Performance Benchmark Assessment of FY2017 DC Sustainable Energy Utility Programs

FINAL

September 28, 2018

SUBMITTED TO:
District of Columbia Department of Energy and Environment

SUBMITTED BY:
NMR Group, Inc.
Ecometric Consulting
Demand Side Analytics
Blue Path Labs
Setty and Associates

Table of Contents

Key Highlights

This report presents the results of an independent assessment of the performance of the District of Columbia Sustainable Energy Utility (DCSEU) energy programs against established benchmarks for Fiscal Year 2017 (FY2017). In FY2017 the DCSEU achieved the minimum target for all five annual benchmarks and achieved the maximum target for three of five annual benchmarks (Table 1). The second year of the DCSEU contract should provide the DCSEU with the opportunity to leverage external funds to achieve the maximum green jobs target and realize savings from longer-term low-income projects to achieve the maximum low-income savings target.

Table 1: FY2017 Annual Performance Benchmarks Summary

Annual Benchmark		Minimum Target Achieved	Maximum Target Achieved
Reduce Electricity Consumption		✓	✓
Reduce Natural Gas Consumption		✓	✓
Increase Renewable Energy Generating Capacity		✓	✓
Improve Energy Efficiency of Low-income Properties	Expenditures	✓	*n/a*
	Savings	✓	X
Increase Green-collar Jobs		✓	X

The cost of first-year electricity savings for the DCSEU in FY2017 is less than that of nearby PECO Energy and Baltimore Gas and Electric indicating that the DCSEU is delivering programs at a cost that is better than neighboring utilities. In addition, cost-effectiveness testing found that the DCSEU portfolio was cost-effective as a whole although the two residential programs were not cost-effective.

Executive Summary

NMR Group, EcoMetric Consulting, Demand Side Analytics, BluePath Labs, and Setty – collectively referred to as *the NMR team* – were contracted by the District of Columbia Department of Energy and Environment (DOEE) to evaluate the energy-efficiency and renewable energy programs implemented by the District of Columbia Sustainable Energy Utility. This report presents the results of our independent assessment of the DCSEU's Fiscal Year 2017 programs and performance against established benchmarks. The DCSEU FY2017 programs began on October 1, 2016 and ended on September 30, 2017.

Unlike the previous DCSEU contract, which involved a series of one-year renewals, the current DCSEU contract has a five-year base period, with an option to extend for an additional five years. The DCSEU officially began working under this new multiyear contract in April 2017. The DCSEU's performance against established benchmark targets is based upon all results attained against performance benchmarks under Option Year 6 of Contract No. DDOE-2010-SEU-001 combined with FY2017 results achieved under the new multiyear contract.

The NMR team and DOEE agreed to contract terms on March 30, 2018. In order to quickly measure the DCSEU's progress towards its FY2017 performance benchmarks, the NMR team focused our evaluation efforts on an abbreviated gross savings verification of the DCSEU's FY2017 energy programs. For more details on our evaluation methodology and findings for each of the residential and commercial energy programs selected for evaluation, please review the *Evaluation of DC Sustainable Energy Utility FY2017 Programs* report. In addition, Appendix A provides descriptions for each of the program tracks offered by the DCSEU in FY2017.

PERFORMANCE BENCHMARK AND TRACKING GOALS ASSESSMENT

The DCSEU contract specifies six performance benchmarks related to energy savings, renewable energy generation capacity, expenditures, leveraging funds, and job creation that the DCSEU is responsible for achieving as outlined in Table 2. Three of the six benchmarks provide performance incentives associated with meeting or exceeding the minimum performance targets on an annual basis and cumulative basis, while the leveraging external funds benchmark provides an incentive at the end of a cumulative five-year period. Additionally, the low-income and green jobs benchmarks provide incentives for meeting or exceeding the minimum performance targets on an annual basis only. Likewise, penalties will be assessed on an annual basis if the DCSEU fails to achieve the minimum targets for the low-income and green jobs benchmarks; while penalties for the electric, gas, renewable energy, and leveraging funds benchmarks will be assessed at the end of the five-year period if the DCSEU fails to achieve the cumulative minimum targets.

In FY2017, the DCSEU achieved the minimum target for each of the five performance benchmarks with annual targets (Table 2). In addition, the DCSEU achieved the maximum target for three of the five benchmarks with annual targets.

Table 2: FY2017 Performance Benchmarks Summary

Benchmark Type	Benchmark		Verified Results	Minimum Benchmark		Maximum Benchmark	
				Target	Achieved	Target	Achieved
Annual Target	Reduce Electricity Consumption (MWh)		92,686	60,878	✓	86,473	✓
	Reduce Natural Gas Consumption (Therms)		1,998,033	852,565	✓	1,705,129	✓
	Increase Renewable Energy Generating Capacity (kW)		2,244	650	✓	1,000	✓
	Improve Energy Efficiency of Low-income Properties	Expenditures	$3,898,925	$3,834,596	✓	*n/a*	*n/a*
		Savings (MMbtu)	28,858	23,278	✓	46,556	X
	Increase Green-collar Jobs		84	66	✓	88	X
Five-Year Cumulative Target	Leverage External Funds		$439,111	$2.5M	*n/a*	$5.0M	*n/a*

Figure 1 illustrates the percentage progress towards each of the six benchmarks with annual performance targets. The DCSEU exceeded the minimum target for each of the first three benchmarks by a substantial degree – ranging from 152% for electric savings to 345% for renewable energy capacity. While the DCSEU achieved the minimum targets for both low-income benchmarks and the green jobs benchmark, they did so to a lesser degree – with achievement of between 102% and 127%.

In addition, the DCSEU exceeded the maximum target for each of the first three benchmarks with achievement of 107% for electric savings, 117% for gas savings, and 224% for renewable energy capacity. However, the DCSEU fell short of the maximum target for both the low-income savings (62%) and green jobs (95%) benchmarks.

Figure 1: FY2017 Progress towards Annual Performance Benchmarks

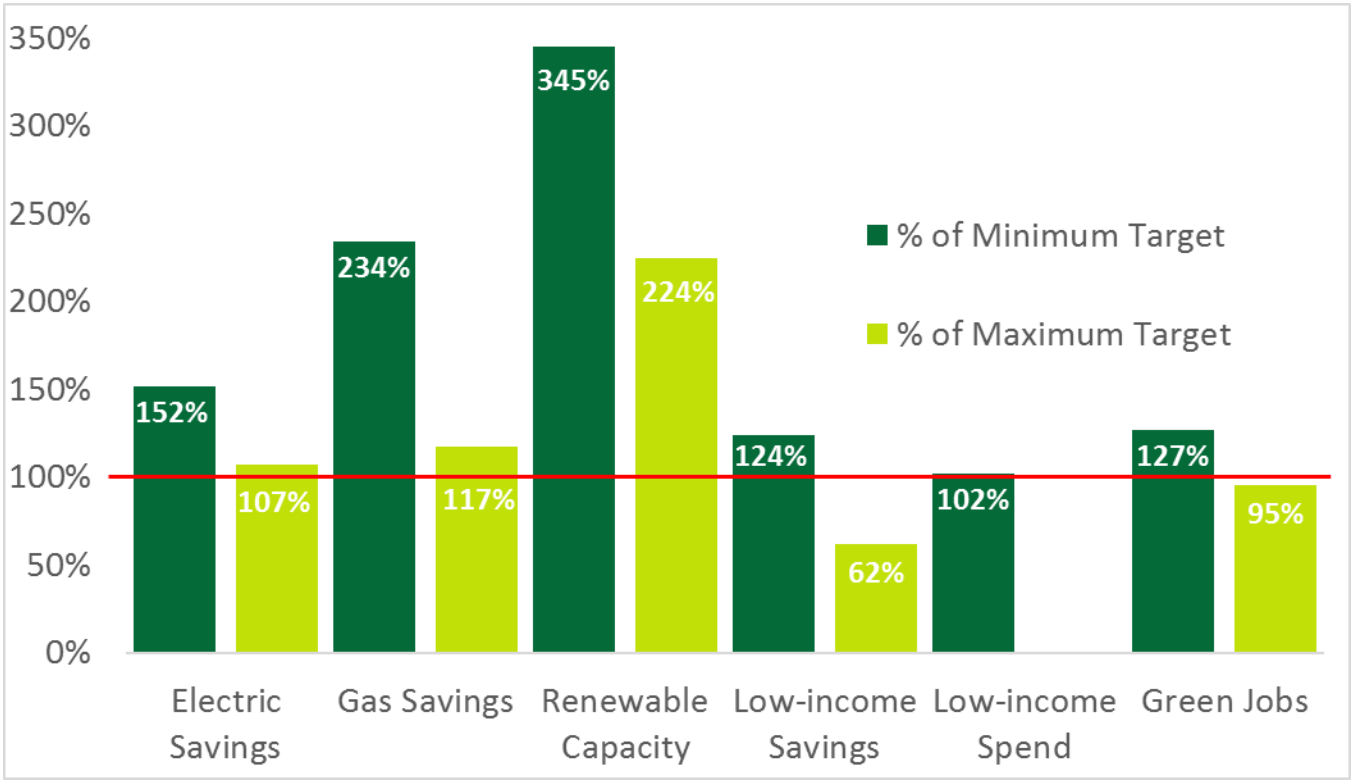


Table 3 displays the DCSEU's progress towards the cumulative leveraged funds benchmark and its two tracking goals. In FY2017, the DCSEU obtained $439,111 in external funds, which represents 18% of the five-year cumulative minimum performance target and 9% of the maximum performance target. In addition, the DCSEU achieved 12,409 kW of summer peak demand savings and completed 104 projects with large energy users in FY2017.

Table 3: FY2017 Progress Towards Cumulative Performance Benchmark and Tracking Goals

Benchmark or Tracking Goal	Evaluated Number	Percent of Minimum Target	Percent of Maximum Target
Leverage External Funds from non-District Government Sources	$439,111	18%	9%
Reduce Growth in Peak Demand (kW)	12,409	*n/a*	*n/a*
Reduce Growth in Energy Demand of Largest Energy Users	104	*n/a*	*n/a*

COST-EFFECTIVENESS ASSESSMENT

The NMR team calculated the costs of saved energy and conducted cost-effectiveness testing for the DCSEU's FY2017 programs.

Costs of Saved Energy

To inform future planning of budgets and savings goals we calculated the DCSEU's cost of acquiring the FY2017 verified energy savings. The cost of gross and modified gross first-year electricity savings, excluding the DCSEU's renewables programs, was $162 per megawatt hour ($162/MWh) and $150/MWh, respectively (Table 4). In addition, we calculated that the DCSEU's cost for gross and modified gross electricity savings from renewables programs was $236/MWh and $190/MWh, respectively. For natural gas savings, the DCSEU's cost of gross and modified gross savings, excluding renewables programs, was $3.19/therm and $2.57/therm, respectively.

Modified gross electricity savings exceed gross electricity savings due to adjustments for line losses, as well as for spillover from renewable energy projects (see Section 1.1.1 for more details). In addition, modified gross natural gas savings exceed gross natural gas savings due to the exclusion of cross-fuel interactive effects (see Section 1.1.2 for more details).

Table 4: DCSEU FY2017 Cost of First-Year Energy Savings

Fuel Savings Type	Cost per Unit of Saved Energy	
	Gross	Modified Gross
Electric savings excluding renewables	$162/MWh	$150/MWh
Electric savings from renewables only	$236/MWh	$190/MWh
Gas savings excluding renewables	$3.19/therm	$2.57/therm

At $162/MWh, the DCSEU's cost for gross first-year electricity savings in FY2017 is less than the cost for either PECO Energy ($248/MWh) from June 2016 to May 2017 or Baltimore Gas & Electric ($204/MWh) from 2016.

