Evaluation of DC Sustainable Energy Utility FY2017 Programs

FINAL

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SUBMITTED TO:
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Executive Summary

NMR Group, EcoMetric Consulting, Demand Side Analytics, BluePath Labs, and Setty – collectively referred to as *the NMR team* – were contracted by the DC Department of Energy and Environment (DOEE) to evaluate the energy-efficiency and renewable energy programs implemented by the DC Sustainable Energy Utility (DCSEU). This report presents the results of the evaluation of the Fiscal Year 2017 (FY2017) programs.

The NMR team and the DOEE agreed to contract terms on March 30, 2018. In order to quickly measure SEU progress towards its annual performance benchmarks, the NMR team focused our efforts on a gross savings verification of the FY2017 programs. Therefore, we did not measure Net-to-Gross (NTG) ratios or conduct a process evaluation of the FY2017 programs. We plan to include these two activities in the evaluation of the FY2018 programs.

In FY2017, the commercial sector represented 83% 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 33% of portfolio savings, while heating measures contributed 36% of portfolio savings.

Evaluation Methodology

Due to the abbreviated timeframe available to complete the FY2017 evaluation, we limited our efforts to the following two savings verification activities:

- Tracking database review
- Desk reviews

We targeted a subset of programs for evaluation: a total of five residential programs and three commercial programs (Table 1). The NMR team selected these programs because they either represented a large share of portfolio savings or they contained a key measure of interest, such as commercial lighting. See Section 1.4 for details of our sampling approach.

Appendix A provides descriptions for each of the program tracks offered by the DCSEU in FY2017.

Table 1: FY2017 Program Evaluation Summary

Sector	Program Name	Track Number	Percent of FY2017 Gross Electric & Gas Savings (MMbtu)	Completed FY2017 Gross Savings Verification
Renewables	Solar PV Market Rate	7101PVMR	1%	
	Solar Photo Voltaic	7107PV	0%	
	Solar Hot Water	7110SHOT	0%	
Residential	Income Qualified	7401FHLB	0%	
	Home Performance with Energy Star	7420HPES	0%	
	C& I RX - Equipment Replacement	7511CIRX	7%	✓
	Market Transformation Value	7512MTV	2%	
Commercial	Commercial Upstream (Lighting)	7513UPLT	1%	✓
	Retrofit - Custom	7520CUST	45%	✓
	Market Opportunities - Custom	7520MARO	16%	
	New Construction - Custom	7520NEWC	12%	
	Implementation Contractor DI	7610ICDI	2%	✓
Low-Income Multifamily	LI Custom Projects	7610LICP	1%	
	Low-Income MF Comprehensive	7612LICP	2%	✓
	Retail Efficient Appliances	7710APPL	1%	✓
Retail	Retail Lighting	7710LITE	8%	✓
	Retail Efficient Products Gas	7711GAS	2%	✓
	Retail Lighting Food Bank	7717FBNK	0%	

The NMR team assigned FY2017 programs that did not undergo an evaluation a default gross savings realization rate based on either (1) FY2017 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 FY2017 tracked gross savings, realization rate, 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 96% of the DCSEU tracked peak demand reduction, and the actual portfolio gas savings is 93% of the DCSEU tracked gas savings.

Table 2: DCSEU FY2017 Portfolio-level Gross Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
Electric Savings (MWh)	86,488	99%	85,312
Peak Demand Savings (MW)	12.1	96%	11.6
Gas Savings (MMBtu)	172,757	93%	161,011

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 realization rate for DCSEU is similar to the 100% and 102% values for PECO and BG&E, respectively. At 96%, the demand realization rate for DCSEU is slightly higher than the 91% value for BG&E though substantially lower than the 138% figure for PECO.

Table 3: Comparison of Portfolio-level Realization Rates

Savings Type	DCSEU FY2017	PECO Energy Program Year 8[1]	Baltimore Gas & Electric 2016[2]
Electric Savings	99%	100%	102%
Peak Demand Savings	96%	138%	91%

Table 4 displays the tracked gross savings, realization rate, 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 peak demand and gas 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 8. NMR Group, Ecometric, Demand Side Analytics. http://www.puc.state.pa.us/filing_resources/issues_laws_regulations/act_129_information/act_129_statewide_evaluator_swe_.aspx

[2] EmPOWER Overview Memo – Calendar Year 2016 Deliverables. Navigant and Cadmus September 29, 2017. https://sites.google.com/view/empowermarylandevaluation/home

Table 4: DCSEU Gross Meter-level Program Realization Rates and Savings

Sector	Program	FY2017 Electric Savings (MWh)			FY2017 Peak Demand Savings (MW)			FY2017 Gas Savings (MMBtu)		
		Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated
Renewables	Solar PV Market Rate	2,033	100%	2,033	0.5	100%	0.5	-	-	-
	Solar Photo Voltaic	390	101%	392	0.1	101%	0.1	-	-	-
	Solar Hot Water	(1)	100%	(1)	-	-	-	191	101%	194
Residential	Income Qualified	2	99%	2	0.0	92%	0.0	20	106%	21
	Home Performance with Energy Star	30	97%	29	0.0	92%	0.0	145	109%	157
Commercial	C& I RX - Equipment Replacement	11,572	100%	11,586	1.2	125%	1.5	(6,788)	76%	(5,165)
	Market Transformation Value	3,141	100%	3,145	0.3	125%	0.3	(1,536)	76%	(1,169)
	Commercial Upstream (Lighting)	1,175	109%	1,279	0.2	108%	0.2	(276)	192%	(530)
	Retrofit - Custom	32,276	97%	31,264	4.2	94%	3.9	102,328	94%	95,831
	Market Opportunities - Custom	3,756	97%	3,638	0.5	94%	0.5	64,272	94%	60,191
	New Construction - Custom	9,629	100%	9,597	2.6	78%	2.0	21,289	98%	20,864
Low-income Multifamily	Implementation Contractor DI	1,430	100%	1,430	0.1	99%	0.1	2,645	100%	2,645
	LI Custom Projects	864	94%	815	0.1	97%	0.1	1,358	100%	1,358
	Low-Income MF Comprehensive	2,159	95%	2,046	0.5	97%	0.4	2,336	100%	2,336
Retail	Retail Efficient Appliances	876	100%	877	0.1	100%	0.1	(400)	100%	(399)
	Retail Lighting	15,511	100%	15,533	1.7	101%	1.7	(16,481)	114%	(18,791)
	Retail Efficient Products Gas	760	100%	760	-	-	-	4,919	100%	4,910
	Retail Lighting Food Bank	887	100%	888	0.1	101%	0.1	(1,263)	114%	(1,440)
Portfolio		**86,488**	**99%**	**85,312**	**12.1**	**96%**	**11.6**	**172,757**	**93%**	**161,011**

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	FY2017 Electric Savings (MWh)		FY2017 Peak Demand Savings (MW)		FY2017 Gas Savings (MMBtu)	
		Tracked	Evaluated	Tracked	Evaluated	Tracked	Evaluated
Renewables	Solar PV Market Rate	2,524	2,524	0.6	0.6	-	-
	Solar Photo Voltaic	484	487	0.1	0.1	-	-
	Solar Hot Water	(1)	(1)	(0.0)	(0)	220	223
Residential	Income Qualified	3	3	0.0	0.0	22	23
	Home Performance with Energy Star	32	31	0.0	0.0	153	166
Commercial	C& I RX - Equipment Replacement	12,498	12,513	1.3	1.6	-	-
	Market Transformation Value	3,393	3,397	0.3	0.3	-	-
	Commercial Upstream (Lighting)	1,269	1,381	0.2	0.2	-	-
	Retrofit - Custom	34,891	33,797	4.4	4.2	110,882	103,842
	Market Opportunities - Commercial Custom	4,056	3,929	0.6	0.5	65,278	61,134
	New Construction - Commercial Custom	10,520	10,485	2.7	2.1	21,724	21,290
Low-income Multifamily	Implementation Contractor DI	1,544	1,544	0.1	0.1	4,065	4,065
	LI Custom Projects	938	885	0.2	0.2	1,358	1,358
	Low-Income MF Comprehensive	2,331	2,199	0.5	0.5	2,416	2,416
Retail	Retail Efficient Appliances	946	947	0.1	0.1	370	369
	Retail Lighting	16,751	16,775	1.8	1.8	-	-
	Retail Efficient Products Gas	821	821	-	-	4,919	4,910
	Retail Lighting Food Bank	957	959	0.1	0.1	9	10
Portfolio		**93,958**	**92,686**	**12.9**	**12.4**	**211,414**	**199,803**

Findings and Recommendations

Our gross savings verification of the FY2017 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 tracked energy savings were calculated with a reasonable degree of accuracy.

However, our evaluation yielded several key findings and recommendations, as described below. Below are several bullets outlining our global recommendations.

- **Consider collecting and applying project-specific efficiency levels, wattages, capacities, and configurations to improve the accuracy of the tracked savings**. Deemed values or ranges for efficiency levels, wattages, capacities, and configurations were input into savings algorithms for some measures, including LEDs, refrigerators, and boilers. However, in some cases, project-specific input values were available or could be available if recorded, which would improve the accuracy of tracked savings.
- **Increase the precision of database entries to limit rounding errors.** We found that for certain measures some database values, in particular efficiency levels, were rounded up or down, which led to errors in the savings estimates.

Because the FY2017 commercial program evaluations emphasized lighting measures, most of our recommendations are specific to the calculation of lighting savings.

- **Apply the Waste Heat Factor based on the installation location of the lighting product rather than the measure code**. SEU currently assumes that 26% of lighting products are installed in exterior or unconditioned spaces. Waste heat factors[4] are applied to all measures that are considered likely to be interior equipment regardless of 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. Assigning waste heat factors in this fashion should be straightforward to implement and would improve the accuracy of tracked savings. This recommendation applies to both commercial and residential programs.
- **Calculate summer coincidence factors to ensure that peak demand savings are not understated due to an incongruency in energy and demand load shapes.** The blended interior commercial lighting coincidence factor[5] (CF) is set at about 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 in order for savings to be accurately estimated.
- **Reduce the summer coincidence factors from 4% to 0% for most exterior fixtures.** Most exterior LEDs come standard with integral photocells and an analysis of historical

[4] The waste heat factor accounts for cooling savings from efficient lighting.
[5] 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 on non-holiday weekdays from June through September.

sunrise and sunset times found that fixtures controlled by photocells will not have any summer coincidence. However, exceptions should be made for lighting that is permanently turned on and would therefore have a summer coincidence factor of 100%.

- **Update the TRM to reflect LED sub-measures**. It appears that the reported savings for some LEDs rely on sub-measures that are not specified in the TRM. The wattage assumptions differ between the TRM measure and the sub-measures, with a more accurate realization rate calculated based on the sub-measures wattage. Therefore, we recommend updating the TRM to include these sub-measures.
- **Consider requiring distributors to document the building type and anticipated locations of upstream bulbs and fixtures.** Due to the nature of upstream programs, there was very little documentation available for review. However, other upstream lighting programs have required distributors to record the building type and the anticipated location of installed fixtures at the point of sale which would allow for more accurate load-shapes and waste heat factors.

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

Section 1 Methodology

As discussed in the previous section, the FY2017 evaluation had an abbreviated scope due to the compressed timeframe. Therefore, the NMR team undertook the following evaluation activities:

- Program tracking database review
- Desk audits

1.1 Program Tracking Data Review

The first evaluation task was to conduct a comprehensive QA/QC review of DCSEU's participant database in order to assess evaluation priorities and identify key measures. The NMR team used the database for multiple tasks, including 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 measures account for the largest share of savings
- Which measures have the most and least uncertainty around their estimated savings
- How much evaluation work has been done for each measure in the past

1.2 Desk Audits

For the retail programs, this task entailed a measure-level review of the TRM savings algorithms for each measure, covering the entire program tracking database. In addition, we typically reviewed supporting files for a sample of projects. For the commercial and multifamily programs, we conducted a thorough review of detailed files for a sample of projects. Because the custom C&I projects are more complex than other projects, the custom C&I project file reviews entailed a more detailed and comprehensive engineering analysis.

