F to 0.5°F higher than the control group. The actual set point difference shown by the green line indicates a spread between approximately -0.2°F and 0.2°F, suggesting that the control group is occasionally running a higher average setpoint than the ITT group. The black line indicates the program start date of June 19, 2018. The difference-in-difference model, detailed below, considers the difference between the treatment and control groups in the pre-period, and nets this out to observe the difference in the adjusted trends after the program start date.

Figure 8: Set Point Differences



While the scheduled set point differences are evident, the actual set point differences show mixed results. Figure 10 shows the average daily cooling runtime for the treatment and control groups during the 2018 season. The difference curve is the ITT minus the control group. A positive difference for this line indicates that the ITT group has higher air conditioning runtime than the control group. Effective program implementation occurs when the difference curve drops below zero. Note 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 9: Cooling Runtime, by Group and Date



The randomized encouragement design allows for a clean control group and an ideal set up for a difference-in-difference (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 and treatment (*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 CDD variable calculated at base 65°F (*cdd*), and a mix of interactions between the CDD variable, post (*post*), and treatment (*treat*). These interactions are denoted with the use of "*" between the appropriate variables. The specific models are shown in Table 97. Model 6 replicates the regression used by Nest.

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

Table 97: 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	cdd	device
4	post, post*treat	cdd, date	device
5	post, post*treat	weekend, cdd, cdd*treat, cdd*post, date	device
6	post, post*treat	cdd, cdd*treat, cdd*post, cdd*post*treat	device
7	post, post*treat	cdd, cdd*treat, cdd*post, cdd*post*treat	device, date
8	post, post*treat	weekend, cdd, cdd*post, cdd*treat, cdd*post*treat	device

The impacts provided by a randomized encouragement design are for the ITT group. The true program impacts, the Average Treatment Effect on the Treated (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 savings per season.

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

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

For the intention-to-treat group, there were a maximum of 103 possible post period days. On average, opt-in devices had 95.22 days of post period data. Daily savings multiplied by this average provides the cooling runtime savings for the summer 2018 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 cooling system to kWh of energy use. This rate depends on average unit efficiency, system size, climate, and the number of cooling systems connected to a single thermostat. The evaluation team used the 2018 DCSEU TRM for the average capacity assumption, the Nest runtime data for device distribution, and SEER estimates from the most recent Pennsylvania Residential Baseline Study to arrive at the connected load assumption provided in Table 98. The estimate indicates that one hour of cooling runtime equates to 2.432 kWh of energy use.

Table 98: Connected Load Assumption

Parameter	CAC	ASHP	Source
Capacity (BTU/hr)	32,000	28,373	2018 DCSEU TRM. ASHP is blend of Tier 1 and Tier 2
Count (treated)	4,227	2,715	Nest devices data
SEER	12.1	13.5	Pennsylvania Baseline Study 2018[21]
Connected Load	2.645	2.102	(Capacity / 1000)*(1 / SEER)
Weighted Mean	**2.432**		$(Count_{CAC} * Connected\ Load_{CAC}) + (Count_{ASHP} * Connected\ Load_{ASHP})$

C.2 FINDINGS

The summer 2018 ITT and ATT impacts (in kWh) for each of the eight models, along with an average daily impact (in minutes), are provided in Table 99. The ITT column shows the impact estimate and the ATT column inflates this estimate by dividing by the opt-in rate. 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 Air Conditioning runtime saved in the ITT group on an average day. The ITT impacts are graphically provided in Figure 11. The model used by Nest (Model 6) is shaded light blue. Nest used a connected load assumption of 3.17 kW, so their kWh savings estimate from the same runtime model was larger (See page 6 of the Nest Analysis report imbedded below).