Cost-Effectiveness Testing

The NMR Team conducted a benefit-cost analysis of the DCSEU's FY2017 offerings at the program and portfolio level using a Societal Cost Test (SCT). The SCT examines cost-effectiveness from the perspective of the utility, program participants, and non-participants. The model inputs were taken largely from DCSEU tracking data, which were then adjusted using the results of the FY2017 evaluation. The mechanics of the DCSEU tracking database are well-organized to facilitate benefit cost modeling and their application was well-documented. However, several of the financial assumptions used to monetize program impacts were outdated as the primary analysis used to develop the forecast is almost five years old. Therefore, four scenarios were considered for the FY2017 benefit-cost analysis:

- **Modified Replica**: This scenario replicated the DCSEU cost-effectiveness calculations to ensure that our model returned comparable results to the DCSEU model. Once we confirmed that our model produced the same results with the same data, we implemented some corrections to inputs and formulas.
- **Updated Avoided Costs**: This scenario incorporates an updated avoided cost forecast to monetize program benefits.
- **Gross Verified Savings**: This scenario relies on the updated avoided cost forecast and incorporates the realization rates as determined by the impact evaluation.
- **Net Verified Savings**: This scenario relies on the updated avoided cost forecast and adjusts the tracked savings by both the realization rate and net-to-gross ratio. Incremental measure costs are discounted by the applicable freeridership rate.

Table 5 lists the DCSEU portfolio-level cost-effectiveness ratios under each scenario. Overall, we found that the DCSEU program portfolio, when taken as a whole, was cost-effective under each of the four scenarios, with SCT benefit/cost ratios declining from 2.25 in the Modified Replica scenario to 1.76 under the Net Verified Savings scenario. These results mean that, from a societal cost test perspective, for every $1.00 spent, the District realized between $2.25 to $1.76 return on its investment.

All of the individual programs implemented by the DCSEU were cost-effective with the exception of two residential programs (Income Qualified and Home Performance with ENERGY STAR) which were not cost-effective under all four scenarios. The Solar Hot Water program was also not cost-effective under the Modified Replica scenario only.

Table 5: Portfolio-Level Societal Cost Test Results

Scenario	Benefit/Cost Ratio
Modified Replica	2.25
Updated Avoided Costs	1.93
Gross Verified Savings	1.89
Net Verified Savings	1.76

In Section 2.2.3 we offer several recommendations to improve the accuracy of future cost-effectiveness testing.

CONCLUSIONS

Our assessment of the DCSEU's progress towards its FY2017 benchmarks found that the DCSEU is performing well in meeting the minimum targets for all annual benchmarks, particularly for the portfolio energy savings and renewable energy generating capacity benchmarks. Because the full array of benchmarks reflects diverse and sometimes competing objectives, achieving these benchmarks requires constant monitoring on the part of the DCSEU. However, there is opportunity to improve performance on the green jobs benchmark and, in particular, the low-income savings benchmark. The second year of the five-year contract should provide the DCSEU with the opportunity to leverage additional external funds to create more jobs and realize savings from longer-term low-income projects that may allow for the achievement of these maximum performance targets.

The cost of FY2017 electricity savings for the DCSEU is less than that for neighboring utilities. In addition, the cost-effectiveness testing found that the DCSEU portfolio was cost-effective although the two residential programs were not cost-effective.

Because the FY2017 evaluation was streamlined due to the compressed timeframe, we do not offer any key recommendations in this report. For our recommendations to improve the accuracy of DCSEU tracked savings, please see the *Evaluation of DC Sustainable Energy Utility FY2017 Programs* report.

Section 1 Performance Benchmarks and Tracking Goals Assessment

In this section, we assess the DCSEU's FY2017 progress towards its performance benchmarks and tracking goals.

1.1 Performance Benchmarks

In this section, we assess the DCSEU's FY2017 progress towards each of the following performance benchmarks:

- Reduce Electricity Consumption
- Reduce Natural Gas Consumption
- Increase Renewable Energy Generating Capacity
- Improve the Energy Efficiency of Low-income Properties
- Increase the Number of Green-collar Jobs
- Leverage External Funds

1.1.1 Reduce Electricity Consumption

The enumerated benchmark for reductions in electricity consumption states that the DCSEU shall develop and implement energy efficiency programs that directly lead to annual reductions of weather-normalized total electricity consumption, measured as a percentage of the total consumption of electricity in the District in 2014. The contract requires that the DCSEU achieves a minimum of 60,878 MWh savings in the first year, which represents 0.53% of 2014 weather-normalized consumption in the District. The maximum target equals 86,473 MWh savings, which represents 0.75% of 2014 weather-normalized consumption in the District.

The DCSEU tracks electric savings in two ways: gross meter-level savings and modified gross generator-level savings. The gross meter-level savings reflect the first-year electric savings that the customer is expected to receive at the meter. The modified gross generator-level savings are calculated by increasing all gross meter-level electric savings by 8% to adjust for line losses, and by further increasing savings from renewable energy projects by 15% to reflect spillover. Spillover reflects the assumption that renewable energy projects are likely to lead to additional savings beyond the savings from the incentivized projects. The formulas are displayed below.

*Modified gross electric savings for solar projects = Gross electric savings * 1.08 * 1.15*

*Modified gross electric savings for non-solar projects = Gross electric savings * 1.08*

Modified gross generator-level savings are used to assess progress towards this performance benchmark.

Table 6 displays the modified gross generator-level electric savings as tracked by the DCSEU, our calculated portfolio-level realization rate, and the evaluated savings. The realization rate equals the ratio of evaluated savings to tracked savings (i.e., DCSEU savings recorded in their

tracking database). The NMR team estimates that the actual portfolio electric savings equals 92,686 MWh, which is 99% of the DCSEU reported tracked electric savings of 93,958 MWh.

Table 6: Modified Gross Generator-level Electric Savings Verification

Tracked Modified gross Savings (MWh)	Realization Rate	Evaluated Modified gross Savings (MWh)
93,958	99%	92, 686

Our gross savings verification of the FY2017 programs found that DCSEU expended the appropriate amount of rigor on their savings calculations. In general, the documentation provided was thorough and the methods and assumptions were suitable. Therefore, we believe the tracked electricity savings were calculated with a reasonable degree of accuracy. However, the reported savings calculations were sometimes affected by the propagation of error that occurs when intermediate calculation values are truncated, which leads to greater inaccuracy of the final value. In addition, some lighting projects used ranges for wattage values and some custom projects did not apply the correct unit conversions or included incorrect equipment quantities or efficiencies.

Our evaluation yielded several key findings and recommendations to improve the accuracy of savings estimates. See the *Evaluation of DC Sustainable Energy Utility FY2017 Programs* report for more details.

Table 7 displays our assessment of the DCSEU's progress towards the electric savings benchmark. Our evaluation found that the DCSEU achieved 92,686 MWh, which represents 152% of the minimum target and 107% of the maximum target.

Table 7: FY2017 Reduce Electricity Consumption Benchmark Performance

Measurement	Minimum Target	Maximum Target	Evaluated Savings	Percent of Minimum Target	Percent of Maximum Target
Modified Gross first-year electric savings achieved in FY2017 (MWh)	60,878	86,473	92,686	152%	107%

1.1.2 Reduce Natural Gas Consumption

The contract requires that DCSEU achieves a minimum of 852,565 therms of savings in the first year, which represents 0.25% of 2014 weather-normalized consumption in the District. The maximum target equals 1,705,130 therms of natural gas reductions, which represents 0.50% of 2014 weather-normalized consumption in the District.

The DCSEU tracks natural gas savings in two ways: gross savings and modified gross savings. The gross savings reflect the estimated first-year savings including both cross-fuel and like-fuel interactive effects, but excluding free-ridership and spillover. Per the DCSEU contract, modified gross savings are calculated by excluding cross-fuel interactive effects and are used to assess progress towards this performance benchmark.

Interactive effects reflect the increase or decrease in energy usage due to the installation of an energy-efficiency measure. 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).

The NMR team converted the gas savings, which the DCSEU tracks in MMBtu, to therms by multiplying by a factor of 10.

Table 8 displays the modified gross gas savings as tracked by the DCSEU, our calculated portfolio-level realization rate, and the evaluated savings. The realization rate equals the ratio of evaluated savings to tracked savings. The NMR team estimates that the actual portfolio gas savings equals 1,998,033 therms, which is 95% of the DCSEU tracked gas savings of 2,114,138 therms.

Table 8: Modified Gross Gas Savings Verification

Tracked Modified Gross Savings (Therms)	Realization Rate	Evaluated Modified Gross Savings (Therms)
2,114,138	95%	1,998,033

The realization rate of less than 100% is primarily due to two custom boiler projects that contained errors in reported values. However, overall, our evaluation found that the tracked gas savings were calculated with a reasonable degree of accuracy. See the *Evaluation of DC Sustainable Energy Utility FY2017 Programs* report for our findings and recommendations regarding savings estimation.

Table 9 displays our assessment of the DCSEU's progress towards the gas savings benchmark. Our evaluation found that the DCSEU achieved 1,998,033 therms of savings, which represents 234% of the minimum target and 117% of the maximum target.

Table 9: FY2017 Reduce Gas Consumption Benchmark Performance

Measurement	Minimum Target	Maximum Target	Evaluated Savings	Percent of Minimum Target	Percent of Maximum Target
Modified gross first-year gas savings achieved in FY2017 (therms)	852,565	1,705,129	1,998,033	234%	117%

1.1.3 Increase Renewable Energy Generation Capacity

The DCSEU is tasked with increasing the renewable energy generation capacity in the District, primarily through the installation of solar photovoltaic (PV) and solar thermal systems. The contract requires that the DCSEU provide incentives to fund the installation of a minimum of 650 kW of renewable energy generating capacity in its first year. The maximum target is 1,000 kW.

According to the DCSEU tracking database, solar PV systems were installed at 11 sites and solar thermal systems were also installed at one site in FY2017. These installations spanned multiple programs, as illustrated in Table 10. The solar hot water project with a -1 kW capacity is due to the pumping penalty associated with the system.

Table 10: FY2017 Solar System Summary

Program Name	Track Number	Number of Sites	Solar Capacity (kW)
Solar PV Market Rate	7101PVMR	7	1,325
Solar Photo Voltaic	7107PV	1	259
Solar Hot Water	7110SHOT	1	-1
Retrofit - Custom	7520CUST	1	138
New Construction - Custom	7520NEWC	1	500
LI Custom Projects	7610LICP	1	22
Total		**12**	**2,244**

For these 12 sites, we calculated the renewable energy capacity of solar PV or solar thermal systems using the *KWLoad* variable[1] included in the DCSEU tracking database. The NMR team estimates that the actual renewable energy generation capacity is 2,244 kW, which equals the DCSEU tracked capacity of 2,244 kW. The majority of FY2017 renewable energy projects and energy savings were completed at commercial buildings.

Table 11 displays our assessment of the DCSEU's progress towards the renewable energy generating capacity benchmark. Our evaluation found that the DCSEU incentivized 2,244 kW, which represents 345% of the minimum target and 224% of the maximum target.

Table 11: FY2017 Renewable Energy Capacity Benchmark Performance

Measurement	Minimum Target	Maximum Target	Evaluated Savings	Percent of Minimum Target	Percent of Maximum Target
Electric generation capacity from solar PV and solar thermal sources (kW)	650	1,000	2,244	345%	224%

[1] The *KWLoad* variable reflects the electric generation capacity of solar PV systems in kilowatts.

1.1.4 Improve the Energy Efficiency and Renewable Energy Generating Capacity at Low-income Properties

Per the DCSEU contract, the low-income benchmark includes two separate metrics:

- Spend 20% of Sustainable Energy Trust Fund (SETF) funds on low-income housing, shelters, clinics, or other buildings serving low-income residents in the District.
- Achieve 45,556 MMBtu in electricity and natural gas savings from low-income programs.