1.2.1 Prescriptive Measures

For prescriptive measures, we assessed the accuracy and reasonableness of the savings parameters, in particular, measure quantities, efficiency levels, and baseline assumptions. In addition, we re-created the savings calculations using the TRM algorithms to ensure that the savings listed in the tracking database are accurate.

Evaluation efforts for prescriptive measures focused on the following:

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

1.2.2 Custom Measures

The thrust of the custom project desk audits involved the review of calculations 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.
- Review projects for the appropriateness of the baseline assumptions.
- Ensure the measure complies with program rules and is eligible.

1.3 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. The NMR team applied these realization rates to the tracked savings for each program and then summed them across the entire portfolio.

For FY2017 programs that did not undergo an evaluation, the NMR team assigned a default gross savings realization rate based on either (1) FY2017 realization rates for similar programs or measures or (2) previous realization rates for the same program. See Section 4.1 for more details.

1.4 Program 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 historical 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.

1.4.1 Program Savings Overview

Table 6 displays the percent of FY2017 tracked overall energy, electric, gas, and 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: FY2017 Tracked Gross Savings Summary by Sector

Sector	Percent of FY2017 Tracked Savings			
	Total Energy Savings (MMbtu)	Electric Savings (MWh)	Gas Savings (MMbtu)	Peak Demand Savings (MW)
Renewables	1%	2%	0%	5%
Residential	0%	0%	0%	0%
Commercial	83%	70%	103%	73%
Low-income Multifamily	5%	5%	4%	6%
Retail	11%	21%	-8%	16%
Total	**467,854**	**86,488**	**172,757**	**12.1**

Table 7 displays the percent of FY2017 tracked overall energy, electric, gas, and demand savings by program track. The three commercial custom programs, in particular the Retrofit Custom program, contribute the largest share of savings to the portfolio. Other programs that also contribute a significant share of savings include the Commercial Rx Equipment Replacement track and the Retail Lighting track. Appendix A provides descriptions for each of the program tracks offered by the DCSEU in FY2017.

Table 7: FY2017 Tracked Gross Savings Summary by Program

Sector	Program Name	Percent of FY2017 Tracked Savings			
		Total Energy Savings (MMbtu)	Electric Savings (MWh)	Gas Savings (MMbtu)	Peak Demand Savings (MW)
Renewables	Solar PV Market Rate	1%	2%	0%	4%
	Solar Photo Voltaic	0%	0%	0%	1%
	Solar Hot Water	0%	0%	0%	0%
Residential	Income Qualified	0%	0%	0%	0%
	Home Performance with Energy Star	0%	0%	0%	0%
	C&I RX - Equipment Replacement	7%	13%	-4%	10%
	Market Transformation Value	2%	4%	-1%	2%
Commercial	Commercial Upstream Lighting	1%	1%	0%	1%
	Retrofit - Custom	45%	37%	59%	35%
	Market Opportunities - Custom	16%	4%	37%	4%
	New Construction - Custom	12%	11%	12%	21%
Low-income Multifamily	Implementation Contractor DI	2%	2%	2%	1%
	LI Custom Projects	1%	1%	1%	1%
	Low-income MF Comprehensive	2%	2%	1%	4%
Retail	Retail Efficient Appliances	1%	1%	0%	1%
	Retail Lighting	8%	18%	-10%	14%
	Retail Efficient Products Gas	2%	1%	3%	0%
	Retail Lighting Food Bank	0%	1%	-1%	1%
Portfolio		**467,854**	**86,488**	**172,757**	**12.1**

Table 8 displays the percent of FY2017 tracked overall energy, electric, gas, and demand savings by measure type. Lighting represented about one-third of all energy savings, two-thirds of electric savings, and over one-half of demand savings. It also resulted in negative gas savings due to the heating penalty associated with efficient lighting. Heating measures represented over one-third of total energy savings and most of the gas savings.

Table 8: FY2017 Tracked Gross Savings Summary by Measure Type

Measure Type	Percent of FY2017 Tracked Savings			
	Total Energy Savings (MMbtu)	Electric Savings (MWh)	Gas Savings (MMbtu)	Peak Demand Savings (MW)
Cooling	6%	9%	0%	7%
Comprehensive	10%	7%	15%	16%
Hot Water	1%	0%	2%	0%
Lighting	33%	65%	-22%	54%
Motors	6%	9%	1%	8%
Solar	2%	4%	0%	7%
Heating	36%	2%	94%	4%
Building Shell	1%	0%	3%	1%
Other HVAC	4%	2%	7%	2%
Other	1%	1%	1%	1%
Total	**467,854**	**86,488**	**172,757**	**12.1**

1.4.2 Commercial and Renewable Programs

Because lighting represented 59% of electric savings and 28% of overall energy savings from the commercial and renewable sectors in FY2017, it was selected as the deep dive measure of interest. Therefore, we selected three programs for the evaluation that feature lighting as a key measure. Table 9 lists the number of projects and the sample size for desk reviews.

Table 9: C&I Impact Evaluation Sampling Plan

Program	FY2017 Participation	Desk Reviews
CI RX – Equipment Replacement	147	17
Commercial Midstream/Upstream	43	8
Retrofit - Custom	128	17
Total	**308**	**42**

1.4.3 Residential, Retail, and Low-income Multifamily Programs

While the Retail Lighting program represents the majority of residential, retail, and low-income multifamily program savings, lighting measures are a significant component of other programs too, in particular the Low-Income Multifamily programs. However, residential lighting impact parameters have already been thoroughly evaluated, and the EISA 2020 backstop requirement means that residential lighting will represent a declining share of portfolio savings in the future. Therefore, we distributed the impact evaluation effort more equitably across the residential programs, with a focus on programs that contribute a large share of savings, and on those with emerging measures (such as smart thermostats or heat pump technologies) that may help replace lighting savings.

Table 10 lists the number of projects and the sample size for desk reviews.

Table 10: Residential Impact Evaluation Sample Plan

Program	FY2017 Participation	Desk Audits
Low-income Multifamily Comprehensive	20	5
Low-income Multifamily Implementation Contractor Direct Install	17	5
Retail Lighting*	34,516	0
Retail Efficient Appliances	3,650	50
Retail Efficient Products - Gas	2,388	30
Total	**40,591**	**90**

*Because the Retail Lighting program is an upstream program, there are no individual projects available for review. However, we reviewed the TRM savings algorithms.

1.5 NET SAVINGS ESTIMATION

As described earlier, the NMR team will delay NTG measurement until FY2019, when the evaluation of the FY2018 programs commences. For the evaluation of the FY2017 programs, the 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.

Section 2 Commercial & Renewable Programs

In this section, we present a brief program summary, as well as the evaluation methodology, findings, and recommendations from our verification of gross savings for each of the three commercial sector programs selected for the FY2017 evaluation:

- CI RX Equipment Replacement
- Commercial Midstream/Upstream
- Custom Retrofit

2.1 CI RX Equipment Replacement (7511CIRX)

The CI 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, $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.

Savings were accrued and incentives were provided for 171 unique projects, completed at 147 sites, with lighting measures providing nearly all savings. See Table 11 for the measure types contributing savings to the FY2017 program.

Table 11: CI RX Equipment Replacement Savings Contributions

Measure Type	Percent of FY2017 Combined Energy Savings	Percent of FY2017 Electric Savings	Percent of FY2017 Gas Savings	Percent of FY2017 Peak Demand Savings
Lighting	99%	99%	100%	98%
VFD	1%	1%	0%	2%
Refrigeration	<1%	<1%	0%	<1%

2.1.1 Impact Evaluation

Table 12 displays the tracked savings, realization rate, and evaluated savings for the CI RX Equipment Replacement program. Overall, the evaluation proved the tracked energy savings to be calculated with a high degree of accuracy, garnering an electric realization rate of 100%. The

NMR team found that demand savings were significantly understated, while the natural gas heating penalty was significantly overstated.

Table 12: CI RX Equipment Replacement Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2017 Electric Savings (MWh)	11,572	100%	11,586
FY2017 Peak Demand Savings (MW)	1.18	125%	1.47
FY2017 Gas Savings (MMBtu)	-6,788	76%	-5,165

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 ±15% at 80% confidence, this required a selection of 17 unique sample sites. We employed stratified random sampling with ratio estimation for the prescriptive project selection. Utilizing the Dalenius-Hodges[6] method, we allocated the number of sample points across two substrata (large and small projects) based on each substratum's contribution to the program savings. Table 13 presents the final sampling plan for the CI RX Equipment Replacement Program.

Table 13: 7511CIRX Sampling Plan

Substratum	MWh Savings	Percent of Electric Savings	FY2017 Participation (Sites)	Number of Sampled Sites	Number of Sampled Projects*
Large	8,793	70%	40	12	12
Small	3,705	30%	107	5	6

*While the sample was designed at the site-level, the NMR team ultimately reviewed all individual projects contributing to a site. The final rollup of results is calculated at the project-level.

The selected sample included 17 sites and covered 17 lighting projects and one VFD project. The sample encompassed 1,501 MWh or 13% of the total tracked electric savings from the CI RX Equipment Replacement program.

2.1.1.2 Methodology

The NMR team conducted a desk review for each of the selected sample sites, through which we calculated the evaluated savings. The desk reviews relied on algorithms and assumptions presented in the Technical Reference Manual (TRM). When project files supported deviations in the TRM, the NMR team overwrote TRM assumptions with site specific data.

[6] The Dalenius-Hodges method is used in stratified random sampling to determine the optimal number of strata and where the strata cutoff points should be designed to maximize the explanatory power of each sample point.

The TRM-based algorithms and assumptions for prescriptive lighting measures are detailed below.

- 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	=	Change in connected load for the measure
ΔkWh	=	Electrical energy savings for the measure
ΔMMBtu	=	Natural gas savings for the measure
HOURS	=	Annual lighting hours of use; 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 (1.252 interior / 1.00 exterior)
WHF_e	=	Waste heat factor for energy to account for cooling savings from efficient lighting (1.133 interior / 1.00 exterior)
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%)

To facilitate the prescriptive lighting savings calculations, we employed a prescriptive lighting savings calculator tool. 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 (for example, the TRM makes the assumption 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 then mapped site specific inputs to the appropriate TRM baseline and installed wattages, coincidence factors, 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 made adjustments to the deemed values when enough information supported off-TRM values. 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 in order to more accurately portray the hours these fixtures were in use.

In addition to the 17 lighting projects reviewed, the evaluation team reviewed one VFD project. The TRM-based algorithms and assumptions for VFD measures are presented below.

- Electric Demand Savings (ΔkW):
  - $\Delta\text{kW} = DSVG * HP * OTF$

- Electric Energy Savings (ΔkWh)
  - $\Delta\text{kWh} = ESVG * HP * OTF$

Where:

ΔkW	=	Change in connected load for the measure
ΔkWh	=	Electrical energy savings for the measure
DSVG	=	Summer demand savings factor; provided in the TRM by equipment type
ESVG	=	Energy savings factor; provided in the TRM by equipment type
HP	=	Horsepower of the motor to which the VFD is applied
OTF	=	Operational testing factor (1.00 when project undergoes operational testing or commissioning services, 0.90 otherwise)

Similar to the methodology of the lighting projects, the evaluation team created a custom calculator, which was used to evaluate VFD 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 values differed from TRM assumptions.

2.1.1.3 Results

The program-wide impact results of the CI RX Equipment Replacement Program are shown in Table 14. The findings contributing to the realization rates are detailed in the text that follows.