Nest Seasonal Savings Summer 201

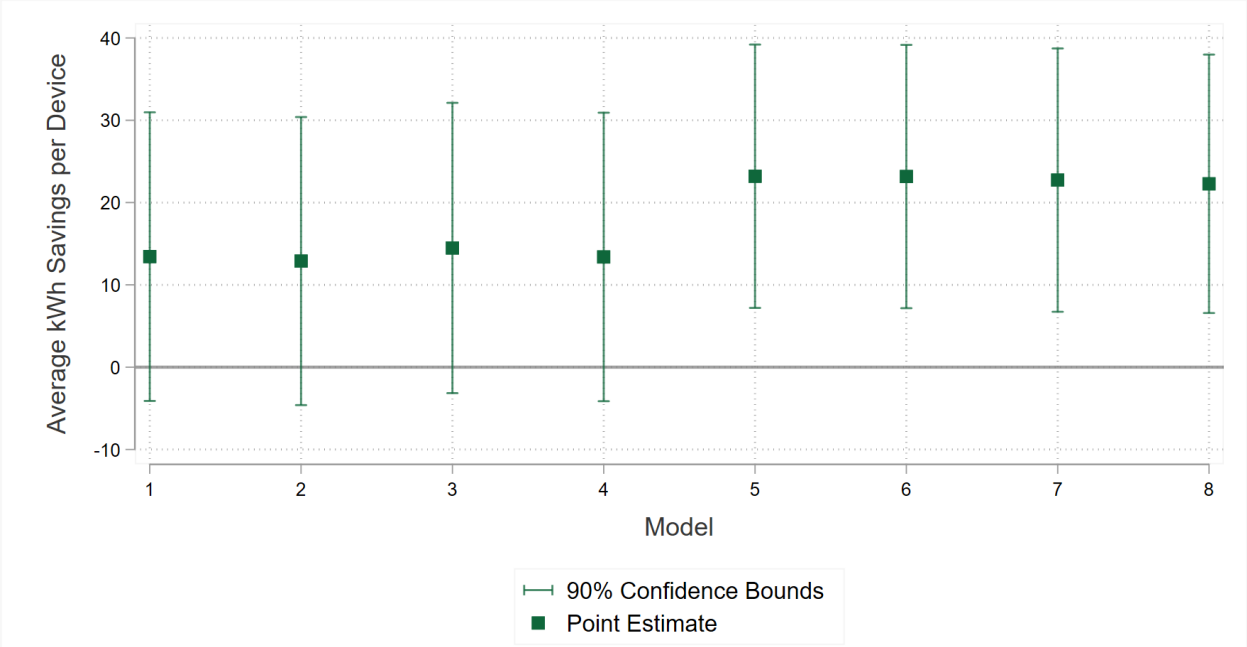
Table 99: Seasonal Savings Impacts

Model Number	ITT (kWh)	ATT (kWh)	Daily Runtime Savings (minutes)
1	13.4	23.4	3.5
2	12.9	22.4	3.3
3	14.5	25.2	3.8
4	13.4	23.3	3.5
5	23.2	40.4	6.0
6	23.2	40.3	5.9
7	22.7	39.6	5.9
8	22.3	38.8	5.8
Average	**18.2**	**31.7**	**4.7**

[21] http://www.puc.state.pa.us/Electric/pdf/Act129/SWE-Phase3_Res_Baseline_Study_Rpt021219.pdf

There are two distinct clusters of results centering around ITT impacts of 13 kWh (Models 1-4) and 23 kWh (Models 5-8). 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. The point estimates in the first cluster are not statistically significantly different from zero at the 90% level, as can be seen by the confidence interval dropping below zero. We support the validity of all models presented, and suspect the true impact is bracketed by the two clusters of results. Because of this, we support taking an average of all eight models represented in this study and using 18.2 kWh as the savings impact per ITT device.

Figure 10: ITT Impacts and Confidence Intervals



The ITT treatment effect has a percent savings of 1.22%. The ATT treatment effect corresponds to 2.16% savings. Table 100 shows the CDD calculated at base 65° (F), average monthly cooling hours for the opt-in customers (with the estimated savings added back), and monthly cooling load for the opt-in devices (with the estimated savings added back). The air conditioning equipment in this program would have used close to 2,100 kWh during summer 2018, absent the Seasonal Savings offering. Savings of 2.16% of the full summer load would be approximately 45 kWh per thermostat. However, the algorithm was deployed mid-to-late June in both 2017 and 2018. The timing of the roll-out as well as the weather conditions will likely affect the observed kWh savings in future years.