In order to verify that tracked low-income program expenditures and savings were accrued to eligible low-income projects, we reviewed the ten low-income multifamily projects that were sampled for the FY2017 gross savings verification activities to ensure that they met low-income program requirements. For FY2017, low-income *households* are defined as those with annual incomes equal to or below 80% of the Area Median Income ("AMI"). The District's stock of affordable, low-income *housing* is defined as one of the following:

> *(a) a single home where the owner or occupant meets the definition of 'low-income households';*
>
> *(b) a multifamily building where at least 66% of the households meet the definition of 'low-income households';*
>
> *(c) buildings owned by non-profit organizations or government that meet the definition of 'low-income households' ; or*
>
> *(d) buildings where there are contracts or other legal instruments in place that assure that at least 66% of the housing units in the building will be occupied by low-income households."*[2]

In addition to low-income housing, the DCSEU contract allows low-income programs to target shelters, clinics, or other buildings serving low-income residents in the District. After reviewing supporting documentation and third-party sources, the NMR team was able to verify that all ten sampled low-income multifamily projects met at least one of these low-income criteria. Table 12 displays these ten sites and notes the verification category or categories they met to achieve low-income status.

[2] "DC SEU Low-Income Qualification for FY2017" and "Government of the District of Columbia Department of Housing and Community Development (DHCD) Rent and Income Limits – 2016"

Table 12: Low-Income Site Verification

Program Track	Site ID	Project ID	Site Name	Verified (Y/N)	Verification Criteria
Low-income Multifamily Implementation Contractor Direct Install (7610ICDI)	7001	14030	New York Avenue Low Barrier Shelter	Y	Low-Income Shelter; On Federally Qualified Health Centers (FHQC) List; Verified Non-Profit
	14520	12421	Capital Area Food Bank	Y	Well-established food bank in DC metro area; Supporting income forms; Verified Non-Profit
	15867	13630	Coalition for the Homeless/Emery Work Bed Program	Y	Bed program for homeless men, run by coalition for the homeless; Verified non-profit and United Way organization
	800	13996	Capitol Park Plaza	Y	500 low-income units out of 648 (77%); meets 66% threshold (d)
	13223	12762	Jetu Properties	Y	426 low-income units out of 426 (100%); meets 66% threshold (d)
Low-income Multifamily Comprehensive (7612LICP)	11803	10939	Archer Park	Y	190 out of 190 units (100%) with 60% AMI or less; meets 66% threshold (b)
	584	7461	N Street Village	Y	On FHQC List; 92 out of 92 units (100%) with 60% AMI or less; meets 66% threshold (b)
	8694	7527	Parkside 7	Y	186 out of 186 units (100%) with 60% AMI Limit; meets 66% threshold (d)
	149	14292	Wingate Vista	Y	383 low-income units out of 383 (100%); meets 66% threshold (d)
	520	11733	Atlantic Gardens	Y	107 out of 107 units (100%) with 60% AMI or less; meets 66% threshold (b)

Based on our review of these ten sampled projects, we assume that all program costs and savings allocated to low-income programs were accrued by eligible low-income properties.

Next, we assess progress towards the expenditure benchmark, followed by the savings benchmark.

1.1.4.1 Spend 20% of SETF funds at Low-income Housing, Shelters, Clinics, or Other Buildings

The DCSEU contract specifies that the calculation of the low-income spend percentage include portfolio-wide administrative and support costs in the denominator but not the numerator. Therefore, the NMR team applied the following equation:

$$\textit{Low-income spend \%} = \frac{\textit{Low-income program costs}}{\textit{Cumulative program costs + Portfolio administrative \& support costs}}$$

The DCSEU provided a spreadsheet titled *FY2017 Program Cost Update 8-6-18ASJ* that included both program-specific costs and portfolio-wide administrative and support costs for FY2017. The total cost across the entire DCSEU FY2017 portfolio equaled $19,172,978. In order to calculate the total low-income program costs, we summed the individual program costs for each of the seven programs that serve low-income customers (Table 13).

Table 13: FY2017 Low-Income Expenditures by Program

Program	Track	Expenditures
Solar Photo Voltaic	7107PV	$29,695
Solar Hot Water	7110SHOT	$2,300
Income Qualified	7401FHLB	$20,296
Low-income Multifamily Implementation Contractor Direct Install & Custom Projects	7610ICDI & 7610LICP	$3,110,790
Low-income Multifamily Comprehensive	7612LICP	$508,904
Retail Lighting Food Bank	7717FBNK	$226,940
Total		**$3,898,925**

Table 14 displays our assessment of DCSEU's progress towards the low-income expenditure benchmark. Based on total FY2017 portfolio expenditures of $19,172,978, the contract requires that DCSEU spend a minimum of $3,834,596 (20%) on low-income programs. There is no maximum target for low-income expenditures.

We calculated that the DCSEU spent $3,898,925 across the seven low-income programs, which represents 102% of the target.

Table 14: FY2017 Low-Income Expenditure Benchmark Performance

Measurement	Minimum Target	Evaluated Number	Percent of Minimum Target
Dollars spent on low-income properties	$3,834,596	$3,898,925	102%

1.1.4.2 Achieve 46,556 MMBtu in Electricity and Gas Savings from Low-income Programs

In Table 15, we list the tracked energy (electric plus gas) savings and evaluated savings for each of the seven low-income programs offered by the DCSEU in FY2017. Overall, the DCSEU tracking database reported 29,434 MMBtu in savings, of which we verified 28,858 MMBtu.[3]

In our review of the Low-income Multifamily Comprehensive program, we found that baseline and efficient wattages sometimes differed in the tracking database versus the project files which led to a realization rate less than 100%. This same realization rate was applied to the Low-income Multifamily Custom program, which did not undergo evaluation for FY2017.

Table 15: FY2017 Low-Income Savings by Program

Program	Track	Tracked Modified gross Savings (MMBtu)	Evaluated Modified gross Savings (MMBtu)
Solar Photo Voltaic	7107PV	1,651	1,662
Solar Hot Water	7110SHOT	216	219
Income Qualified	7401FHLB	30	32
Low-income Multifamily Implementation Contractor Direct Install	7610ICDI	9,333	9,333
Low-income Multifamily Custom	7610LICP	4,559	4,377
Low-income Multifamily Comprehensive	7612LICP	10,370	9,954
Retail Lighting Food Bank	7717FBNK	3,275	3,281
Total		**29,434**	**28,858**

Table 16 displays our assessment of DCSEU's progress towards the low-income savings benchmark. The contract requires that the DCSEU achieve a minimum of 23,278 MMBtu savings from low-income programs. The maximum target equals 46,556 MMBtu.

Our evaluation found that DCSEU achieved 28,858 MMBtu in energy savings from low-income programs, which represents 124% of the minimum target and 62% of the maximum target. As discussed in more detail in Section 2.1, the costs of saved energy for low-income programs is typically multiple times greater than for other types of programs.

[3] The DCSEU tracking database reports natural gas savings in MMBtu and electricity savings in kWh. The kWh electricity savings were converted to MMBtu by multiplying by a factor of 0.003412.

Table 16: FY2017 Low-Income Savings Benchmark Performance

Measurement	Minimum Target	Maximum Target	Evaluated Number	Percent of Minimum Target	Percent of Maximum Target
Modified gross electric savings plus modified gross gas savings from low-income properties (MMBtu)	23,278	46,556	28,858	124%	62%

The DCSEU did not achieve the maximum target for low-income savings because FY2017 was the first year where both a low-income spending target and low-income savings target were required. These new requirements necessitated the DCSEU to adjust their program offerings. The new low-income programs launched in FY2017 required ramp up time before higher levels of energy savings could be realized in the low-income sector.

1.1.5 Increase the Number of Green-collar Jobs

This benchmark requires that the DCSEU create green jobs in the District during each year of the contract. The contract requires that the DCSEU create a minimum of 66 full-time equivalent (FTE) jobs each year. The maximum annual target is 88 jobs.

In order to calculate the number of FTE jobs created, the contract specifies the following criteria:

- One FTE green job equals 1,950 hours worked by the DCSEU staff and subcontractors.
- One FTE green job equals $200,000 worth of DCSEU incentives provided to customers or manufacturers.
- Only direct jobs are to be considered. Indirect jobs and induced jobs are not counted.

In order to calculate the number of green jobs created by the DCSEU staff and subcontractors, DOEE provided a spreadsheet of payroll hours worked by the DCSEU staff and subcontractors in FY2017. Dividing the total number of hours worked by 1,950 yielded the number of green jobs created by the DCSEU (Table 17).

In addition, the DCSEU provided a spreadsheet with the total incentive amount distributed in FY2017, which equaled $8,673,908. However, a portion of these incentives flowed through DCSEU subcontractors, whose created jobs were already counted under the payroll hours calculation. Therefore, we excluded a total of $2,092,045 in subcontractor incentives and used the remaining $6,581,663 as the basis for the calculation of jobs created due to incentives (Table 17).

Table 17: Green Jobs Calculation

Category	Total Hours or Dollars (A)	Assumed Hours or Dollars per Job (B)	Number of Green Jobs Created (A / B)
DCSEU Staff Hours	75,230 hours	1,950 annual hours	38.6
DCSEU Subcontractor Hours	24,098 hours	1,950 annual hours	12.4
Incentive Dollars	$6,581,663	$200,000	32.9
Total Green Jobs Created			**83.9**

Table 18 displays our assessment of the DCSEU's progress towards the green jobs benchmark. We calculated that the DCSEU created 84 jobs, which represents 127% of the minimum target and 95% of the maximum target.

Table 18: FY2017 Green Jobs Benchmark Performance

Measurement	Minimum Target	Maximum Target	Evaluated Number	Percent of Minimum Target	Percent of Maximum Target
Number of FTE jobs created by the DCSEU	66	88	83.9	127%	95%

The DCSEU did not achieve the maximum target for green jobs due to staff turnover and the loss of one FTE green job due to lack of sufficient proof of residency for a former employee. In addition, the DCSEU completed less direct install work with their subcontractors in FY2017 which resulted in fewer green job hours being reported by subcontractors.

1.1.6 Leverage External Funds

The contract requires the DCSEU to secure outside funds, excluding SETF funds or other District government funds, to support the energy programs implemented by the DCSEU. The DCSEU is required to obtain a total of $5,000,000 of outside funds over the five-year period of the base contract. There is no annual target for this benchmark; there is only a cumulative five-year goal. Therefore, we tracked the DCSEU's annual progress towards the $5,000,000 five-year benchmark.

The NMR team obtained two documents from the DCSEU to support our review of this benchmark. The *FY2017 Leveraging Benchmark* spreadsheet provides details regarding the outside funds received in FY2017. The *DOE 1168 Summary* document summarizes the details of the U.S. Department of Energy (DOE) grant, described in Table 19.

In FY2017, the DCSEU obtained $375,972 from participating in PJM forward capacity market and $63,138 for the DOE grant.

Table 19: FY2017 Leveraged Funds Calculation

Funding Source	Description	Amount
PJM Interconnection - A Regional Transmission Organization	Forward Capacity Market Credits	$375,973
U.S. Department of Energy	The U.S. DOE awarded a grant to the Institute for Market Transformation (IMT), in partnership with VEIC/DCSEU, to develop energy outreach programs for leveraging ENERGY STAR Portfolio Manager data.	$63,138
Total		**$439,111**

We calculated that the DCSEU secured $439,111, which represents 18% of the $2,500,000 minimum target and 9% of the $5,000,000 maximum target (Table 20). Because it often requires time to secure outside funds, and FY2017 was the first year of the DCSEU contract, we anticipate that future years will yield higher levels of external funding.