Table 14: 7511CIRX Impact Results

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2017 Energy Savings (MWh)	11,572	100%	11,586	±9.4% @ 80%
FY2017 Peak Demand Savings (MW)	1.18	125%	1.47	±8.3% @ 80%
FY2017 Gas Savings (MMBtu)	-6,788	76%	-5,165	±12.3% @ 80%

While the program-level electric realization rate is 100%, project-specific realization rates ranged from 42% to 258%. Likewise, the project-specific demand realization rates ranged from 0% to 511%, and the gas savings realization rates ranged from 0% to 286%. The selected sample ultimately achieved an error ratio of 0.52 and ±9.4% precision at 80% confidence for electric savings. While the sample was not designed to achieve any precision thresholds at the measure-level, measure-level realization rates are presented in Table 15 for reference.

Table 15: 7511CIRX Realization Rates by Measure Type

Measure Type	Electricity Realization Rate	Peak Demand Realization Rate	Natural Gas Realization Rate
Lighting	100%	125%	76%
VFDs	100%	100%	N/A

The largest contributor to the project-level electric realization rates being less than or greater than 100% was the binning of LED wattages, which created either overstated or understated savings in 15 of the 17 reviewed lighting projects. The DCSEU TRM provides binned wattage assumptions that oftentimes vary considerably from the actual wattage of installed fixtures. For example, all omnidirectional lamps are assumed to be rated at 11.9 watts. However, as is evident in the translation from project-level to program-level realization rates, some wattages for fixtures were overstated and some were understated, such that the binning is deemed effective.

The largest contributor to the demand realization rate was an incongruence between hours of use (HOU) and coincidence factors (CF). 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 on non-holiday weekdays from June through September. Prescriptive lighting projects generally used a blended CF 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 in order for savings to be appropriately estimated. For example, if a customer inputs an HOU value of 8,760, the appropriate coincidence factor is 100% as the lights are guaranteed to be on during the peak window, but the reported savings will rely on 57.82%. This affected the reported savings adversely in six of the 17 reviewed lighting projects.

The largest contributor to the natural gas realization rate was differences in waste heat factors. The evaluation team noted that prescriptive lighting projects often utilize default waste heat factors (WHF) when more accurate site-specific data are available. There were several instances where WHFs were applied to exterior lighting, and other instances where they were overlooked for interior lighting of presumably air-conditioned spaces. DCSEU confirmed that a standard WHF is applied to all projects regardless of lamp location and that the WHF was developed to reflect the assumption that 26% of bulbs are installed in either exterior spaces or unconditioned interior spaces. The evaluation team's approach was to use site-specific data to more accurately apply waste-heat factors by space type.

2.1.2 Recommendations

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

- 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 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 off-TRM 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. While it is not recommended to use a standard CF value with a variable HOU value, for reference, the team calculated the blended coincidence factor based on the 17 lighting projects in the sample to be 73%.
- The TRM assigns a 4% summer coincidence factor 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. Exceptions should be made for 8,760-hour lighting where the summer coincidence factor would be 100%.
- The NMR team understands that the reported savings calculations rely on sub-measures that are not specified in the TRM. For example, pre-approval applications detail measures named such as LED-101, LED-102, LED-103, LED-104, and LED-105 that all map in the reported savings database to a measure code of LBLSBLED. The wattage assumptions vary between the TRM measure and the sub-measures. An alternate analysis was completed using sub-measure wattage assumptions, which garnered realization rates 8% and 9% lower for energy and demand savings, respectively. As these sub-measures provide more conservative savings and seem to be more in alignment with a market that has already shifted away from incandescent lighting, we recommend that the TRM be updated to reflect the sub-measures.

2.2 COMMERCIAL MIDSTREAM/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 for a discounted rate of $3 to $5 per lamp. Available lamp types include Energy Star 2.0 certified LED directional, omnidirectional, and

decorative bulbs, as well as DLC certified linear LED tubes. Savings were accrued and incentives were provided for 11 projects, spanning 33 sites and encompassing 8,881 new LEDs.

2.2.1 Impact Evaluation

Table 16 displays the tracked savings, realization rate, and evaluated savings for the Commercial Midstream/Upstream program. Overall, the evaluation found the tracked electric savings to be understated with realization rates of greater than 100% for both energy and demand, and the natural gas heating penalty to be significantly understated with a realization rate of 192%.

Table 16: Commercial Midstream/Upstream Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2017 Electric Savings (MWh)	1,175	109%	1,279
FY2017 Peak Demand Savings (MW)	0.15	108%	0.17
FY2017 Gas Savings (MMBtu)	-276	192%	-530

2.2.1.1 Sampling

Given the homogenous makeup of the program, we again assumed a coefficient of variation (C_v) of 0.5 for our initial sample design. With a precision target of ± 20% at the 80% confidence level, we required a selection of eight unique sample sites. We employed stratified random sampling, designating a certainty stratum to ensure the selection of key large projects.

Four sampling units within the Upstream Lighting Program contributed 71% of the total program savings. Due to their size, and therefore importance to the program, the NMR team assigned these four sites into a *certainty* stratum, for which we evaluated a census of projects. We selected the remaining four sample points at random from the remaining population. Table 17 presents the final sampling plan.

Table 17: Commercial Midstream/Upstream Sampling Plan

Substratum	MWh Savings	Percent of Program Electric Savings	FY2017 Participation (Sites)	Number of Sampled Sites
Certainty	894.8	71%	4	4
All Others	374.0	29%	29	4

*While the sample was designed at the site-level, projects often spanned multiple sites. For this evaluation, savings were only calculated for the portions of each project occurring at sampled sites.

The selected sample encompassed 914 MWh of tracked savings, or 83% of the total savings from the Commercial Midstream/Upstream program.

2.2.1.2 Methodology

As with the prescriptive lighting projects in the CI RX Equipment Replacement Program, we used our prescriptive lighting savings calculator to facilitate the upstream lighting savings calculations. The calculator auto-populated as much information as could be mined from the tracked savings database, and an engineer reviewed project documentation to make changes where values differed from TRM assumptions.

2.2.1.3 Results

The program-wide impact results are shown in Table 18. The findings contributing to the realization rates are detailed in the text that follows.

Table 18: Commercial Upstream/Midstream Lighting Program Impact Results

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2017 Electric Savings (MWh)	1,175	109%	1,279	±1.0% @ 80%
FY2017 Peak Demand Savings (MW)	0.15	108%	0.17	±1.0% @ 80%
FY2017 Gas Savings (MMBtu)	-276	192%	-530	±28.6% @ 80%

Each project in the sample had electric and demand realization rates of greater than 100%. The selected sample ultimately achieved ±1.0% precision at 80% confidence for electric and demand savings though a wider precision for gas savings.

The elevated electric energy and demand realization rates were caused by the binning of LED wattages, as described in the CI RX Equipment Replacement Program section. However, in the Commercial Upstream Lighting Program, all of the fixtures rebated through the program belonged to bins, which created understated savings, signifying that the wattage binning yields conservative savings for this program.

Project-level realization rates for natural gas were consistently observed around 200%, with one outlier (Project ID 14191) receiving a realization rate of 593%. While the binning of LED wattages contributed slightly to this result, the evaluation team believes there is an error in the calculating and reporting of the natural gas savings.

The TRM-based equation for calculating natural gas savings for the midstream program is given below:

$$\Delta\text{MMBtu} = \left(\frac{-\Delta Watts}{1000}\right) \times ISR \times HOURS \times 0.003412 \times \frac{(1 - OA) \times AR \times HF \times DFH}{\eta_{Heat}}$$

All variables in the equation with the exception of the ΔWatts term are constants. The HOURS term is dependent on whether the lamp is a linear replacement lamp or an integrated screw-based LED lamp. For simplicity of reporting, the equation reduces to the following two equations:

$$\Delta\text{MMBtu}_{Linear} = -3.09 \times \Delta\text{kW}$$

$$\Delta\text{MMBtu}_{Screw} = -2.04 \times \Delta\text{kW}$$

Table 19 provides examples of the suspected miscalculations.

Table 19: Examples of Miscalculated Natural Gas Savings

Measure ID	Type	Tracked ΔkW	Constant from Equation	Calculated MMBTU	Tracked MMBTU
203552	Linear	16.5	-3.09	-51.0	-37.5
196809	Screw	55.6	-2.04	-113.4	-24.0
196810	Screw	67.7	-2.04	-138.1	-29.2

2.2.2 Recommendations

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

- While the wattage bins provided conservative savings estimates, collecting actual installed lamp wattages would enhance the accuracy of reported savings.
- Due to the nature of upstream programs, there was very little documentation available for review and therefore savings calculations relied solely on TRM assumptions. Other upstream lighting programs have had success with requiring distributors to document the building type and anticipated location of installed fixtures, which would allow for better assignment of load-shapes and waste heat factors.
- Correct errors in the calculation and reporting of natural gas savings to match the TRM-supported algorithm and assumptions.
- Apply waste heat factors and other measure parameters based on readily available site-specific data such as space types.

2.3 CUSTOM RETROFIT (7520CUST)

The Custom Retrofit Program provides incentives to owners of large buildings who replace equipment prior to the end of its useful life. The program offers incentives for a variety of equipment types, including lighting, chillers, boilers, heat pumps, steam systems, insulation, refrigeration, and various building and 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, in which participants are paid per unit of energy saved, but also through partnerships with lenders in the District who may provide up to 100% of a project's cost.

In FY2017, the program provided incentives for 119 projects completed at 128 sites[7]. Table 20 details the breakdown of tracked savings by measure type. All measure types contributing less than 1% of the total combined savings are listed as other; this category includes industrial process

[7]The Commercial Custom Retrofit program allows customers to apply for rebates for upgrades completed at multiple sites on one application. Therefore, projects can span across several sites, leading to larger site counts than project counts.

upgrades, domestic hot water measures, commercial kitchen equipment, refrigeration measures, water conservation measures, and photovoltaic systems.

Table 20: Custom Retrofit Program Savings Contributions

Measure Type	Percent of FY2017 Combined Energy Savings	Percent of FY2017 Electric Savings	Percent of FY2017 Gas Savings	Percent of FY2017 Peak Demand Savings
Central Plant	40%	3%	84%	10%
Lighting	22%	47%	-8%	50%
HVAC	16%	19%	12%	13%
Motor/VFD	11%	20%	1%	18%
Whole Building	8%	10%	6%	4%
Building Envelope	2%	0%	4%	4%
Other	1%	1%	1%	1%

2.3.1 Impact Evaluation

Table 21 displays 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 the 90% to 100% range.

Table 21: Custom Retrofit Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2017 Electric Savings (MWh)	32,276	97%	31,264
FY2017 Peak Demand Savings (MW)	4.18	94%	3.92
FY2017 Gas Savings (MMBtu)	102,328	94%	95,831

2.3.1.1 Sampling

Due to the heterogeneous makeup of the program, the Custom Retrofit Program sample design employed stratified random sampling. The NMR team designed the sampling plan to ensure the sample included a diverse mix of measure types – encompassing both lighting and non-lighting measures. We created a lighting stratum, from which we selected projects at random. We then delineated a non-lighting stratum into large and small substrata, with sample points allotted based

on savings contributions in accordance with the Dalenius-Hodges[8] method. Table 22 presents the final sampling plan for the Custom Retrofit program.

Table 22: Custom Retrofit Sampling Plan

Stratum	Percent of Program Energy Savings	FY2017 Participation*	Number of Sampled Sites
Lighting	20%	65	3
Non-Lighting, Large	75%	24	11
Non-Lighting, Small	5%	59	3

*The total participation for the Retrofit Commercial Custom program is based on number of sites in the program. The participation in strata is not mutually exclusive (i.e., one project can be selected with either its lighting or non-lighting measures in its respective stratum).