Table 100: Projected Monthly Savings

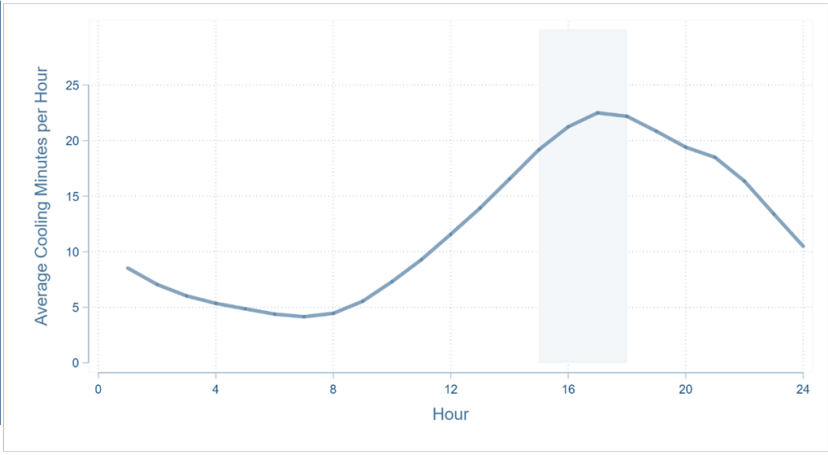
Month	Cooling Degree Days base 65(F)	Cooling Hours	Cooling kWh
May	191.8	119.8	291.2
June	292.5	158.8	386.2
July	427.1	219.9	534.8
August	431.2	215.6	524.4
September	256.0	144.3	350.8
2018 Total[22]	**1,598.7**	**858.3**	**2,087.5**

C.3 PEAK DEMAND

Because the Seasonal Savings algorithm reduces cooling setpoints during summer months, there is a reduction in peak demand as well as energy savings. Figure 12 shows a Mid-Atlantic Central Air Conditioning load shape. The DCSEU peak demand period is taken from PJM and occurs from 2PM to 6PM during June through August. Using this load shape, we estimate that about 29.0% of the daily cooling runtime occurs during these peak energy-use hours (7.3% average across the four hours). On average, the opt-in treatment effect is 0.33 kWh per day. The peak demand impact per opt-in device when the program is operating is 0.024 kW. In 2018, the program operated for 58 of the 70 (82.9%) non-holiday weekdays of the peak demand season. The per-unit peak demand savings impact is 0.02 kW.

Figure 11: Mid-Atlantic Central Air Conditioning Weekday Load Shape

Hour	Share of Day	Hour	Share of Day
1	2.9%	13	4.8%
2	2.4%	14	5.6%
3	2.1%	15	6.5%
4	1.8%	16	7.2%
5	1.7%	17	7.7%
6	1.5%	18	7.6%
7	1.4%	19	7.1%
8	1.5%	20	6.6%
9	1.9%	21	6.3%
10	2.5%	22	5.6%
11	3.2%	23	4.6%
12	3.9%	24	3.6%



[22] October 2018 runtime was not provided. Based on the weather conditions in the DC area during the first two weeks of October, there was likely additional cooling energy used.

Table 101 compares the reported and verified savings for the Seasonal Savings offering in 2017 and 2018. The 2017 verified results are based on our analysis of summer 2018 and the summer 2017 opt-in counts.

- The electric energy realization rate is 32.56%.
- The peak demand realization rate is 1,123%, largely due to a faulty air conditioning CF assumption in the DCSEU TRM measure characterization.[23]
- The natural gas realization rate is 0% because the program did not operate during the winter season.

Table 101: Final Program Savings

Deployment Period	Reported			Verified		
	kWh	kW	MMBtu	kWh	kW	MMBtu
Summer 2017	504,305.9	9.23	4,664.7	164,181.4	103.66	0
Summer 2018	677,791.8	12.40	6,269.4	220,661.4	139.32	0

[23] The DCSEU TRM assumes a 66% CF for residential air conditioning. The Seasonal Savings measure uses an annual characterization of 4% rather than a summer specific value. This results in a significant underestimate of the summer Seasonal Savings peak demand.