Table 20: FY2017 Leveraged Funds Benchmark Performance

Measurement	Minimum Target	Maximum Target	Evaluated Number	Percent of Minimum Target	Percent of Maximum Target
Dollars received from external sources	$2,500,000	$5,000,000	$439,111	18%	9%

1.2 TRACKING GOALS

In this section we assess the DCSEU's FY2017 progress towards its two tracking goals:

- Reduce Growth in Peak Demand
- Reduce Growth in Energy Demand of Largest Energy Users

1.2.1 Reduce Growth in Peak Demand

While the DCSEU is not required to offer programs to exclusively reduce peak demand, demand savings result from the electric savings programs, and the DCSEU is required to report on demand savings. Because the peak demand savings goal is for tracking purposes only, it does not have a contractual performance target.

The DCSEU tracks peak demand savings in two ways: gross meter-level savings and modified gross generator-level savings. The contract requires that modified gross generator-level peak demand savings be used to assess progress towards this tracking goal.

The gross meter-level savings reflect the first-year peak demand savings that the customer is expected to receive at the meter. Per the DCSEU contract, the modified gross generator-level savings are calculated by increasing all gross meter-level peak demand savings by 6% to adjust for line losses, and by further increasing savings from solar projects by 15% to reflect spillover. The formulas are displayed below.

*Modified gross peak demand savings for solar projects = Gross peak demand savings * 1.06 * 1.15*

*Modified gross peak demand savings for non-solar projects = Gross peak demand savings * 1.06*

The peak demand period occurs between 2:00 PM and 6:00 PM on non-holiday weekdays from June through September. In FY2017, the peak demand usage of 6,097 MW for the Pepco service territory (including DC and Maryland) occurred on July 20, 2017 at about 6:00 PM.

Table 21 displays the modified gross peak demand savings as tracked by the DCSEU, our calculated portfolio-level realization rate, and the evaluated modified gross peak demand savings. The realization rate equals the ratio of evaluated savings to tracked savings. The NMR team estimates that the actual portfolio peak demand savings equals 12,409 kW, which is 96% of the DCSEU tracked peak demand savings of 12,934 kW.

The evaluated peak demand savings of 12,409 kW represents about 0.2% of the peak demand usage of 6,097 MW for the entire Pepco service territory in FY2017.

Table 21: Modified Gross Summer Peak Demand Savings Verification

Measurement	Tracked Savings (kW)	Realization Rate	Evaluated Savings (kW)
Modified gross electric demand savings during summer peak period (kW)	12,934	96%	12,409

The evaluation team and DCSEU often used different methodologies to analyze the peak coincidence of custom measures which contributed to the portfolio realization rate equaling less than 100%. In addition, an incongruence between hours of use and coincidence factors for lighting measures contributed as well. However, overall, the evaluation found that the tracked peak demand savings were calculated with a reasonable degree of accuracy. See the *Evaluation of DC Sustainable Energy Utility FY2017 Programs* report for more details regarding our findings and recommendations regarding savings calculations.

The evaluated peak demand savings of 12,409 kW for FY2017 is substantially higher than the 8,917 kW from FY2016 and prior years (Table 22).

Table 22: Evaluated Modified Gross Summer Peak Demand Savings Trends

Measurement	FY2013	FY2014	FY2015	FY2016	FY2017
Evaluated modified gross electric demand savings during summer peak period (kW)	8,016	7,912	7,950	8,917	12,409

1.2.2 Reduce Growth in Energy Demand Of Largest Energy Users

While the DCSEU is not required to offer programs aimed exclusively at reducing the energy usage of large energy users, they are required to track projects with large users. Because the large user goal is for tracking purposes only, it does not have any contractual performance targets.

The DCSEU contract's definition of a large energy user is as follows:

> *'Large energy users are defined as organizations, individuals, or government entities that own a building with more than 200,000 square feet of gross floor area or own a campus of buildings in a contiguous geographic area that share building systems or at least one common energy meter without separate metering or sub-metering, such that their energy use cannot be individually tracked. Gross floor area includes infrastructure that contain heated and unheated space that is connected to a qualifying building. Energy-efficiency or renewable energy measures must be installed in a qualified building or an infrastructure connected to a qualified building in order to qualify as a large energy user project.'*

The DCSEU provided a spreadsheet listing the FY2017 large user projects, titled *Largest Energy Users FY2017*. This spreadsheet includes the square footage at most sites, allowing easy verification of large energy users (i.e., sites of 200,000+ square feet, or campus buildings sharing common meters). However, some sites are listed with a square footage of zero. In these cases, the NMR team reviewed the District Assessor's Database to verify if a site qualified as a large user.[4] Because there was insufficient data to verify four sites, which were listed with an area of zero square feet, the team was able to verify 104 out of 108 sites (96%) as large users (Table 23).

Table 23: Large Energy User Verification

Total Number of Sites Tracked in Large Energy User Database	Tracked Number of Sites ≥200,000 s.f.	Tracked Number of Sites <200,000 s.f.	Verified Number of Sites ≥ 200,000 s.f.
108	75	33	104

[4] The assessor database can be accessed at: https://otr.cfo.dc.gov/page/real-property-tax-database-search

In FY2017, the majority of large energy user projects fell under the Retrofit-Custom program (52), followed by the CIRX-Equipment Replacement program (36). There is a total of 125 unique sites listed in Table 24, which exceeds the 104 verified large energy user sites due to multiple projects being completed at some sites.

Table 24: FY2017 Large Energy User Sites

Program	Track	Number of Unique Sites
Solar PV Market Rate	7101PVMR	1
CI RX - Equipment Replacement	7511CIRX	36
Market Transformation Value	7512MTV	5
Retrofit - Custom	7520CUST	52
Market Opportunities - Custom	7520MARO	19
New Construction - Custom	7520NEWC	7
Low-income Multifamily Implementation Contractor Direct Install	7610ICDI	3
Low-income Multifamily Custom Projects	7610LICP	1
Low-income Multifamily Comprehensive	7612LICP	1
Total		**125**

Based on our review, in FY2017, the DCSEU completed projects with 104 large energy users (Table 25).

Table 25: FY2017 Large Energy User Verification

Measurement	Evaluated Number
Number of large energy users with completed projects	104

The 104 completed projects with large energy users in FY2017 is lower than the 132 projects from FY2016 but higher than the 52 projects from FY2015 and 67 projects from FY2014 (Table 26).

Table 26: Evaluated Large Energy User Trends

Measurement	FY2014	FY2015	FY2016	FY2017
Number of large energy users with completed projects	67	52	132	104

Section 2 Cost-Effectiveness Assessment

In this section, we describe our evaluation efforts to assess the cost of saved energy and the cost-effectiveness of the DCSEU programs.

2.1 Cost of Saved Energy

To inform future planning of budgets and savings goals we calculated the DCSEU's cost of first-year verified energy savings in FY2017. In order to calculate the cost of saved energy, the DCSEU provided the NMR team with a spreadsheet titled *FY2017 Cost-effectiveness Gas-Electric split 07.16.2018* which lists estimated program-specific electric and natural gas costs, as well as portfolio-wide administrative and support costs for FY2017. In order to calculate total electric and natural gas costs, we allocated the portfolio-wide administrative and support costs to each program and fuel type based on its program-specific cost. We then summed the total costs by fuel type and program.

Because solar projects typically cost more per unit of energy savings than energy-efficiency projects, we calculated costs separately for energy-efficiency projects and renewable energy projects. Therefore, we provide the costs for four categories of fuel savings:

- Electric savings excluding renewables programs
- Electric savings from renewables programs only
- Natural gas savings excluding renewables programs
- Natural gas savings from renewables programs only

As described in Section 1.1.1, modified gross electricity savings exceed gross electricity savings due to adjustments for line losses, as well as for spillover from solar projects. In addition, modified gross gas savings exceed gross natural gas savings due to the exclusion of cross-fuel interactive effects, as described in Section 1.1.2. Therefore, the DCSEU's costs for modified gross energy savings are less than the costs for gross energy savings.

We calculated that the DCSEU's cost for gross and modified gross electricity savings excluding renewables programs was $162/MWh and $150/MWh, respectively (Table 27). In addition, we calculated that the DCSEU's cost for gross and modified gross electricity savings from renewables programs was $236/MWh and $190/MWh, respectively.

For natural gas savings, we calculated that the DCSEU's cost of gross and modified gross savings excluding renewables programs was $3.19/therm and $2.57/therm, respectively. There was only one solar hot water project that yielded natural gas savings, therefore these costs are included to provide a comprehensive assessment of portfolio costs.

Table 27: DCSEU FY2017 Cost of First-Year Energy Savings

Fuel Savings Type	Cost	Evaluated Energy Savings		Cost per Unit of Saved Energy	
		Gross	Modified Gross	Gross	Modified Gross
Electric savings excluding renewables programs	$13,469,131	82,888 MWh	89,675 MWh	$162/MWh	$150/MWh
Electric savings from renewables programs	$573,176	2,424 MWh	3,010 MWh	$236/MWh	$190/MWh
Gas savings excluding renewables programs	$5,124,231	1,606,644 therms	1,994,188 therms	$3.19/therm	$2.57/therm
Gas savings from renewables programs	$3,604	1,935 therms	2,226 therms	$1.86/therm	$1.62/therm
Total	**$19,170,142**	**452,095 MMBtu**	**516,047 MMBtu**	**$42/MMBtu**	**$37/MMBtu**

Due to the similar geographic location and climate, we compare the DCSEU's costs to those from two nearby utilities: PECO Energy in Pennsylvania and Baltimore Gas & Electric (BG&E) in Maryland. While this comparison is useful, it is important to understand that these jurisdictions have different markets, savings goals, regulatory requirements, program maturity, and delivery systems that all may affect costs.

PECO Energy serves the city of Philadelphia and surrounding counties, which are less urban than DC. PECO is subject to the Pennsylvania's Act 129 which requires that energy efficiency programs achieve nearly a 4% cumulative reduction in annual electricity use (or approximately 0.8% per year) over the five-year period of the Phase III programs that launched in 2016. In addition, at least 5.5% of savings must come from programs solely directed at low-income customers in multifamily housing and at least 3.5% from government, non-profit, and institutional organizations.

BG&E services the city of Baltimore as well as surrounding counties, which are also less urban the DC. Beginning with the 2016 program year, the Maryland EmPOWER programs are designed to achieve an annual incremental gross energy savings equivalent to 2.0% of the weather normalized gross retail sales baseline, with a ramp-up rate of 0.20% per year. The programs are screened on the following four factors: cost effectiveness; impact on the rates of each ratepayer class; impact on jobs; and impact on the environment.

In comparison, the DCSEU has multiple benchmarks, in particular low-income and green jobs, that may impact costs. In addition, the DCSEU budget and goals are a fraction of those for either PECO or BG&E.

At $162/MWh, the DCSEU's FY2017 cost for gross electricity savings is less than the cost for either PECO ($248/MWh) or BG&E ($204/MWh) (Table 28). Because PECO and BG&E only offer electric energy-efficiency programs, we only compare the costs to save electricity.

Table 28: Comparison of Cost of First-Year Gross Electricity Savings

Region, Year	Costs	Evaluated Energy Savings	Cost per Unit of Saved Energy
DCSEU excl. renewables, FY2017	$13,469,131	82,888 MWh	$162/MWh
PECO, June 2016 – May 2017[5]	$52,225,000	210,689 MWh	$248/MWh
BG&E, 2016[6]	$105,736,633	518,117 MWh	$204/MWh

Table 29 displays the costs of saved energy across all seven low-income programs listed in Table 15. We calculated that the DCSEU's cost for gross and modified gross electricity savings for low-income programs was $606/MWh and $555/MWh, respectively. In addition, we calculated that the DCSEU's cost for gross and modified gross natural gas savings was $53/therm and $34/therm, respectively.