2.3.1.2 Methodology

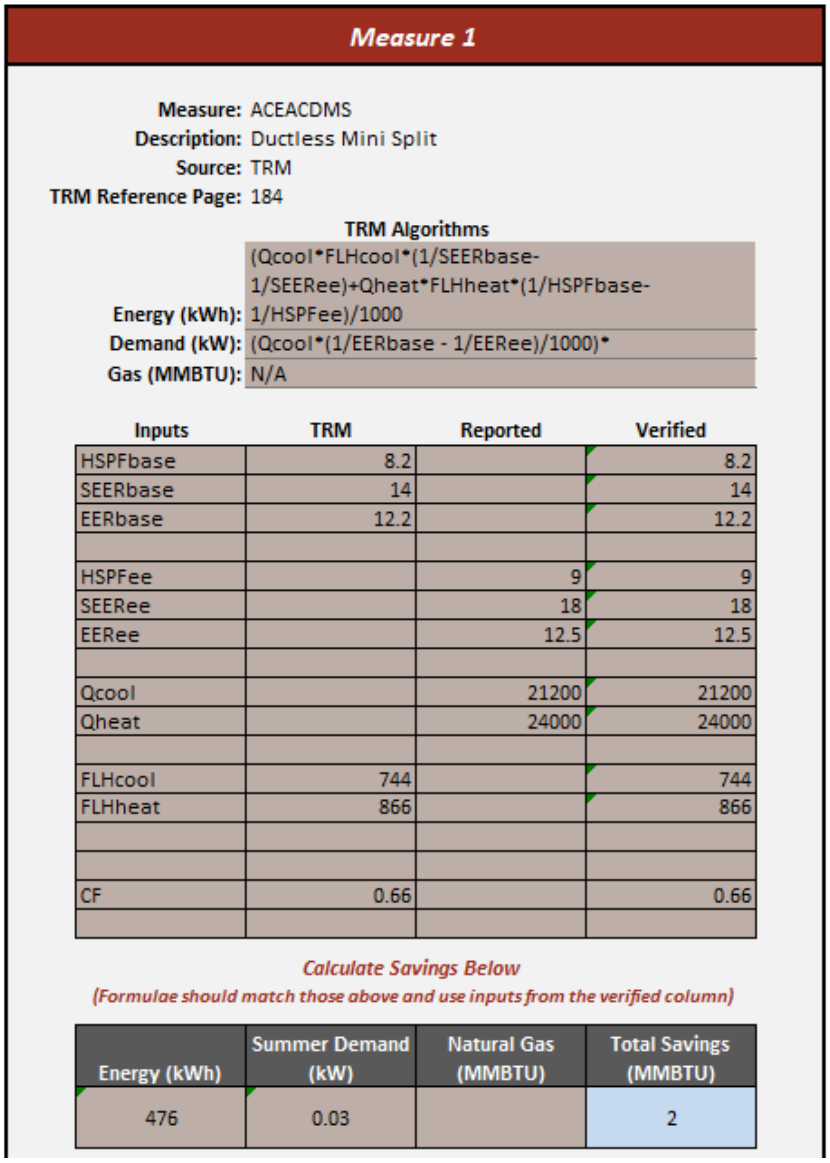
The NMR team conducted a desk review for each of the selected sample sites, through which the verified savings were calculated. The methodology varied by measure; each measure analyzed fell under one of two evaluation paths:

- For measures that exist in the TRM and when TRM algorithms were used by the DCSEU, the NMR team performed a comparative review of the TRM measures and the project details to determine the TRM's applicability. In the event the TRM was deemed relevant and applicable, desk reviews relied on algorithms and assumptions presented in the TRM, with methodological adjustments and adjustments to the assumptions as appropriate for the site-specific information provided.
- For measures that do not exist in the TRM and for TRM measures where the TRM was deemed not applicable, engineers reviewed all submitted documentation and determined the suitability of the equations and assumptions used to calculate the tracked savings. In the event that 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 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 1 shows an example of the calculator used for a Ductless Mini Split measure.

[8] The Dalenius-Hodges method is used in stratified random sampling to determine the optimal number of strata and where the strata cutoff points should be designed to maximize the explanatory power of each sample point.

Figure 1: Example of Custom Savings Calculator



Measure 1

Measure: ACEACDMS
Description: Ductless Mini Split
Source: TRM
TRM Reference Page: 184

TRM Algorithms

Energy (kWh):	(Qcool*FLHcool*(1/SEERbase-1/SEERee)+Qheat*FLHheat*(1/HSPFbase-1/HSPFee)/1000
Demand (kW):	(Qcool*(1/EERbase - 1/EERee)/1000)*
Gas (MMBTU):	N/A

Inputs	TRM	Reported	Verified
HSPFbase	8.2		8.2
SEERbase	14		14
EERbase	12.2		12.2
HSPFee		9	9
SEERee		18	18
EERee		12.5	12.5
Qcool		21200	21200
Qheat		24000	24000
FLHcool	744		744
FLHheat	866		866
CF	0.66		0.66

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)
476	0.03		2

During the desk review process, our engineers created a calculator for each project within the sample. The engineers reviewed the automatically loaded data for correctness and completeness. Then, they reviewed the project files in order to make a determination as to the verified value of each discrete input. Savings calculations ultimately relied on the verified values.

2.3.1.3 Results

The program-wide impact evaluation results for the Custom Retrofit Program are shown in Table 23. The findings that contributed to the realization rates are detailed in the text that follows.

Table 23: Custom Retrofit Program Impact Results

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings	Precision & Confidence
FY2017 Electric Savings (MWh)	32,276	97%	31,264	±1.4% @ 80%
FY2017 Peak Demand Savings (MW)	4.18	94%	3.92	±3.5% @ 80%
FY2017 Gas Savings (MMBtu)	102,328	94%	95,831	±3.4% @ 80%

The program-level realization rates are nearly 100%; the selected sample ultimately achieved a ±1.4% precision at 80% confidence for electric savings, ±3.5% precision for demand savings, and ±3.4% precision for gas savings.

In general, the evaluation 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.

The evaluation team and DCSEU often used different methodologies to analyze the peak coincidence of custom measures which contributed to the 94% realization rate in kW savings. This should not be taken as evidence that the reported savings were not calculated appropriately; on the contrary, the NMR team maintains a high degree of confidence in the reported savings. As this was an independent evaluation, comparisons between the methodologies used between the tracked and verified savings are supplied for the benefit of DCSEU where they are easily understood. However, given the intricacies of methods used to create the reported savings, these comparisons are not as readily available for the custom measures as they are for other programs.

Disparate methodologies aside, minor errors were found in project-level analyses that resulted in realization rates less than or greater than 100%. These issues are detailed below:

- The reported savings calculations were often affected by the propagation of error that occurs when intermediate calculation values are truncated, which provides a larger effect down the line in the calculations. This could be resolved by utilizing active calculations rather than hard-coded input values.
- The NMR team found that select motor calculations omitted the conversion from horsepower to kW.
- Inconsistencies noted in previous sections regarding the calculation of natural gas savings for interactive measures and binned wattages for lighting measures had a larger effect due to fewer lighting measures over which the overestimated and/or underestimated savings could balance themselves.
- The NMR team found that key input parameters such as equipment quantities and efficiencies were misrepresented for four projects.
- The realization rate of less than 100% for natural gas savings comes from two boiler projects which were affected by errors in reported values, as noted in the bullet above. One project (ID 12606) misreported the delta temperature portion of the savings algorithm

for the two largest boilers, leading to overestimated savings. Another boiler project (ID 13995) accidentally used the load factor as the efficiency in the calculation of savings.

2.3.2 Recommendations

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

- Savings calculations would be more easily audited and would achieve a higher level of accuracy if calculations were left intact rather than using macros to import, or otherwise manually inputting hard-coded values into CAT files.
- Inspect the calculation algorithm for the determination of natural gas savings, which currently does not accurately calculate savings.

Section 3 Residential, Retail, and Low-Income Multifamily Programs

In this section, we present a brief program summary, as well as the evaluation methodology, findings, and recommendations from our verification of gross savings for each of the five Retail and Low-income Multifamily sector programs selected for the FY2017 evaluation:

- Retail Efficient Appliances
- Retail Efficient Gas Products
- Retail Lighting
- Low-Income Multifamily Implementation Contractor Direct Install
- Low-Income Multifamily Comprehensive

3.1 Retail Efficient Appliances (7710APPL)

In FY2017, the Retail Efficient Appliances program offered mail-in and online rebates for qualifying refrigerators, clothes washers, clothes dryers, heat pumps, air conditioners, boilers, furnaces, thermostats, and other products. The DCSEU partnered with local retailers and contractors to promote these rebates.

In addition, the program offered free energy-efficient kits to customers in FY2017. Each kit included six LEDs, one advanced power strip, and one faucet aerator. The kit was mailed to customers upon request.

The types of eligible products and the rebate amounts are listed in Table 24.

Table 24: Retail Efficient Appliances, Measures, and Rebates

Measure Category	Eligibility Criteria	Rebate Amount
Energy-Efficiency Kits	None	Free
Clothes Washers	Energy Star/CEE Tier 1, Energy Star Most Efficient/CEE Tier 2 or CEE Tier 3	$50/$75
Clothes Dryers	Energy Star or 2014 Emerging Technology Award criteria	$50/$150*
Refrigerators	Energy Star, CEE Tier 2, CEE Tier 3	$50/$75
Heat Pumps: Water Source+	Minimum 4.6 COP & 14.7 EER	$300 - $750
Air Source, Ductless++	Tier 1, 9 HSPF, 13 EER, 16 SEER Tier 2, 9.5 HSPF, 13 EER, 18 SEER	
Central Air Conditioners	Tier 2: 13 EER, 16 SEER Tire 3: 13 EER, 18 SEER	$250/$500
Boilers	Energy Star with AFUE ≥ 85%	$750
Furnaces	AFUE ≥ 90% and a fan furnace efficiency ≤ 2.0%	$500

Measure Category	Eligibility Criteria	Rebate Amount
Water Heaters	Energy Star	$300
Thermostats	**	$25
Dehumidifiers	Energy Star	$25

*$50 for electric; $150 for gas.
+ Capacity of under 135,000 Btu/h.
++ Capacity under 65,000 Btu/h.
**For programmable thermostats: a programmable thermostat is installed and programmed by a professional. For advanced thermostats: replacement of a manual-only or programmable thermostat, with one that has the default enabled capability – or the capability to automatically – establish a schedule of temperature setpoints according to driving device inputs above and beyond basic time and temperature data of conventional programmable thermostats; must employ two-way communication.

3.1.1 Impact Evaluation

Table 25 displays the tracked savings, realization rate, and evaluated savings for the Retail Efficient Appliances program. We found some discrepancies with the tracked savings due to the incorrect application of prescriptive values and rounding errors. Despite these variances, the realization rates still equaled 100%.

Table 25: Retail Efficient Appliances Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2017 Electric Savings (MWh)	876	100%	877
FY2017 Peak Demand Savings (MW)	0.1	100%	0.1
FY2017 Gas Savings (MMBtu)	-400	100%	-399

3.1.1.1 Methodology

We reviewed the tracking database to ensure that the savings algorithms from the TRM were applied correctly for 9,968 measures that represent 100% of FY2017 program electricity savings and demand savings. In addition, we conducted desk reviews, which entailed reviewing rebate invoices from EFI; customer lists; rebate lists; and summary files containing customer names, addresses, item codes, quantities, efficiencies, product specifications, and rebate amounts for the sampled sites.

3.1.1.2 Sampling Plan

Table 26 displays the percent of FY2017 energy savings, total number of customer sites, and the number of desk audits by measure category for the Efficient Appliances program. We allocated 50 desk reviews to the Efficient Appliances program given the diversity of measures that contribute savings as well as the anticipated future savings opportunities for emerging measures such as clothes dryers and heat pumps. While the energy-efficiency kits are responsible for the majority of program savings, we understand there is no supporting documentation available and therefore did not assign any desk reviews.