Table 29: DCSEU FY2017 Cost of First-Year Low-income Energy Savings

Fuel Savings Type	Cost	Evaluated Energy Savings		Cost per Unit of Saved Energy	
		Gross	Modified Gross	Gross	Modified Gross
Electric	$3,376,742	5,571 MWh	6,085 MWh	$606/MWh	$555/MWh
Gas	$2,726,596	51,133 therms	80,939 therms	$53/therm	$34/therm
Total	**$6,103,338**	**24,123 MMBtu**	**28,858 MMBtu**	**$253/MMBtu**	**$211/MMBtu**

Because low-income projects typically require greater levels of program investment, the costs of saved energy are higher than for other types of programs. We calculated the cost of saved energy for DCSEU's low-income programs to be about six times greater than the cost of saved energy across the entire DCSEU portfolio. This result is similar to the findings from a recent national study that estimated the cost of saved electricity for low-income programs as approximately four times greater than for other types of programs.[7]

[5] 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

[6] *Verification of the 2016 Empower Maryland Energy Efficiency Program Impact Evaluation*. Itron. October 20, 2017. *The Empower Maryland Energy Efficiency Act STANDARD REPORT OF 2017 With Data for Compliance Year 2016*. Maryland Public Service Commission. September 2017.

[7] *The Cost of Saving Electricity Through Energy Efficiency Programs Funded by Utility Customers: 2009–2015.* Lawrence Berkeley National Laboratory. June 2018.

2.2 COST-EFFECTIVENESS ASSESSMENT

The NMR team modeled the cost-effectiveness of the DCSEU FY2017 program offerings at the portfolio level and for each of the energy-efficiency programs that were active in FY2017. All of the NMR team's modeling was done using a Societal Cost Test (SCT) perspective. The SCT is a variant of the Total Resource Cost (TRC) Test, which includes various externalities and a lower societal discount rate than the utility weighted average cost of capital discount rate used in the TRC. The discount rate determines the net present value of future resource savings. Table 30 lists the cost and benefit elements included in the SCT Test.

Table 30: Societal Cost Test – Costs and Benefits

SCT Costs	SCT Benefits
Incremental Measure Cost	Avoided Energy Costs (kWh, MMBtu)
Other Financial or Technical Support Costs	Avoided Generating Capacity Costs
Program Administration Costs	Avoided T&D Capacity Costs
Evaluation, Measurement, & Verification	Avoided Water Cost
	Reduced Risk\Increased Reliability
	Reduced Operation and Maintenance Cost
	Benefits from reducing environmental externalities, including air and water pollution, greenhouse gas emissions, and cooling water use.
	Non-Energy Benefits (NEBs) including comfort, noise reduction, aesthetics, health and safety, ease of selling/leasing home or building, improved occupant productivity, reduced work absences due to illness, ability to stay in home/avoided moves, and macroeconomic benefits.

The primary data sources that the NMR team used for the cost-effectiveness assessment were as follows:

- Measure-level energy savings, effective useful life (EUL) assumptions, incremental measure cost values, incentive amounts, and projections of operation and maintenance (O&M) savings from the DCSEU tracking database.
- Non-incentive expenditures for program administration and delivery, as provided by the DCSEU. This includes both costs that were allocated to specific tracks ($5,238,670) and common costs for support services that are assigned at the portfolio level ($5,260,401).
- Avoided cost assumptions as documented in a Program Implementation Procedure document. The NMR team updated the forecast of several key energy elements to reflect current market conditions in the Mid-Atlantic region, as discussed in Section 2.2.2.

- Realization rates and net-to-gross ratios as determined by the FY2017 impact evaluation. The net-to-gross estimation for FY2017 was based on a review of prior evaluation results from the DCSEU and the Mid-Atlantic region.

In addition to the detailed information contained in the DCSEU program tracking database, the DCSEU provided the NMR team with its cost-effectiveness findings for FY2017. The DCSEU calculated a portfolio SCT ratio of 2.40 at the portfolio level for FY2017. As a first step in the analysis, the NMR team developed an analogous set of calculations using identical inputs, assumptions, and formulas. This analysis returned a portfolio SCT ratio of 2.38. The minor difference was due to some differing cost values between the DCSEU results summary and the NMR team's replica model using the detailed program tracking data.

The evaluated portfolio SCT ratio was relatively stable from FY2013 to FY2015 at between 4.44 and 5.09 but declined to 3.48 in FY2016 then to 2.38 in FY2017 (Table 31). This decline is likely driven by the reduced savings available from residential lighting measures due to the 2020 Energy Independence and Security Act (EISA) Phase II backstop. While the EISA backstop reduces first-year savings due to halogen bulbs serving as the baseline rather than incandescent bulbs, the impact is more pronounced on lifetime savings due to the shortened lifetime.[8]

Table 31: Evaluated Portfolio Societal Cost Test Trends

Measurement	FY2013	FY2014	FY2015	FY2016	FY2017
Portfolio-level SCT Ratio	4.44	5.03	5.09	3.48	2.38

Once satisfied with the results of the analogous model, the NMR team implemented a series of changes to produce different result scenarios. The four scenarios are described below. The results are summarized in Table 32, and presented in detail in Section 2.2.1.

- ***Scenario #1 – Modified Replica:*** Replicates the DCSEU calculations with corrections to inputs and formulas. In reviewing the FY2017 financial data, the NMR team noticed a project in the Commercial Custom track with approximately $2.5 million of annual O&M savings. After discussing the issue with the DCSEU, it was discovered that the annual O&M savings cost savings was approximately $500,000. Over the 18-year life of the project measures, this change amounted to approximately $25 million of reduced benefits (in 2017 dollars). The other modification in Scenario #1 was formulaic. Some measures have interactive effects on other fuels. For example, installation of cooler LED lighting increases the consumption of fossil fuel heating systems because there is less waste heat in the space. The DCSEU treated this heating "penalty" as a cost for fossil fuels and a benefit for electricity and water. The NMR team standardized the accounting

[8] The Retail Lighting program represented 37% and 33% of first-year portfolio electric savings in FY2014 and FY2015, respectively. In FY2017, the Retail Lighting program represented 18% of first-year portfolio electric savings.

across resources and treated all interactive penalties (and associated externalities) as a negative benefit. This does not affect the Present Value of Net Benefits (PVNB) calculation, but does change the SCT ratios because dollars are moved from the denominator to the numerator.

- ***Scenario #2 – Updated Avoided Costs****:* An initial review of the DCSEU screening assumptions revealed that several key energy benefits were based on a somewhat dated forecast (2013). This forecast was developed at a time when market prices were higher in the region and the study forecasted an increase in energy costs over time. In fact, market prices of electricity and natural gas have fallen over the last five years. Section 2.2.2 discusses the development of updated screening assumptions in more detail. Scenario #2 relies on unadjusted energy impacts as captured in the DCSEU tracking system.

- ***Scenario #3 – Gross Verified Savings****:* This scenario relies on the updated avoided cost forecast and incorporates the realization rates as determined by the impact evaluation. Realization rates are applied to the first-year savings and future adjusted savings (in the case of measures with dual baselines) equally.

- ***Scenario #4 – Net Verified Savings****:* This scenario relies on the updated avoided cost forecast and adjusts the reported savings in the DCSEU system by both the realization rate and net-to-gross ratio. Regardless of program delivery mechanism (incentive vs. direct install), incremental measure costs are discounted by the applicable free-ridership rate.

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

Table 32: Societal Cost Test Ratios by Scenario

Program(s)	Scenario #1	Scenario #2	Scenario #3	Scenario #4
Solar PV Market Rate	1.82	1.23	1.23	1.23
Solar Photo Voltaic	1.64	1.10	1.10	1.10
Solar Hot Water	0.85	1.10	1.11	1.11
Income Qualified	0.49	0.46	0.47	0.45
Home Performance with Energy Star	0.71	0.77	0.79	0.76
C& I RX - Equipment Replacement	5.51	4.63	4.79	4.23
Market Transformation Value	3.97	3.33	3.44	3.37
Commercial Upstream - Lighting	10.24	8.38	8.38	7.99
Commercial Custom	2.16	1.88	1.82	1.78
Implementation DI & LI Custom	1.72	1.58	1.57	1.57
Low-income MF Comprehensive	4.32	3.47	3.41	3.35
Retail Lighting & Retail Efficient Appliances	3.46	2.88	2.82	2.54
Retail Efficient Products Gas	2.07	2.46	2.46	2.25
Retail Lighting Food Bank	2.62	2.14	2.06	2.06
Total Portfolio Level	**2.25**	**1.93**	**1.89**	**1.76**

Incentives are neither a cost nor a benefit in the SCT Test. The incremental cost of the efficient measure is included in the SCT regardless of the proportion paid by the participant and program administrator. Program administration costs are treated as a cost in the SCT and include planning, IT, evaluation, marketing, customer service and all other non-incentive costs. Table 33 provides a breakdown of the FY2017 cost elements after moving increased fuel consumption to the benefits side of the ledger.

Table 33: FY2017 Cost Summary

Parameter	Cost Component	FY2017 Portfolio Total
A	Incentive Payments	$8,673,908
B	Participant Cost (Net of Incentives)	$67,448,887
C	Incremental Measure Cost (A + B)	$76,122,795
D	Track-specific Administrative Costs (Non-incentive)	$5,238,670
E	Portfolio Administrative Costs	$5,260,401
F	Total Program Administration Cost (D+E)	$10,499,071
G	**Total SCT Costs (C+F)**	**$86,621,865**

There are two different bins of administrative cost listed in Table 33. The track-specific administrative costs (Parameter D) are allocated to a specific program track, so are included as a cost in the track-level SCT results, presented in Table 33 and Section 2.2.1. The portfolio-level results presented in this report include both the track-specific administrative costs and portfolio administrative costs (Parameter E). This is the same approach used by the DCSEU to calculate cost-effectiveness, and is commonly used by other states and utilities. The implication of this methodology is that each of the track-level results is slightly overstated because the SCT ratio does not reflect its share of costs allocated to the portfolio as a whole. If track-level cost-effectiveness results are important to DOEE, we could work with the DCSEU to develop an allocation method. Possible allocation approaches could include kWh contribution, MMBtu contribution, or spending (Parameter A + D).

The DCSEU takes a strong position on the valuation of NEBs. In addition to a general 5% adder for the items listed in Table 30, a $100 per short ton benefit is assigned to all avoided CO2 emissions. The original DCSEU avoided cost values assume a more conservative marginal emission rate than the updated forecast developed by the NMR team so the value of NEBs differs by scenario. Using the original DCSEU avoided costs, the NEBs (5% adder plus $100 per short ton for CO2) account for 29% of all SCT benefits. Using the updated avoided cost forecast, NEBs represents 40% of all SCT benefits. Without NEBs, the portfolio SCT ratios are still cost-effective using the updated avoided cost forecast. However, the ratios are much closer to one at 1.16, 1.12, and 1.04 for Scenarios #2, #3, and #4, respectively. Table 34 shows the estimated lifetime reduction in CO2 emissions attributable to FY2017 programs by scenario.

Table 34: Lifetime CO2 Emission Reductions – FY2017 Programs

Scenario	Lifetime Avoided CO2 Emissions (Short Tons)
1 – Modified Replica	391,857
2 – Updated Avoided Costs	709,445
3 – Gross Verified Savings	697,256
4 – Net Verified Savings	445,040

2.2.1 Cost-Effectiveness Results

Table 35 presents the results of the NMR team's modified replica model. This scenario utilizes the DCSEU savings values, assumptions, and inputs. The key difference between this analysis (SCT ratio = 2.25) and the DCSEU analysis (SCT ratio = 2.40) is the removal of $25 million of erroneous O&M benefits from a Commercial Custom project and the treatment of increased fossil fuel usage as a negative benefit rather than a positive cost. Eleven of the program tracks are cost-effective in this scenario and the portfolio is estimated to achieve $108 million of net benefits (benefits minus costs).

Table 35: Scenario #1 Modified Replica – SCT Results

Program(s)	Sector	SCT Benefit	SCT Cost	SCT Net	SCT Ratio
Solar PV Market Rate	Renewables	$6,037,975	$3,316,576	$2,721,399	1.82
Solar Photo Voltaic	Renewables	$1,507,062	$921,289	$585,773	1.64
Solar Hot Water	Renewables	$80,208	$93,915	-$13,707	0.85
Income Qualified	Residential	$14,369	$29,080	-$14,711	0.49
Home Performance with Energy Star	Residential	$94,186	$132,043	-$37,857	0.71
C& I RX - Equipment Replacement	Commercial	$16,259,636	$2,952,721	$13,306,914	5.51
Market Transformation Value	Commercial	$5,304,341	$1,335,259	$3,969,081	3.97
Commercial Upstream - Lighting	Commercial	$1,546,785	$151,002	$1,395,783	10.24
Commercial Custom	Commercial	$133,357,320	$61,870,712	$71,486,608	2.16
Implementation DI & LI Custom	Low-income MF	$5,995,493	$3,490,198	$2,505,295	1.72
Low-income MF Comprehensive	Low-income MF	$7,520,370	$1,740,434	$5,779,936	4.32
Retail Lighting & Retail Efficient Appliances	Retail	$14,792,466	$4,270,159	$10,522,307	3.46
Retail Efficient Products Gas	Retail	$1,678,485	$810,009	$868,475	2.07
Retail Lighting Food Bank	Retail	$650,939	$248,066	$402,873	2.62
Total Portfolio Level	**Portfolio**	**$194,839,636**	**$86,621,865**	**$108,217,771**	**2.25**

Table 36 presents the results for Scenario #2. The updated forecast produced by the NMR team lowered the avoided costs for several key energy resources (kWh, peak kW, natural gas). This led to a reduction in the overall benefits for this scenario. However, electric externality benefits were increased by updating the marginal carbon emissions rate assumption. As a result, the Solar Hot Water track is estimated to be cost-effective in Scenario #2, while it was not cost-effective in Scenario #1. The improved cost-effectiveness in Scenario #2 for the Solar Hot Water track is due primarily to the higher marginal carbon emission rate assumptions in the updated avoided cost forecast discussed in Section 2.2.2.5. Twelve of the program tracks are cost-effective in this scenario and the portfolio is estimated to achieve almost $81 million of net benefits (benefits minus costs).

Table 36: Scenario #2 Updated Avoided Costs – SCT Results

Program(s)	Sector	SCT Benefit	SCT Cost	SCT Net	SCT Ratio
Solar PV Market Rate	Renewables	$4,072,803	$3,316,576	$756,227	1.23
Solar Photo Voltaic	Renewables	$1,012,557	$921,289	$91,268	1.10
Solar Hot Water	Renewables	$103,230	$93,915	$9,315	1.10
Income Qualified	Residential	$13,357	$29,080	-$15,723	0.46
Home Performance with Energy Star	Residential	$101,682	$132,043	-$30,360	0.77
C& I RX - Equipment Replacement	Commercial	$13,657,039	$2,952,721	$10,704,317	4.63
Market Transformation Value	Commercial	$4,446,691	$1,335,259	$3,111,431	3.33
Commercial Upstream - Lighting	Commercial	$1,264,651	$151,002	$1,113,649	8.38
Commercial Custom	Commercial	$116,307,874	$61,870,712	$54,437,162	1.88
Implementation DI & LI Custom	Low-income MF	$5,511,957	$3,490,198	$2,021,759	1.58
Low-income MF Comprehensive	Low-income MF	$6,033,185	$1,740,434	$4,292,751	3.47
Retail Lighting & Retail Efficient Appliances	Retail	$12,279,563	$4,270,159	$8,009,404	2.88
Retail Efficient Products Gas	Retail	$1,992,353	$810,009	$1,182,344	2.46
Retail Lighting Food Bank	Retail	$529,632	$248,066	$281,567	2.14
Total Portfolio Level	**Portfolio**	***$167,326,574***	***$86,621,865***	***$80,704,709***	***1.93***

Table 37 presents the results for Scenario #3. This scenario uses the same updated avoided costs forecast as Scenario #2. The electric energy, peak demand, and natural gas realization rates developed through the FY2017 impact evaluation were generally close to 100%, so the Scenario #3 SCT results were similar to Scenario #2 at the portfolio level. Twelve of the program tracks are cost-effective in this scenario and the portfolio is estimated to achieve over $77 million of net benefits (benefits minus costs).

Table 37: Scenario #3: Gross Verified Savings – SCT Results

Program(s)	Sector	SCT Benefit	SCT Cost	SCT Net	SCT Ratio
Solar PV Market Rate	Renewables	$4,072,803	$3,316,576	$756,227	1.23
Solar Photo Voltaic	Renewables	$1,016,411	$921,289	$95,121	1.10
Solar Hot Water	Renewables	$104,254	$93,915	$10,339	1.11
Income Qualified	Residential	$13,538	$29,080	-$15,542	0.47
Home Performance with Energy Star	Residential	$104,639	$132,043	-$27,404	0.79
C& I RX - Equipment Replacement	Commercial	$14,149,688	$2,952,721	$11,196,966	4.79
Market Transformation Value	Commercial	$4,597,695	$1,335,259	$3,262,436	3.44
Commercial Upstream - Lighting	Commercial	$1,264,877	$151,002	$1,113,875	8.38
Commercial Custom	Commercial	$112,818,966	$61,870,712	$50,948,254	1.82
Implementation DI & LI Custom	Low-income MF	$5,474,586	$3,490,198	$1,984,389	1.57
Low-income MF Comprehensive	Low-income MF	$5,937,238	$1,740,434	$4,196,804	3.41
Retail Lighting & Retail Efficient Appliances	Retail	$12,046,733	$4,270,159	$7,776,574	2.82
Retail Efficient Products Gas	Retail	$1,990,717	$810,009	$1,180,708	2.46
Retail Lighting Food Bank	Retail	$511,152	$248,066	$263,087	2.06
Total Portfolio Level	Portfolio	**$164,103,297**	**$86,621,865**	**$77,481,432**	**1.89**

Table 38 presents the results of Scenario #4. This scenario uses the updated avoided cost forecast developed by the NMR team and adjusts energy savings by incorporating realization rates and net-to-gross ratios. Twelve of the program tracks are cost-effective in this scenario. Both the benefits and costs are reduced in this scenario because no savings (or benefits) are assigned to free riders and the incremental measure costs associated with free riders are not included as an SCT cost (because they would have purchased the efficient equipment absent the program). Although the SCT ratio is only slightly lower in Scenario #4 compared to Scenario #3 (1.76 vs. 1.89), the net benefits are significantly lower ($44.6 million vs. $77.3 million).

Table 38: Scenario #4: Net Verified Savings – SCT Results

Program(s)	Sector	SCT Benefit	SCT Cost	SCT Net	SCT Ratio
Solar PV Market Rate	Renewables	$3,665,523	$2,991,288	$674,234	1.23
Solar Photo Voltaic	Renewables	$1,016,411	$921,289	$95,121	1.10
Solar Hot Water	Renewables	$104,254	$93,915	$10,339	1.11
Income Qualified	Residential	$12,861	$28,740	-$15,879	0.45
Home Performance with Energy Star	Residential	$94,175	$123,534	-$29,359	0.76
C& I RX - Equipment Replacement	Commercial	$7,074,844	$1,673,364	$5,401,480	4.23
Market Transformation Value	Commercial	$4,137,926	$1,228,197	$2,909,729	3.37
Commercial Upstream - Lighting	Commercial	$1,075,146	$134,596	$940,549	7.99
Commercial Custom	Commercial	$67,691,379	$38,123,425	$29,567,954	1.78
Implementation DI & LI Custom	Low-income MF	$5,474,586	$3,490,198	$1,984,389	1.57
Low-income MF Comprehensive	Low-income MF	$4,927,907	$1,469,152	$3,458,755	3.35
Retail Lighting & Retail Efficient Appliances	Retail	$6,382,718	$2,516,863	$3,865,855	2.54
Retail Efficient Products Gas	Retail	$1,592,574	$707,063	$885,511	2.25
Retail Lighting Food Bank	Retail	$511,152	$248,066	$263,087	2.06
Total Portfolio Level	Portfolio	**$103,761,456**	**$59,010,091**	**$44,751,365**	**1.76**

2.2.2 Avoided Cost Update

As a part of the cost-effectiveness analysis, the NMR team reviewed the cost-effectiveness assumptions utilized by the DCSEU for measure screening. Table 39 summarizes the values and sources.

Table 39: DCSEU FY2017 Avoided Cost Summary

Screening Assumption	Value	Source
Future Inflation Rate	1.70%	Based on past ten years of consumer price index data, calculated October 2016.
Water Avoided Cost	Forecast by year and Sector	"Avoided Costs in Maryland," published April 2014, prepared for the Maryland Dept. of Natural Resources by Exeter Associates, Inc.
Real Discount Rate	3.626%	Ten-year treasury rate posted in the Wall Street Journal on the first business day of October 2016 (1.626%) plus 2% (as specified in the DCSEU contract no. DOEE-2016-C-0002).
Line Losses	8% (energy) 6% (demand)	Based on a PEPCO screening tool developed by ICF International, Inc.
Natural Gas Capacity Adder	5%	Professional judgment, to capture the costs of capacity and delivery of gas.
Transmission Cost	$23.232/kW-year	PEPCO's 2017 filing of the FERC formula transmission rate update.
Distribution Cost	$202.754/kW-year	Calculated, based on PEPCO's indication that distribution costs are 8.73 times that of transmission costs.
Electric & Fuel Externalities	$100 per ton	"2017 DC externality values" memo for methodology.
Electric Energy Cost	Forecast by Year and Period	"Avoided Costs in Maryland," published April 2014, prepared for the Maryland Dept. of Natural Resources by Exeter Associates, Inc.
Electric Power Cost	Forecast by Year	"Avoided Costs in Maryland," published April 2014, prepared for the Maryland Dept. of Natural Resources by Exeter Associates, Inc.
Natural Gas Cost	Forecast by Year and Sector	"Avoided Costs in Maryland," published April 2014, prepared for the Maryland Dept. of Natural Resources by Exeter Associates, Inc.
Other Fuels Cost	Forecast by Year, Fuel, and Sector	Years 2013-2030 were drawn from "Avoided Costs in Maryland," published April 2014, prepared for the Maryland Dept. of Natural Resources by Exeter Associates, Inc.
Risk Adder	5%	Specified in the DCSEU contract no. DOEE-2016-C-0002.
NEB Adder	5%	Specified in the DCSEU contract no. DOEE-2016-C-0002.

The primary source for the core energy benefits in Table 39 are a 2014 avoided cost study from Maryland. There is significant uncertainty in any long-range forecast of commodity prices, and the 2014 Maryland avoided cost proved to be a poor forecast, at least in the short term. The study was developed when market prices for electricity and natural gas were higher than they are currently, and had been increasing for the previous one or two years. The Exeter study forecast them to continue increasing somewhat sharply over time. However, the opposite has

occurred and energy prices have declined. Low natural gas prices, improving average heat rates,[9] and small spark spreads[10] have created very low market prices for electric energy.

Because the vintage of the avoided cost forecast led to questionable SCT results for FY2017 – and because of the fact that several of the non-energy benefits streams were adders to the energy benefits – the NMR team developed updated avoided cost values for several energy benefit streams. The updated values were used to model cost-effectiveness in Scenarios 2, 3, and 4. The methodology of the updates is discussed in detail below.

2.2.2.1 Electric Energy

The DCSEU monetizes electric energy savings (kWh) using time-differentiated avoided costs. Separate avoided cost assumptions are used for Summer On-Peak, Summer Off-Peak, Winter On-Peak, and Winter Off-Peak. All annual energy savings are allocated across these four periods using a load shape for the relevant end-use. All resource savings in the SCT should be valued using marginal costs as that is what is saved by society when a unit of energy is avoided. PJM[11] calculates and archives the locational marginal price (LMP) of electricity as a part of energy market operations. Stakeholders have differing opinions on the mechanics of price formation in PJM; however, the LMPs as defined by PJM are the marginal price of electric energy as set by the market.