Table 26: Efficient Appliances Desk Review Sample Plan

Measure Category	Percent of FY2017 Combined Energy Savings	Percent of FY2017 Electric Savings	Percent of FY2017 Gas Savings	Percent of FY2017 Peak Demand Savings	Total Number of FY2017 Sites	Number of Sampled Sites
Energy-Efficiency Kits	65%	80%	-178%	59%	2,700	0
Clothes Washers	13%	5%	46%	6%	387	15
Clothes Dryers	7%	6%	3%	6%	304	10
Refrigerators	4%	3%	0%	3%	449	10
Heat Pumps	4%	3%	0%	4%	30	5
Central Air Conditioners	3%	2%	0%	20%	58	5
Boilers/Furnaces	3%	0%	19%	0%	12	5
Others	1%	1%	2%	2%	44	0
Thermostats	1%	0%	9%	0%	9	0
Total	100%	100%	-100%	100%		50

3.1.1.3 Results

For the majority of measures, the customer names, quantities, item codes, and product efficiency values in the program tracking data matched those in the documentation that DCSEU provided. In addition, we recreated the savings calculations using the TRM algorithms in order to calculate realization rates.

Energy-Efficiency Kits

The home energy kit savings are calculated using prescriptive savings factors and therefore do not require site-specific input.

- Advance power strip – the advance power strip inputs correlate to the TRM deemed savings values. Electricity and demand savings realization rates equal 100%.
- Faucet aerator/flow restrictor – for the faucet aerators, prescriptive inputs are used and electricity and demand savings realization rates equal 100%. However, the gas realization rate came out to 140% due to a rounding error in the database: the entered MMBtu savings of 0.0279 is rounded to 0.02.
- LED screw base lamp – the SEU estimated the energy and demand savings using the savings factors in the TRM. Electricity, demand, and gas realization rates all equal 100%.

Clothes washers

- We were unable to match the deemed gas savings using the TRM equations due to the incorrect placement of parentheses in the TRM equation. However, using the parentheses placement in the FY2018 TRM equation, we achieved a realization rate of 100% for the Tier 1 and 2 washers, and 99% for the Tier 3 washers.

Clothes dryers

- Demand realization rates range from 92% for the gas dryer to 128% for the heat pump dryer. The difference in estimated gas dryer demand savings may be due to rounding. The heat pump demand savings' calculation in the database divides by 365, assuming one load per day, rather than utilizing the deemed hours value of 286 provided in the database.

Refrigerators

- The SEU calculated all savings values for Tier 2 models using the weighted base energy consumption rather than the base consumption based on configuration type. Therefore, electricity savings realization rates range from 87%-105%, and demand realization rates range from 95%-115%.

Heat pumps

- The team verified that the heat pump cooling capacities and SEERs had been entered correctly into the program tracking data. However, not all of the inputs required for the heat pump TRM savings algorithms were stored in the program tracking data. Therefore, we manually extracted heating capacities, COPs, and EERs from the Comprehensive Analysis Tool (CAT) files for each measure.
- Calculated electric savings values were in line with database entries. Evaluating the demand savings with the TRM formula resulted in realization rates of 111% for ductless mini-split heat pumps and 45% for the air-source heat pumps.

Dehumidifiers

- Using prescriptive inputs based on the capacity ranges specified by the item codes, we computed electric and demand savings realization rates of 100%. If it is feasible to collect exact capacity values, this would increase savings accuracy in the future.

Central air-conditioners

- The TRM algorithm for central air-conditioning assumes a deemed SEER 15 for all CEE Tier 2 units. However, the SEERs recorded in the summary files for the four sampled CEE Tier 2 units were SEER 16 and above. This suggests that the tracked savings estimates based on the deemed SEER values are conservative.

Natural gas boilers & furnaces

- The tracked energy savings for boilers and furnaces were not based on the site-specific AFUE and capacities that had been entered into the program tracking data. Instead, the DCSEU assumed deemed capacity and AFUE values for all boilers and furnaces due to a concern that these inputs had not been consistently entered into the program tracking

data in consistent units. In its savings estimates, the DCSEU assumed 94% AFUE for furnaces and 85% AFUE for boilers. The AFUEs for the five sampled sites ranged from 95% to 97%, suggesting that the tracked savings estimates based on the deemed AFUEs are conservative. With the deemed capacity and AFUE values, the realization rate for these measures equaled 100%.

Natural gas water heaters

- Realization rates for continuous models equal 100%, while realization rates for the stand-alone models fall just short of 100%, likely due to the rounding of inputs in the TRM and/or the database.

Thermostats

- The program included two types of thermostats: advanced thermostats and setback thermostats. The advanced thermostat TRM characterization assumes that the thermostat is controlling the whole home's heating/cooling load. Even though DCSEU provides incentives for up to two thermostats per home, the TRM characterization states that the second thermostat does not provide any additional savings. Most of the records in the program tracking data were for the purchase of a single thermostat. However, we identified a number of records where two thermostats had been purchased at once and the tracked savings were twice that of a single thermostat. For cases in which two thermostats were purchased and recorded savings were twice that of a single thermostat, the team reduced the evaluated savings by one-half. This adjustment resulted in a gas realization rate of 90%.

Table 27: Retail Efficient Appliances Savings and Realization Rates by Measure Type

Measure Category	FY2017 Electric Savings (MWh)			FY2017 Peak Demand Savings (MW)			FY2017 Gas Savings (MMBtu)		
	Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated
Energy-Efficiency Kits	699	100%	699	0.1	100%	0.1	-713	99%	-706
Clothes Washers	44	100%	44	<0.1	100%	<0.1	184	100%	184
Clothes Dryers	50	100%	50	<0.1	111%	<0.1	11	94%	10
Refrigerators	27	103%	28	<0.1	99%	<0.1	0	-	0
Heat Pumps	28	100%	28	<0.1	81%	<0.1	0	-	0
Central Air Conditioners	19	100%	19	<0.1	101%	<0.1	0	-	0
Boilers/Furnaces	0	-	0	0.0	-	0.0	76	100%	76
Others	8	100%	8	<0.1	100%	<0.1	6	100%	6
Thermostats	<1	100%	<1	0.0	100%	0.0	35	90%	31
Total	**876**	**100%**	**877**	**0.1**	**100%**	**0.1**	**-400**	**100%**	**-399**

3.1.2 Recommendations

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

- Consider using site-specific configurations, capacities, and efficiency levels where available rather than deemed inputs in order to increase the accuracy of database savings.
- Add checks to the tracking data entry process to ensure that key inputs such as heating equipment AFUEs are consistently entered in the same units and that efficiency values are not rounded up to 1.0.
- Clarify in the TRM that demand savings are based on the larger of the heating or cooling load reduction, and provide an equation for calculating the heating load demand reduction.
- Add the section of the advanced thermostat TRM characterization that addresses savings from two thermostats to the setback thermostat TRM characterization.
- Record HSPF and heating capacity values for heat pumps in the program tracking database to expedite the review process by eliminating the need to manually pull these values from each project's CAT file.
- If it is possible to collect exact capacity values for dehumidifiers, rather than specifying a range, this would increase the accuracy and precision of the energy savings calculations.

3.2 Retail Efficient Gas Products (7711GAS)

In FY2017, the DCSEU partnered with local retailers and contractors to promote rebates for thermostats, efficient boilers and furnaces, and efficient water heaters. Customers could submit rebates by mail, email, or by filling out an online rebate form. Through partner agreements with advanced thermostat manufacturers, the DCSEU verified the number of active devices by zip code.

The types of eligible products and the rebate amounts are listed in Table 28.

Table 28: Retail Efficient Gas Products Measures and Rebates

Measure Category	Eligibility Criteria	Rebate Amount
Boilers	ENERGY STAR qualified with AFUE ≥ 85%	$500/$750*
Furnaces	AFUE ≥ 90% & fan furnace efficiency < 2.0%	$500
Water Heaters	Tankless: 0.97 Energy Factor Storage: 0.67 Energy Factor	$300
Advanced Thermostats	Capable of two-way communication**	$100
Setback Thermostats	Capable of scheduling setbacks to heating set points	$25

*$500 for boilers with 90% to 94.9% AFUE; $750 for boilers with 95% AFUE or higher.
**Must replace a manual-only or programmable thermostat, and have the capacity to automatically establish a schedule of temperature setpoints according to driving device inputs above and beyond basic time and temperature data of conventional programmable thermostats.

3.2.1 Impact Evaluation

Table 29 displays the tracked savings, realization rate, and evaluated savings for the Retail Efficient Gas Products program. While we found some minor discrepancies with the tracked savings, the realization rates still equal to 100%.

Table 29: Retail Efficient Gas Products Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2017 Electric Savings (MWh)	760	100%	760
FY2017 Peak Demand Savings (MW)	0.0	-	0.0
FY2017 Gas Savings (MMBtu)	4,919	100%	4,910

3.2.1.1 Methodology

We reviewed the tracking database to ensure that the savings algorithms from the TRM were applied correctly for 2,663 measures that represent 100% of FY2017 program energy savings. In addition, we conducted desk reviews, which entailed reviewing rebate invoices; customer lists; rebate lists; and summary files containing customer names, addresses, item codes, quantities, efficiencies, and rebate amounts for 30 sampled sites.

3.2.1.2 Sampling Plan

Table 30 displays the percent of FY2017 energy savings, total number of customer sites, and the number of desk audits by measure category for the Efficient Gas Products program. We allocated 30 desk reviews to the program given the small number of measures that contribute savings. The

NMR team assigned one-half of the 30 desk reviews to thermostats, which represent nearly all of the Efficient Gas Products program savings.

Table 30: Efficient Gas Products Desk Review Sample Plan

Measure Category	Percent of FY2017 Combined Energy Savings	Percent of FY2017 Electric Savings	Percent of FY2017 Gas Savings	Percent of FY2017 Peak Demand Savings	Total Number of FY2017 Sites	Number of Sampled Sites
Thermostat	94%	100%	94%	100%	2,336	15
Boiler/Furnace	6%	0%	6%	0%	44	10
Water Heating	1%	0%	1%	0%	20	5
Total	**100%**	**100%**	**100%**	**100%**		**30**

3.2.1.3 Results

We found that product quantities and item codes in the program tracking data matched those in the documentation that DCSEU provided; however, product capacity and efficiency values sometimes did not match. In addition, while we calculated a realization rate of 100% for each of the measure categories, we identified several issues that could potentially decrease the accuracy of savings estimates.

Thermostats

- The program included two types of thermostats: advanced thermostats and setback thermostats. The advanced thermostats accounted for about 99% of thermostat energy savings, and all 15 thermostat sites sampled for desk reviews were advanced thermostats. The advanced thermostat TRM characterization assumes that the thermostat is controlling the whole home's heating/cooling load. Even though DCSEU provides incentives for up to two thermostats per home, the TRM characterization states that the second thermostat does not provide any additional savings. Most of the records in the program tracking data were for the purchase of a single thermostat. However, we identified several records where two thermostats had been purchased at once and the tracked savings were twice that of a single thermostat.
- Unlike the advanced thermostat TRM characterization, the setback thermostat TRM characterization does not explicitly state that there should be no additional savings when a second thermostat is purchased. For cases in which two thermostats were purchased, and recorded savings were twice that of a single thermostat, the team reduced the evaluated savings by one-half. However, this adjustment did not impact the realization rate because there were very few instances where two thermostats were purchased at once.
- The tracked electric and demand savings for advanced thermostats installed in multifamily homes did not follow the TRM algorithm. The team reviewed source files referenced in the

TRM and discovered that the FY2017 TRM algorithm omitted the household factor[9] variable for cooling savings. The DCSEU corrected this error in the FY2018 TRM characterization for advanced thermostats.