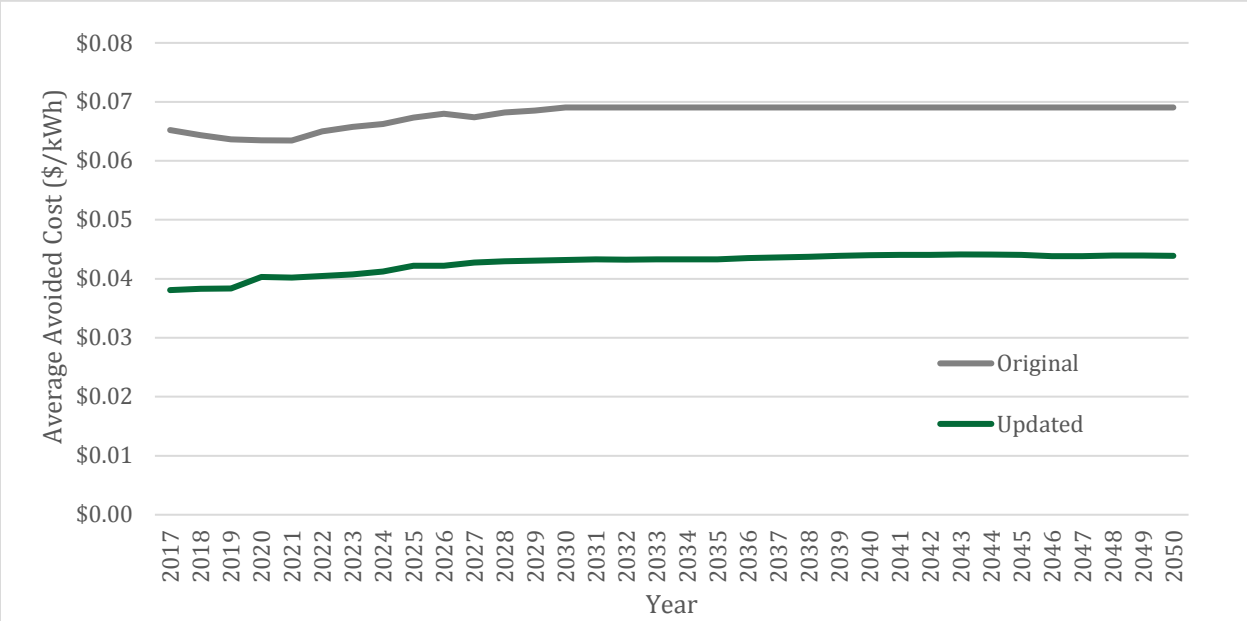
The NMR team used the following steps to refresh the avoided cost of electric energy:

1. Downloaded hourly real-time LMPs for PEPCO zone from January 2015 to May 2018. We assigned each hour to the relevant energy period.
2. Downloaded hourly load data for PEPCO zone for the same period.
3. Calculated load-weighted marginal price by energy period. This established the 2017 value.
4. The NMR team calculated the escalation over the remainder of the forecast horizon (2018-2050) by averaging growth projections from a series of EIA Annual Energy Outlook forecasts for the Mid-Atlantic region.

Figure 2 compares the original and updated avoided cost forecasts used to monetize electric savings. The NMR team used a simple average of the four energy periods to create the trend lines in Figure 2. On average, the updated forecast reduced the marginal cost per kWh by approximately 2.5 cents, which is a reduction of almost 40%.

[9] The heat rate of a power plant is the amount of fuel (Btu) used to generate one kWh. The more efficient the plant, the lower the heat rate.
[10] Spark spread is the difference between the fuel cost and price received per unit of electricity for a gas-fired generator.
[11] PJM is a regional transmission organization that coordinates the movement of wholesale electricity in all or parts of 13 states and the District of Columbia.

Figure 2: Comparison of Avoided Energy Price Forecasts



2.2.2.2 Electric Generation Capacity

The value of electric generation capacity in the Mid-Atlantic is determined by a forward capacity market organized by PJM. PJM's Reliability Pricing Model (RPM) holds competitive auctions for generation capacity three years prior to the beginning of the delivery year. Traditional generators bid alongside demand resources and all resources that clear receive the market clearing price. Because of the *forward* nature of this market, the value of generation capacity is known with certainty for the first part of the forecast. In May 2018, PJM held its Base Residual Auction for the 2021 – 2022 delivery year (June 1, 2021 to May 31, 2022) and the clearing price was $51.10/kW-year for the PEPCO zone. This is quite a bit lower than the $89.43 avoided cost value projected in the 2014 Exeter report.

The NMR team used the following steps to update the avoided cost of generation capacity:

1. Compiled Base Residual Auction clearing prices for all PJM delivery years where the auction has occurred.
2. Used the clearing price as the avoided cost of generation capacity for the DCSEU fiscal years where the auction has occurred (FY2017 through FY2022).
3. Estimated the remaining years of the avoided cost horizon using the average clearing price for the 15 delivery years PJM has held capacity auctions.

Figure 3 compares the time-series to the average. Because clearing prices have been so variable, the NMR team did not feel confident projecting a long-run increase, or decrease, in the avoided cost of generation capacity and held the value constant at $56.81 (in $2017) from 2023 to 2050.

Figure 3: Base Residual Auction Clearing Price by Delivery Year

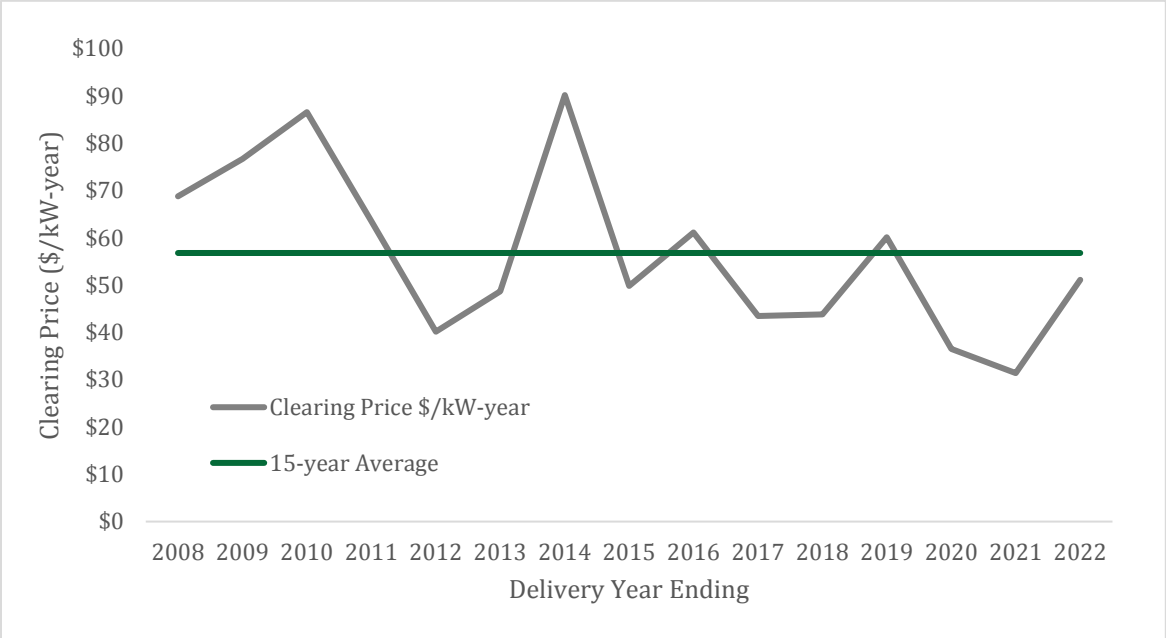


Table 40 compares the original and updated forecasts of the avoided cost of generation capacity. Both forecasts are flat beyond 2030.

Table 40: Avoided Cost of Generation Capacity Comparison ($2017)

Year	Original	Updated
2017	$68.55	$43.48
2018	$72.30	$43.80
2019	$76.24	$60.14
2020	$80.40	$36.50
2021	$84.80	$31.40
2022	$89.43	$51.10
2023	$94.31	$56.81
2024	$99.46	$56.81
2025	$104.89	$56.81
2026	$110.62	$56.81
2027	$116.66	$56.81
2028	$123.03	$56.81
2029	$129.75	$56.81
2030	$136.84	$56.81

2.2.2.3 Electric Distribution Capacity

The avoided cost of distribution capacity assumption of $202.754/kW-year in the original DCSEU screening assumptions is an outlier compared to other jurisdictions in North America. Typically, these values range from $20 to $100/kW-year. Table 41 is reproduced from a 2015

report by the Brattle Group[12]. It does not differentiate transmission and distribution capacity, but does provide a useful benchmark.

Table 41: Avoided T&D Capacity Table – 2015 Brattle Group Report

Entity	State(s)	Avoided Cost ($/kW-Year)
Pepco Holdings	DE, DC, MD, NJ	$0.00
Portland General Electric	OR	$18.00
Pennsylvania Statewide Evaluator	PA	$25.00
Connecticut Light and Power	CT	$29.20
Xcel Energy	CO, MN	$30.00
Southern California Edison	CA	$54.60
San Diego Gas & Electric	CA	$74.80
Pacific Gas & Electric	CA	$76.60

Another interesting aspect of Table 41 is that PEPCO is listed as having a $0/kW-year avoided cost of T&D capacity – at least for demand response. This is very different from the $225.99/kW-year value used by the DCSEU for avoided T&D capacity. The avoided cost of distribution capacity is not like energy or generation capacity. There is not an organized and transparent market to collect cost data from. As an interim measure, the NMR team lowered the avoided cost of distribution capacity to $80/kW-year for the FY2017 cost-effectiveness based on professional judgement. This approaches the values used by ConEd in New York City, which we believe is a reasonable upper bound given the network complexity and amount of underground infrastructure.

We also recommend that DOEE reach out to Pepco about undertaking a focused avoided cost of distribution capacity study as part of the FY2018 evaluation. A key aspect of distribution capacity is that it is inherently locational. For areas of a system where a large investment like a substation upgrade can be deferred or avoided with peak demand reduction, peak demand reduction might be worth even $300 or $400/ kW-year. However, most areas in a network do not have load growth-related investments that can be deferred so there is no value. Ideally, avoided cost of distribution capacity would be mapped to location and value assigned where it exists. This is very complex from a program tracking standpoint – especially for the DCSEU, who is not the electric utility and does not have infrastructure information to map participants to substations and feeders. A system-wide average, or an average of Pepco's DC service territory that excludes Prince George and Montgomery counties, is a more practical outcome for the study.

2.2.2.4 Avoided Cost of Natural Gas

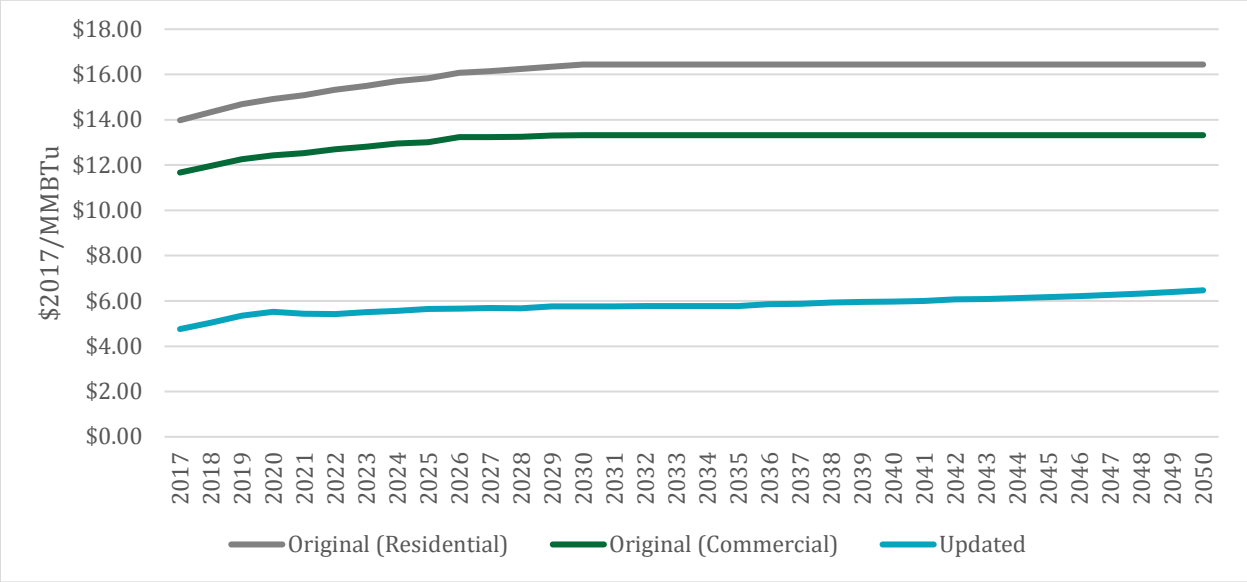
The vintage considerations of the 2014 Exeter report discussed in Section 2.2.2.1 also apply to natural gas. The forecasted increase in natural gas prices has not occurred, at least in the short

[12] http://files.brattle.com/files/5766_valuing_demand_response_-_international_best_practices__case_studies__and_applications.pdf (page 20)

term. We also believe that there was some confusion in the report about marginal vs. retail cost. In a Societal Cost Test, all resources should be valued at the marginal cost – meaning the cost avoided to supply one additional unit. Retail natural gas rates (like electricity and water) are designed to recover both variable costs and fixed costs. Therefore, reducing natural gas consumption does not affect the fixed delivery costs, only the variable usage costs. The fixed costs still need to be recovered through rates. The fact that the current screening assumptions have separate assumptions by sector is an issue tied to the retail rate driven calculations used in the Exeter analysis. In the SCT, the correct avoided cost of natural gas is the marginal cost to the system and is independent of sector – just like the electric avoided costs.

To refresh the natural gas avoided cost forecast, the NMR team gathered projected prices for the industrial sector (Mid-Atlantic region) from the EIA Energy Price by Sector and Source report.[13] We used the retail industrial prices because the industrial price will approximate the marginal cost since fixed costs are spread across such a high volume in industrial rates. Figure 4 compares the original and updated natural gas avoided cost forecasts.

Figure 4: Avoided Cost of Natural Gas Forecast Comparison ($2017/MMBtu)



The NMR team used the updated values shown in Figure 4 in our models for Scenario 2, 3, and 4 for both natural gas conservation and for fuel penalties when the installation of efficient lighting equipment led to an increase in gas heating load.

2.2.2.5 Carbon Emissions from Electricity Production

The electric and fossil fuel externality assumptions used in the DCSEU screening assumptions rely on a $100 per ton value for avoided carbon emissions. The NMR team did not modify this

[13] https://www.eia.gov/outlooks/aeo/

assumption. However, we did update the assumed marginal emissions rates for production of electricity. Table 42 shows the emission rates (tons of CO_2 per MWh) that the NMR team used to calculate the electric externality assumptions. We took these values from the 2014 Exeter report for Maryland. The NMR team was puzzled by the abrupt increase in emissions in 2026. It appears to be tied to Regional Greenhouse Gas Initiative Allowances, but the methodology was unclear.

Table 42: CO_2 Emissions Savings Forecast

Year	tons/MWh reduced
2017	0.380508
2018	0.477764
2019	0.483077
2020	0.480017
2021	0.389844
2022	0.227033
2023	0.279783
2024	0.279645
2025	0.267995
2026	0.605269
2027	0.701522
2028	0.848989
2029	0.861441
2030	0.722058

To update the emissions rate assumptions, the NMR team relied on PJM's 2013-2017 CO_2, SO_2, and NO_x Emissions Rate Report,[14] published in March 2018. This report provides the marginal emission rates by month for on-peak and off-peak hours. The definition of on-peak and off-peak align with the DCSEU definitions. Table 43 shows the compiled emissions rates and calculation of externality benefits by energy period. The NMR team used these values for the full forecast horizon.

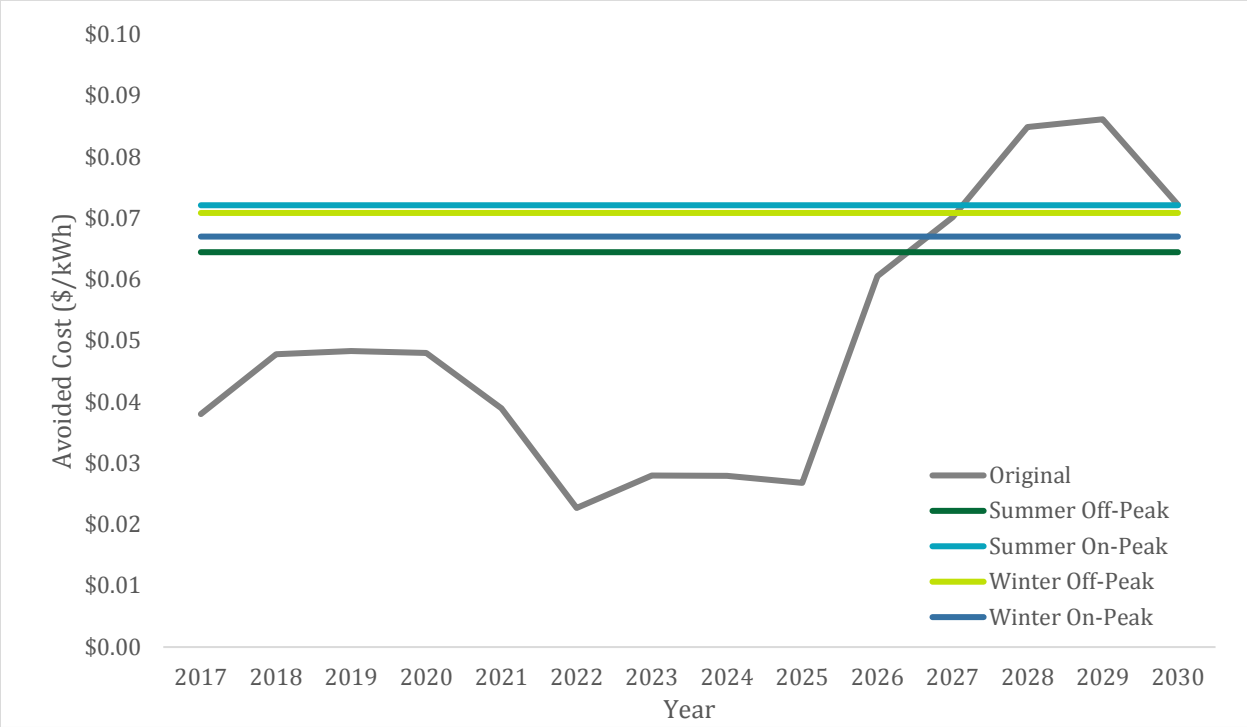
Table 43: Updated Emission Rates and Electric Externality Benefits

Period	Average (lbs/MWh)	Tons/MWh	$/Ton	$/kWh
Summer Off-Peak	1,289	0.6445	$100	$0.0645
Summer Peak	1,442	0.7211	$100	$0.0721
Winter Off-Peak	1,417	0.7086	$100	$0.0709
Winter Peak	1,340	0.6700	$100	$0.0670

[14] http://www.pjm.com/-/media/library/reports-notices/special-reports/20180315-2017-emissions-report.ashx?la=en

Figure 5 compares the original and updated electric externality benefit time-series. Both forecasts are held constant at 2030 values for the remainder of the forecast horizon. For the first ten years, the updated values are significantly higher than the original value. This difference largely offsets the reduction in benefits from lowering the avoided cost of electric energy.

Figure 5: Comparison of Original and Updated Electric Externality Benefits



2.2.3 Cost-Effectiveness Recommendations

The FY2017 cost-effectiveness analysis required the NMR team to explore in detail several of the energy, economic, and policy assumptions used by the DCSEU. Based on the review, we offer the following observations and recommendations:

- The mechanics of the DCSEU tracking system are expertly organized to facilitate benefit cost modeling. The application was well-documented and the DCSEU staff was very responsive to inquiries.

- Several of the financial assumptions used to monetize program impacts were questionable. The issues are largely a function of vintage as the primary analysis used to develop the forecast is almost five years old.
    - Many of the key inputs were updated as part of the FY2017 evaluation.
    - We recommend DOEE reach out to PEPCO about undertaking an avoided cost of distribution capacity study. NMR team members have completed these studies in multiple jurisdictions and can complete the analysis if PEPCO shares the necessary data.

  - Avoided costs should receive a complete and thorough review at the beginning of each new contract period. The current contract period is for five years and was begun without a refresh of avoided cost values. Updates to avoided costs should be an initial step in planning program cycles.

- The handling of dual baselines was well executed in the DCSEU system. The most important dual baseline measure is LED lighting. The DCSEU savings assumptions for FY2017 assume implementation of the 2020 Energy Independence and Security Act (EISA) Phase II backstop.
  - The enforcement of the 2020 backstop provision is increasingly uncertain. Some jurisdictions are delaying the change in lighting baselines based on this uncertainty.
  - Delaying the lighting baseline shift would increase lifetime electric savings and improve the cost-effectiveness of LED lighting measures. The treatment of this issue by the DCSEU can be considered conservative.
  - For FY2019 and FY2020, we recommend the DCSEU weigh the available evidence and decide how to handle the EISA backstop provision in lighting baseline assumptions.

- Incremental costs for LED lighting were significantly overstated. The assumed incremental cost for an omnidirectional (A-lamp) LED was $10.52 for FY2017. The retail cost of ENERGY STAR LED lamps has dropped rapidly and is currently $4-$5 per lamp. Assuming a $1.50 cost for a halogen bulb means the incremental measure cost should be closer to $3/lamp.
  - The DCSEU tracking system has actual retail prices for all upstream lamps, so it is unclear why the calculations rely on dated assumptions rather than actual values.
  - Reducing the incremental cost assumptions would improve cost-effectiveness.

- Operation and maintenance cost assumptions were implausible for some LED projects.
  - The NMR team observed one non-residential LED lighting project that assumed $140 per year of O&M savings per screw-in LED bulb.
  - LED lamps do last significantly longer than halogens, so avoided future replacements (and associated labor) should be included as a benefit. However, it is important that the values used are defensible.
- The DCSEU uses separate line loss rates for energy (8%) and demand (6%). Losses are largely a function of resistance, so when separate assumptions are used, the peak demand line loss factor is typically higher than the year-round energy assumption because loads are higher on-peak than on-average.
  - We recommend the DCSEU review the original screening tool that provided the line loss assumptions. We also recommend DOEE confer with PEPCo about the appropriate filings to use as the basis for energy and demand line loss assumptions.

- The DCSEU cost-effectiveness calculations assume a 5% adder for avoided risk and uncertainty in energy supply and a 5% adder for Non-Energy Benefits. Although emissions benefits (avoided CO2) are calculated separately and in addition to NEBs, the 5% NEB adder only applies to energy benefits. The avoided CO2 benefits are not part of the total used to calculate the monetary value of either adder.
    - The 5% adders are proxy values to recognize tangible benefits that are challenging to directly quantify. As the NMR team develops its five-year evaluation plan, we will seek to conduct some NEB research to measure the non-energy impacts of the DCSEU programs.

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.