Boilers and Furnaces

- For two of the ten sampled sites, the 0.95 and 0.98 AFUEs listed in the summary files had been rounded up to 1.0 in the program tracking data. The summary files generally did not contain unit capacities, so the team was unable to validate the capacity values in the program tracking data.
- The tracked energy savings for boilers and furnaces were not based on the site-specific AFUE and capacities that had been entered into the program tracking data. Instead, the DCSEU assumed deemed capacity and AFUE values for all boilers and furnaces due to a concern that these inputs had not been consistently entered into the program tracking data. In its savings estimates, the DCSEU assumed 94% AFUE for furnaces and 85% AFUE for boilers. Since 85% is the minimum required boiler AFUE for ENERGY STAR qualification, and many of the boiler AFUEs listed in summary files exceeded 85%, the team considers these savings estimates to be conservative. Therefore, the DCSEU could potentially accrue more accurate and higher boiler savings by utilizing actual AFUEs rather than the deemed 85% AFUE.

Water Heaters

- The energy factor listed in the summary files had been entered correctly into the program tracking data for four of the sampled sites, but had been rounded up to 1.0 for one site.

[9] The household factor adjusts consumption for multifamily households based on the premise that average multifamily heating and cooling loads are smaller than those of single-family households.

Table 31: Retail Efficient Gas Products Savings and Realization Rates by Measure Type

Measure Category	FY2017 Electric Savings (MWh)			FY2017 Peak Demand Savings (MW)			FY2017 Gas Savings (MMBtu)		
	Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated
Thermostat	760	100%	760	0.0	-	0.0	4,606	100%	4,596
Boiler/Furnace	0	-	0	0.0	-	0.0	278	100%	278
Water Heating	0	-	0	0.0	-	0.0	35	100%	35
Total	**760**	**100%**	**760**	**0.0**	**-**	**0.0**	**4,919**	**100%**	**4,910**

3.2.2 Recommendations

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

- Add the section of the advanced thermostat TRM characterization that addresses savings when two thermostats are purchased to the setback thermostat TRM characterization.
- Add checks to the tracking data entry process to ensure that key inputs such as heating equipment AFUEs are consistently entered in the same units and that efficiency values are not rounded up to 1.0.
- Consider using actual capacities and AFUEs for boilers and furnaces (rather than deemed values) in order to increase the accuracy of savings estimates.

3.3 RETAIL LIGHTING (7710LITE)

The Retail Lighting initiative is an upstream program that works to increase availability and sales of LED and CFL bulbs in the District of Columbia. Partnering with retailers and manufacturers, the 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 FY2017, the Retail Lighting Initiative offered rebates for qualifying ENERGY STAR CFL and LED lightbulb purchases, including LED recessed surface or pendant downlights, LED screw base lamps, LED lighting fixtures, and compact fluorescent screw-base bulbs. Working with area distributors, the 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. These manufacturers work with stores to gather sales reports that they submit along with the invoice requests.

3.3.1 Impact Evaluation

Table 32 displays the tracked savings, realization rate, and evaluated savings for the Retail Lighting program. We found some minor discrepancies with the tracked electric and demand savings, however the realization rates were within ±1% of 100%. The gas savings realization rate was 114% due to several issues, as described below.

Table 32: Retail Lighting Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2017 Electric Savings (MWh)	15,511	100%	15,533
FY2017 Peak Demand Savings (MW)	1.73	101%	1.74
FY2017 Gas Savings (MMBtu)	-16,481	114%	-18,791

3.3.1.1 Methodology

We reviewed the tracking database to ensure that the savings algorithms from the TRM were applied correctly for all 207,089 measures that represent 100% of FY2017 program electric savings and demand savings. With no site-specific inputs, the NMR team used deemed wattage values and prescriptive inputs to calculate electric, demand, and gas savings.

3.3.1.2 Results

While the team calculated a realization rate of 100% for electric savings, we identified several issues that could potentially reduce the accuracy of savings estimates.

LED screw-base bulbs

- The electric and demand savings analysis resulted in realization rates of 100%, while the calculated fuel penalty differs from the values in the tracking database. For the residential and Community Promotional Event measures, this difference stems from rounding errors in the database. Calculated values for fuel savings in commercial installations are over six times higher than the database values. This stems in part from a discrepancy in formulas, and is also due to a rounding error. The equation for commercial installations multiplies by the residential heating factor in addition to the equation on the TRM page. It also multiplies by the heating system efficiency rather than dividing by it, as prescribed in the TRM.

LED fixtures

- The deemed electric savings and demand savings listed in the TRM for outdoor commercial lighting fixtures are overestimated. Because these are outdoor fixtures, it is not necessary to apply a waste heat factor to account for cooling savings from reducing waste heat from efficient lighting.
- An incorrect waste heat factor was also applied for indoor residential demand savings, which led to under-estimated savings. When calculating residential energy savings, our result, using the TRM formula, exceeds the deemed value by 3%. In addition, indoor commercial energy and fuel savings calculations differ from database entries due to rounding by 1% and 7%, respectively.
- Residential fuel consumption changes utilize an in-service rate (ISR) of 1.0, a heating factor value of 0.5, and a %GasHeat value of 62.5%. These values represent the prescriptive inputs listed in the FY2018 TRM, as opposed to the values of 0.95, 0.23, and 76% listed on the FY2017 TRM page, respectively.

LED recessed downlights

- Calculated heating penalty values failed to line up with database entries. The residential gas heating disparity is due to a rounding error in the database. For commercial heating penalties, we were unable to corroborate the deemed savings value in the TRM, calculating a value over twice the deemed value. A rounding error in the database added to the discrepancy.

CFL screw-base bulbs

- Residential and commercial heating penalty realization rates equal 47% and 112%, respectively. For the commercial value, this variation derives from a rounding error in the database. For residential installations, we were unable to confirm the deemed gas savings using the TRM algorithm, resulting in a realization rate of 47%.

Table 33: Retail Efficient Lighting Savings and Realization Rates by Measure Type

Measure Category	FY2017 Electric Savings (MWh)			FY2017 Peak Demand Savings (MW)			FY2017 Gas Savings (MMBtu)		
	Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated
LED Screw-Base Bulb	13,583	100%	13,591	1.5	100%	1.5	-14,391	117%	-16,889
LED Lighting Fixture	958	101%	971	0.1	112%	0.1	-965	58%	-562
LED Downlight	929	100%	929	0.1	100%	0.1	-1,074	122%	-1,313
CFL Screw-Base Bulb	41	100%	41	<0.1	104%	<0.1	-52	52%	-27
Total	**15,511**	**100%**	**15,533**	**1.73**	**101%**	**1.74**	**-16,481**	**114%**	**-18,791**

3.3.2 Recommendations

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

- Increase the precision of database entries to limit rounding errors.
- Apply waste heat factors by lighting fixture type for interior installations.
- In order to identify and correct any potential errors in either the TRM or the tracking data, DCSEU should investigate why the reported gas heating penalties in the tracking data do not match the deemed values listed in the TRM.
- Doublecheck equations in the TRM to ensure that they produce the deemed savings results.

3.4 LOW-INCOME MULTIFAMILY COMPREHENSIVE (7612LICP)

The Low-Income Multifamily Comprehensive (LICP) initiative 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 FY2017, ECMs included heating and cooling systems, domestic hot water systems, in-unit and common area lighting, appliances, controls, and low flow water fixtures.

3.4.1 Impact Evaluation

Table 34 displays the tracked savings, realization rate, and evaluated savings for the Low-Income Multifamily Comprehensive Savings program. Realization rates range from 94% for electric savings to 100% for gas savings.

Table 34: Low-Income Multifamily Comprehensive Savings and Realization Rates

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2017 Electric Savings (MWh)	2,159	95%	2,046
FY2017 Peak Demand Savings (MW)	0.45	97%	0.44
FY2017 Gas Savings (MMBtu)	2,336	100%	2,336

3.4.1.1 Methodology

We performed measure reviews for the five sampled projects with corresponding TRM characterizations to check that tracked savings were reasonable and to determine which measures merited further review. The NMR team identified twenty-four measures within the LICP track for closer analysis. Each measure review and audit examined product documentation, particularly Comprehensive Analysis Tool (CAT) files, to identify the source of any discrepancies between verified and reported savings, and to assess the accuracy of the savings parameters.

3.4.1.2 Sampling Plan

We conducted desk reviews of supporting documentation for the five projects with the most energy savings. For the Low-Income Multifamily Comprehensive program, the top five sites represented about 47% of the tracked energy savings from all 20 sites that participated in the program in FY2017.

3.4.1.3 Results

For most measures, we found a realization rate of about 100%. We summarize the evaluation findings for each measure below.

Heat Pumps

- The program tracking database contained two air-source heat pump records with demand savings listed. Peak demand savings calculated using the TRM formula failed to line up

with tracking database values. The electricity savings realization rates equaled 100% for both projects.

Water fixtures

- The project with faucet aerator/restrictors included a file in the supporting documentation that shows the calculations used for this measure. However, the formulas and some of the inputs in this file do not match those in the TRM. Electric savings were overstated, while the demand savings were underestimated.
- The low-flow water mixture, mixed types measure lacks a TRM algorithm to confirm savings. Therefore, we could only validate that the database savings match those in the CAT file. One project provided an ea_template file, which calculates savings; however, values calculated do not match those in database.
- Supporting documentation for the low-flow showerhead project shows that incorrect inputs were utilized to calculate the savings entered into the CAT file and database for base flow rates, minutes/person/day, and recovery efficiency. TRM values and calculations yield an energy savings realization rate of 80% and demand savings realization rate of 306%.

Lighting

For the lighting measures as a whole the electric realization rate equaled 88%, while the demand and gas realization rates equaled 100%.

- The baseline and efficient wattages used to calculate LED flood light fixture tracked savings differed from the baseline and efficient wattages listed in a project file in which the existing and proposed fixture wattages were stored. We recalculated the savings based on the verified baseline and efficient wattages, resulting in electric and demand realization rates of 80%.
- The LED surface/pendant downlight measure had one project sampled. Applying inputs from the program database and CAT file into the TRM algorithm produces an electric realization rate of 99% and a demand realization rate of 116%.
- The relamp/reballast conversion of an existing fixture to standard T8 measures included one sampled project. The electric and demand savings we calculated based on the TRM algorithm exceeded database savings, so we believe the database entries are conservative estimates.

Furnaces & Boilers

- For the natural gas boiler measure, we found that our gas savings were reasonably close to the tracked savings calculated with the more sophisticated boiler savings tool, which we assume provides a more accurate estimate of gas savings. Therefore, we applied a realization rate of 100%.
- The efficiency level recorded in the program tracking database for the sampled natural gas furnace is 1.0, which suggests that the database inappropriately rounded it up to the nearest whole number.

Appliances

- For the project with clothes washers, we validated electric and demand savings using inputs from the spec sheet to produce an electric realization rate of 100% and a demand realization rate of 99%. Additionally, we observed a lack of consistency in reported savings and capacity values across the supporting documentation for the one project reviewed. The capacity listed in the project narrative was not used in Energy Star Appliance Calculator calculations. Also, the energy savings listed in the narrative as derived from the Energy Star Appliance Calculator do not match the values in the database.
- Because no TRM characterization exists for dishwashers, we attempted to validate the savings using the Energy Star calculator. Plugging the reported input values into the Energy Star Appliance Calculator produces energy and demand savings realization rates of 85%.
- Although a TRM characterization exists for refrigerators, the SEU estimated the refrigerator savings using the Energy Star Appliance Calculator. The NMR team accepts the Energy Star Appliance Calculator savings as they are based on the actual refrigerator configuration and volume, as opposed to the deemed TRM savings which are based on a market weighted average of configurations. The capacities and configurations listed on spec sheets had been entered correctly into the Energy Star Appliance Calculators for all sampled records but one. After updating the savings for this record by revising the Energy Star Appliance Calculator inputs to match the spec sheet, we calculated an overall electric realization rate of 84%. The Energy Star Appliance Calculator does not calculate demand savings. Following the TRM algorithm, we calculated a demand realization rate of 135%.

Unitary Air-Conditioners

- Following the TRM algorithm, we calculated an electric savings realization rate of 123%. We determined that the discrepancy between the tracked savings and our evaluated savings was due to the use of full load cooling hours for a unit smaller than the size of the unit recorded in the database.
- The Demand Efficiency Factor (DEFee) listed in the database was incorrect; however, plugging in the DEFee from a supporting CAT file produced a 100% demand realization rate.

Table 35: Low-Income Multifamily Comprehensive Savings and Realization Rates by Measure Type

Measure Category	FY2017 Electric Savings (MWh)			FY2017 Peak Demand Savings (MW)			FY2017 Gas Savings (MMBtu)		
	Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated
Boilers/Furnaces	0	100%	0	0.0	-	0.0	806	100%	806
Clothes Washers	84	100%	84	<0.1	99%	0.1	0	-	0
Comprehensive Building-Wide Savings	723	100%	723	0.2	100%	0.2	852	100%	852
Controls	0	-	0	0.0	-	0.0	89	100%	89
Cooling	97	123%	119	<0.1	100%	<0.1	0	-	0
Dishwashers	16	85%	14	<0.1	85%	<0.1	20	100%	20
Exhaust Fans	42	84%	36	0.0	69%	0.0	0	-	0
Furnace Fan Motors	24	100%	24	<0.1	-	<0.1	0	-	0
Heat Pumps	101	100%	101	<0.1	79%	<0.1	0	-	0
Insulation	5	100%	5	0.0	-	0.0	0	-	0
Lighting	680	88%	598	<0.1	100%	<0.1	-80	100%	-80
Low Flow Water Fixtures	98	61%	60	<0.1	232%	<0.1	270	100%	270
Refrigerators	38	84%	32	<0.1	135%	<0.1	0	-	0
Variable Frequency Drive	251	100%	251	<0.1	100%	<0.1	0	-	0
Water Heating	0	-	0	0.0	-	0.0	380	100%	380
Total	**2,159**	**95%**	**2,046**	**0.45**	**97%**	**0.44**	**2,336**	**100%**	**2,336**

3.4.2 Recommendations

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

- Review the calculation of demand savings for heat pumps to ensure the savings are calculated based on cooling demand rather than heating demand.
- Add checks to the program tracking data entry process to ensure that key inputs are consistently entered in the same units, and to ensure that efficiency values are not rounded up to 1.0. As noted earlier in this report, we observed instances in which the efficiency rating stored in the program database had been rounded up to 1.0.
- Provide a high-level summary of calculation logic and input parameters for custom calculators. Several measures in this track do not have TRM characterizations. In some cases, the SEU used relatively complex calculators to estimate savings. Providing a summary of the calculation logic and input parameters similar to those in the TRM could improve the accuracy and efficiency of evaluation efforts.
- To ensure the evaluation team can confirm TRM equations, provide deemed values on TRM pages (or in available linked files), especially for lighting measures. This would be helpful to verify whether a discrepancy is due to an error in our application of the formula or an aberration in the data.

3.5 Low-Income Multifamily Implementation Contractor Direct Install (7610ICDI)

The Low-Income Multifamily Implementation Contractor Direct Install (ICDI) initiative was promoted to property owners, property managers, developers, architects, and engineers. The initiative covered 100% of the costs (products and direct installation) and hired implementation contractors to directly install the equipment. Through the ICDI initiative, all spaces in a building could be served, including common areas and individual residential units. In FY2017, measures included heating and cooling systems, domestic hot water systems, in-unit and common area lighting, refrigeration, and controls.

3.5.1 Impact Evaluation

Table 36 displays the tracked savings, realization rate, and evaluated savings for the Low-Income Multifamily Implementation Contractor Direct Install program. We found some minor discrepancies with the tracked demand savings, however all realization rates were within ±1% of 100%.

Table 36: Low-Income Multifamily Implementation Contractor Direct Install

Savings Type	Tracked Savings	Realization Rate	Evaluated Savings
FY2017 Electric Savings (MWh)	1,430	100%	1,430
FY2017 Peak Demand Savings (MW)	0.14	99%	0.14
FY2017 Gas Savings (MMBtu)	2,645	100%	2,645

3.5.1.1 Methodology

We performed measure reviews for all sampled database projects to check that tracked savings were reasonable and to determine which measures merited further review. The NMR team identified fifteen measures within the ICDI track for closer analysis. Each measure review and audit examined product documentation, particularly CAT files, to identify the source of any discrepancies between calculated and reported savings and assess the accuracy of the savings parameters.

3.5.1.2 Sampling Plan

We conducted desk reviews of supporting documentation for the five projects with the most energy savings. For the Low-Income Multifamily Implementation Contractor Direct Install program, the top five sites represent about 67% of the tracked energy savings from all 17 sites that participated in the program in FY2017.

3.5.1.3 Results

We summarize the evaluation findings for each measure below.

Natural Gas Boilers

- The boiler savings tool, which is based on the methodology presented in the U.S. DOE's Commercial Packaged Boilers Technical Support Document, is substantially more complex than the TRM algorithm. We replicated gas savings using the TRM algorithm and site-specific inputs from the CAT files. We found that the gas savings we calculated were substantially different from the tracked savings calculated with the more sophisticated boiler savings tool. Because the boiler savings tool requires dozens of inputs and includes detailed documentation, we assume that the tracked savings are correct.

LED Lighting

- Our review of the lighting measures revealed that the calculations in the CAT files utilized different waste heating factors, in-service rates (ISR), and heating system efficiency values than those listed in the TRM. Also, for installations that resulted in a heating penalty, the calculation to determine this penalty varied slightly from the TRM. However, we determined that the inputs that varied from those listed in the TRM were reasonable. Utilizing these inputs in the TRM algorithm results in electric, demand, and gas realization rates of 100% for most of the types of LED lighting installed through the program. One exception is LED surface and pendant downlights, for which we calculated a demand realization rate of 87%.

Unitary Air-Conditioners

- One project was sampled, representing 100% of track measure savings. We validated energy and demand savings using the TRM algorithm and the site-specific inputs pulled from the database and CAT file, producing energy and demand realization rates of 100%.

3.5.2 Recommendations

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

- Provide a high-level summary of calculation logic and input parameters for custom calculators. A high-level summary of the calculation logic and input parameters for the boiler savings tool would allow evaluators to more effectively assess the accuracy of the savings estimates.

Table 37: Low-Income Multifamily Implementation Contractor Direct Install Savings and Realization Rates by Measure Type

Measure Category	FY2017 Electric Savings (MWh)			FY2017 Peak Demand Savings (MW)			FY2017 Gas Savings (MMBtu)		
	Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated	Tracked	Realization Rate	Evaluated
Lighting	1,237	100%	1,237	0.1	99%	0.1	-1,420	100%	-1,420
Cooling	177	100%	177	<0.1	100%	<0.1	0	-	0
Boilers/Furnaces	16	100%	16	<0.1	100%	<0.1	4,065	100%	4,065
Total	**1,430**	**100%**	**1,430**	**0.14**	**99%**	**0.14**	**2,645**	**100%**	**2,645**

Section 4 Realization Rate and Net-to-Gross Review

Because of the compressed timeframe for the FY2017 evaluation, we did not verify gross savings for all programs, nor did we measure the NTG ratio for any program. Therefore, this section provides a description of the reviews undertaken to assign default realization rates and NTG values.

4.1 Default Realization Rates

As described in Section 1.4, the FY2017 evaluation verified the gross savings for eight programs. In order to assign default realization rates for the ten programs that were not evaluated for FY2017, we reviewed previous realization rates for these SEU programs, as well as the calculated FY2017 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 rates for similar programs or similar measures if they exist. If no similar programs exist, we applied the average realization rates from the FY2013 to FY2015 period for the same program as it represents a typical realization rate value.

Table 38 lists each of the ten programs that did not undergo an evaluation in FY2017, the source of the realization rate, and the default realization rate values.

Table 38: FY2017 Default Realization Rates

Sector	Program Name	Source for Default Realization Rate	Default Realization Rates		
			Electric Savings	Peak Demand Savings	Gas Savings
Renewables	Solar PV Market Rate	Avg from FY2013-FY2015 Evaluations	100%	100%	100%
	Solar Photo Voltaic	Avg from FY2013-FY2015 Evaluations	101%	101%	0%
	Solar Hot Water	Avg from FY2013-FY2015 Evaluations	100%	100%	101%
Residential	Income Qualified	Avg from FY2013-FY2015 Evaluations	99%	92%	106%
	Home Performance with Energy Star	Avg from FY2013-FY2015 Evaluations	97%	92%	109%
Commercial	Market Transformation Value	FY2017 Evaluation for Lighting from CI RX program	100%	125%	76%
	Market Opportunities - Custom	FY2017 Evaluation for Retrofit-Custom program	97%	94%	94%
	New Construction - Custom	Avg from FY2013-FY2015 Evaluations	100%	78%	98%
Low-Income Multifamily	Low-income Custom Projects	FY2017 Evaluation for LIMF Comprehensive program	94%	97%	100%
Retail	Retail Lighting Food Bank	FY2017 Evaluation for Retail Lighting	100%	101%	114%

4.2 NET-TO-GROSS REVIEW

As described earlier, the NMR team, with approval from the DOEE, delayed NTG measurement until the evaluation of the FY2018 programs. Therefore, we primarily based the FY2017 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 that launched since FY2014), the team derived NTG values from similar programs from other jurisdictions or applied assumed values. Table 39. presents the recommended NTG estimates for FY2017 programs.

Table 39. Recommended FY2017 NTG Estimates

Sector	Track	Program	NTG Value	Source
Renewables	7101PVMR	Solar PV Market Rate	90%	Assumed
	7107PV	Solar Photo Voltaic	100%	FY2014
	7110SHOT	Solar Hot Water	100%	FY2014
Residential	7401FHLB	Income Qualified	95%	FY2014
	7420HPES	Home Performance with Energy Star	90%	FY2014
Commercial	7511CIRX	C& I RX - Equipment Replacement	50%	FY2014
	7512MTV	Market Transformation Value	90%	FY2014
	7513UPLT	Commercial Upstream Lighting	85%	Lit review
	7520CUST	Retrofit - Custom	60%	FY2014
	7520MARO	Market Opportunities - Custom		
	7520NEWC	New Construction - Custom	60%	Assumed
Low-Income Multifamily	7610ICDI	Implementation Contractor DI	100%	FY2013
	7610LICP	Low-Income Custom Projects	100%	Assumed
	7612LICP	Low-Income MF Comprehensive	83%	FY2013
Retail	7710APPL	Retail Efficient Appliances	Appliances: 65%	FY2014
			HVAC: 70%	FY2014
	7710LITE	Retail Lighting	51%	FY2013
	7711GAS	Retail Efficient Products Gas	80%	Lit review
	7717FBNK	Retail Lighting Food Bank	100%	Assumed

To inform the derived FY2017 NTG estimates, the 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:

- **Solar PV Market Rate (7101PVMR):** This initiative was launched in FY2015; therefore, the NTG was not previously measured. Because we did not identify NTG studies for similar programs in other jurisdictions, we applied a slightly lower NTG value (90%) than was estimated in FY2014 for the income-eligible Solar Photo Voltaic initiative (7107PV, 100%). We assume that the NTG for the market rate program would be slightly lower than the income-eligible program.
- **New Construction - Commercial Custom (7520NEWC):** The NTG for this initiative was not measured in either FY2013 or FY2014 due to low participation – there was just one participant in each year. Most of the NTG studies we reviewed did not report separate NTG values for commercial new construction programs. The evaluation team assumes that the NTG for this initiative would be similar to the Retrofit - Commercial Custom (7520CUST) and Market Opportunities - Commercial Custom (7520MARO) programs, which were jointly measured in FY2014 at ≥60%. For FY2017, we assume 60% for New

Construction - Commercial Custom (7520NEWC), which is within the range reported for commercial custom programs elsewhere (37%-79%).[10]

- **Low-income Custom Projects (7610LICP):** The NTG for this initiative was not measured in either FY2013 or FY2014. We assume the NTG equals 100%, which is commonly applied to low-income programs.
- **Retail Lighting Food Bank (7717FBNK):** The NTG for this program was not measured in either FY2013 or FY2014. We assume the NTG equals 100%, which is regularly assumed for low-income programs.

Table 40. compares the most recent DCSEU NTG estimates with the NTG values from other jurisdictions. The table also includes the evaluation team's assumed estimates where 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 39. are reasonable values for FY2017.

[10] Of the reports that we reviewed, EmPOWER Maryland is the only report that provided NTG values for their C&I new construction program. The NTG was 76%, which is higher than our assumed value of 60% for DCSEU, but is comparable to the 78% that was estimated for the EmPOWER Maryland C&I custom retrofit program.

Table 40. DCSEU NTG Values Compared to Other Jurisdictions

Track	Initiative	DCSEU NTG (FY2013/2014)	Benchmark NTG	Benchmark Source Program Administrator (Program Year)
Renewables				
7101PVMR	Solar PV Market Rate	N/A	--	--
7107PV	Solar Photo Voltaic	~100%	--	--
7110SHOT	Solar Hot Water	100%	--	--
Residential				
7401FHLB	Income Qualified	95-100%	81%	PA Duquesne Light (2015-2016)[a]
			100%	PA First Energy Companies (2016-2017, assumed)[b]
			100%	PA PPL (2016-2017, assumed)[c]
7420HPES	Home Performance with ENERGY STAR	~90%	68%	PA PPL (2016-2017)
			94%	PA PECO (2016-2017)[d]
			50%	PA First Energy Companies (2016-2017)
			81%	EmPOWER Maryland (2016)[e]
Commercial				
7511CIRX	C& I RX - Equipment Replacement	≥50%	77%	PA PPL (2016-2017)
			41-100%	PA First Energy Companies (2016-2017)
			76%	EmPOWER Maryland (2016)
7512MTV	Market Transformation Value	≥90%	66-85%	PA First Energy Companies (2016-2017)
7513UPLT	Commercial Upstream Lighting	N/A	LEDs: 82% Linear fluor: 74%	MA (2012)[f]
			98%	RI National Grid (2016)[g]
			88%	PA Duquesne Light (2016-2017)[1]
			85%	EmPOWER Maryland (2016)[2]
7520CUST 7520MARO	Retrofit - Custom Market Opportunities - Custom	≥60%	79%	PA PPL (2016-2017)
			37-56%	PA First Energy Companies (2016-2017)
			78%	EmPOWER Maryland (2016)
7520NEWC	New Construction - Custom	Not assessed	76%	EmPOWER Maryland (2016)

Track	Initiative	DCSEU NTG (FY2013/2014)	Benchmark NTG	Benchmark Source Program Administrator (Program Year)
7610ICDI	Implementation Contractor DI	Elec=93% Gas=132%	100%	Efficiency Maine (2012-2013, assumed)[h]
Low-Income Multifamily				
7610LICP	LI Custom Projects	Not assessed	--	--
7612LICP	Low-Income MF Comprehensive	83%	71%	PA Duquesne Light (2015-2016)
Retail				
7710APPL	Retail Efficient Appliances	Appliances: ~60-70%	77%	PA PPL (2016-2017)
			66%	PA PECO (2016-2017)
			59%	PA Duquesne Light (2015-2016)
			47-52%	PA First Energy Companies (2016-2017)
			66%	EmPOWER Maryland (2016)
		HVAC: ~70-125%	56%	PA PECO (2016-2017)
			45-56%	PA First Energy Companies (2016-2017)
			63%	EmPOWER Maryland (2016)
7710LITE	Retail Lighting	51%	CFLs, LEDs=69%	PA Duquesne Light (2015-2016)
			CFLs, LEDs= 27-39%	PA First Energy Companies (2016-2017)
			LEDs=83%	PA PPL (2016-2017)
			Std LEDs=51% Spec LEDs=46% CFLs=40%	PA PECO (2016-2017)
			CFLs, LEDs=65%	EmPOWER Maryland (2017)i
7711GAS	Retail Efficient Products Gas	N/A	Furnace=45% Boiler=40%	CT Companies (2017)[j]
			Furnace=81% Boiler=77%, Storage WH=100% Tankless WH=93%	MA (2012)[k]
			Wi-fi t-stat=96%	MA (2012)[l]

Track	Initiative	DCSEU NTG (FY2013/2014)	Benchmark NTG	Benchmark Source Program Administrator (Program Year)
			Wi-fi t-stat=78% Furnace=72% Boiler=77% Conv Boiler=95% Water Heater=78%	Anonymous Northeast State (2016)[3]
			Furnace=76% Boiler=79%	Anonymous Northeast State (2016)[3]
7717FBNK	Retail Lighting Food Bank	Not assessed	--	--

Notes:

[1] Represents NTG value from Duquesne Light's Nonresidential Midstream Lighting Program.

[2] 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.

[3] Results from NTG studies that are not yet published for two Northeastern states.

Sources:

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[j] West Hill Energy and Computing. October 20, 2017. *CT HVAC and Water Heating Process and Impact Evaluation Report and CT Heat Pump Water Heater Impact Evaluation Report. R1614/R1613 Review Draft.* Prepared for the CT EEB Evaluation and Administration Team including Lisa Skumatz, Ralph Prahl, and Robert Wirtshafter. https://www.energizect.com/sites/default/files/R16141613_ResHVAC_ReportReviewDraft122217a.pdf.

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Appendix A Program Descriptions

This appendix provides a description for each of the program tracks offered by the DCSEU in FY2017.

A.1 Renewables Sector

Solar PV Market Rate (7101PVMR), Solar Photo Voltaic (7107PV), & Solar Hot Water (7110SHOT)

These initiatives encourage renewable energy development with both low-income communities and market rate customers. The DCSEU works with contractors to identify potential properties for customer-sited renewable energy systems. The Solar Photo Voltaic track (7107PV) facilitates the installation of solar PV systems in low-income buildings, while the solar hot water track (7110SHOT) facilitates the installation solar domestic hot water systems in low-income buildings. A market rate offering (7101PVMR) including both Solar PV and Solar Hot Water was launched in FY2015.

A.2 Residential Sector

Income Qualified (7401FHLB)

The Income Qualified Home Performance initiative (formerly the Federal Home Loan Bank initiative) tracks low-income single-family existing home projects and provides income eligible customers with funding sources to implement audit recommendations. Through this initiative, income qualified homeowners may receive up to $5,000 in home energy efficiency improvements and up to $1,000 in health and safety improvements for a total of up to $6,000. This initiative is promoted to potential households through referrals from contractors and initiative partners.

Home Performance with Energy Star (7420HPES)

The Home Performance with ENERGY STAR® (HPwES) Initiative is a national program sponsored by the US Department of Energy (US DOE) and operated locally by the DCSEU. Typical HPwES home improvement projects include a comprehensive energy audit of a home conducted by a certified HPwES contractor resulting in a report with recommended energy efficiency improvements. The homeowner then works with the contractor to decide on which improvements make the best sense for the home and the homeowner's budget. The certified contractor then completes the agreed upon home efficiency improvements.

The HPwES initiative targets the District of Columbia's residents living in single-family homes, row homes (each unit is ground to sky), or converted (1 to 4 unit) apartments and row homes.

Both owner-occupied homes and rental properties with the property owners' authorization are eligible to participate.

A.3 COMMERCIAL SECTOR

C&I RX - Equipment Replacement (7511CIRX)

The CI 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.

Market Transformation Value (7512MTV)

The T12 Market Transformation (MTV) initiative targets small- to medium-sized businesses. The MTV program provides upgrades for old, inefficient T12 fluorescent tube lighting to high efficiency T8 products in qualifying businesses, institutions, and multifamily residential buildings in the District. The DCSEU staff and Certified Business Enterprise (CBE) contractors are responsible for outreach to potential participants. The CBE contractors install eligible equipment, and DCSEU staff inspect 100 percent of the projects prior to release of the financial incentive.

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 track is a component of the C&I Custom Services ("Non-prescriptive") initiative, which provides incentives to owners of large buildings who replace equipment prior to the end of its useful life. The program offers incentives for a variety of equipment types, including lighting, chillers, boilers, heat pumps, steam systems, insulation, refrigeration, and various building and 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, in which participants are paid per unit of energy saved, but also through partnerships with lenders in the District who may provide up to 100% of a project's cost.

Market Opportunities - Custom (7520MARO)

The Market Opportunities track is a component of the C&I Custom Services ("Non-prescriptive") initiative. The Market Opportunities track focuses on major renovation projects and retrofit projects where equipment is at the end of its life. The key features of the track offset the incremental costs

of adding more energy efficient equipment compared to the current energy code and provide comprehensive technical services.

New Construction - Custom (7520NEWC)

The New Construction track is a component of the C&I Custom Services ("Non-prescriptive") initiative. The New Construction track focuses on new construction buildings. Typically projects in this track are reviewed and analyzed with energy models from the customer. The key features of the track offset the incremental costs of adding more energy efficient equipment than the current code requires and provide comprehensive technical services during design stage.

A.4 Low-Income Multifamily Sector

Implementation Contractor Direct Install (7610ICDI)

The Low-Income Multifamily Implementation Contractor Direct Install (ICDI) initiative was promoted to property owners, property managers, developers, architects, and engineers. The initiative covered 100% of the costs (products and direct installation) and hired implementation contractors to directly install the equipment. Through the ICDI initiative, all spaces in a building could be served, including common areas and individual residential units. In FY2017, measures included heating and cooling systems, domestic hot water systems, in-unit and common area lighting, refrigeration, and controls.

Low-Income Multifamily Comprehensive (7612LICP) & Custom Projects (7610LICP)

These initiatives are designed to serve low-income multifamily housing—specifically, new construction, substantial renovation, and redevelopment housing. Each project is independently evaluated and specific energy conservation measures (ECM) are chosen depending on the project's needs. Some of these ECMs will include measures affecting the thermal envelope (air and thermal barriers, doors, and windows), domestic hot water systems, in-unit and common area lighting, appliances, and controls. Projects tracked under 7610LICP are generally focused on specific end uses, whereas the 7612LICP projects are comprehensive in nature and related to gut-rehab or new construction type projects.

The initiatives work with developers and owners of low-income multifamily projects who are constructing, redeveloping, or rehabilitating affordable housing projects. The initiatives provide custom technical services and incentives for energy efficiency improvements.

A.5 Retail Sector

Retail Efficient Appliances (7710APPL)

In FY2017, the Retail Efficient Appliances program offered mail-in and online rebates for qualifying refrigerators, clothes washers, clothes dryers, heat pumps, air conditioners, boilers, furnaces, thermostats, and other products. The DCSEU partnered with local retailers and

contractors to promote these rebates. In addition, the program offered free energy-efficient kits to customers in FY2017 that included six LEDs, one advanced power strip, and one faucet aerator.

Retail Lighting (7710LITE)

The Retail Lighting initiative is an upstream program that works to increase availability and sales of LED and CFL bulbs in the District of Columbia. Partnering with retailers and manufacturers, the 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. Working with area distributors, the DCSEU also offered lighting rebates to District contractors and businesses for these products at the time of purchase.

Retail Efficient Products Gas (7711GAS)

In FY2017, the DCSEU partnered with local retailers and contractors to promote rebates for thermostats, efficient boilers and furnaces, and efficient water heaters. Customers could submit rebates by mail, email, or by filling out an online rebate form. Through partner agreements with advanced thermostat manufacturers, the DCSEU verified the number of active devices by zip code.

Retail Lighting Food Bank (7717FBNK)

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