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Energy Efficiency and Renewable Energy Portfolios

2017 Annual Evaluation Report
(Volume II – Program Guidance Document)

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1. Introduction

Volume II of the 2017 Annual Evaluation Report of the Energy Efficiency and Renewable Energy portfolios, the *Program Guidance Document*, provides a program-by-program review of gross and net impacts, as well as a description of the methods employed in Opinion Dynamics's analyses to obtain the impacts. Opinion Dynamics created this document for use by PSEG Long Island and Lockheed Martin program staff to provide data-driven planning actions moving forward and full transparency for the methods used to calculate savings. The Long Island Power Authority (LIPA) administered the Energy Efficiency and Renewable Energy portfolios through 2013. Effective January 1, 2014, PSEG Long Island began a 12-year contract with LIPA. PSEG Long Island assumed day-to-day management and operations of the electric system, including administration, design, budget, and implementation of the Energy Efficiency Portfolio and the Renewable Energy Portfolio. In March 2015, PSEG Long Island transitioned the implementation of the Energy Efficiency Portfolio to its subcontractor, Lockheed Martin. In 2017, PSEG Long Island added the Home Energy Management program to the Energy Efficiency Portfolio, implemented by its subcontractor Tendril. PSEG Long Island continues to implement the Renewable Energy Portfolio. This evaluation covers the period from January 1, 2017 to December 31, 2017.

This section includes a comparison of the estimated demand and energy impacts determined through the Opinion Dynamics team's impact evaluation. Our evaluation calculates three levels of energy and demand savings: verified ex ante, evaluated, and ex post. We compare these savings types to the expected impacts used for program tracking (ex ante impacts). We describe each of these savings calculations and their purpose in Section 1.2.

The remainder of this document is organized as follows:

- Sections 2 through 8 provide a program-by-program review of energy and demand savings. For each program, there is a calculation of energy and demand savings accrued during the 2017 implementation year. We have also included any measure-specific recommendations for updating the gross energy and demand savings calculations.
- Section 9 provides detailed descriptions of research methods, including information on the primary and secondary data collection, as well as the analytical methods used to derive savings estimates.
- Appendix A presents the ex ante and ex post net-to-gross values by program and measure.

1.1 Key Definitions

Below we provide definitions for key terms used throughout the document.

- **Gross Impacts:** The change in energy consumption and/or demand at the generator that results directly from program-related actions taken by participants, regardless of why they participated. These impacts include line losses, coincidence factors (CFs) for demand, and waste-heat factors and installation rates for lighting. Gross impacts are the demand and energy that power plants do not generate due to program-related actions taken by participants.[1]
- **Net Impacts:** The change in energy consumption and/or demand at the generator that results directly from program-related actions taken by customers that would not have occurred absent the program.

[1] While this evaluation includes line losses, CFs, and installations rates when estimating gross impacts, PSEG Long Island does not include these in its gross impact estimates. Additionally, in some cases, such as Thermal Energy Storage projects, program-related activity may result in a decrease in demand while increasing energy consumption.

The only difference between the gross and net impacts is the application of the net-to-gross ratio (NTGR).

- **Net-to-Gross Ratio (Free-Ridership and Spillover):** The factor that, when multiplied by the gross impact, provides the net impacts for a program. The NTGR is defined as the savings that can be attributed to programmatic activity and is composed of free-ridership (FR) and spillover (SO). FR reduces the ratio to account for those customers who would have installed an energy-efficient measure without a program. The FR component of the NTGR can be viewed as a measure of naturally occurring energy efficiency, which may include efficiency gains associated with market transformation resulting from ongoing program efforts. SO increases the NTGR to account for those customers who install energy-efficient measures outside of the program (i.e., without an incentive) but due to the actions of the program. The NTGR is generally expressed as a decimal and quantified through the following equation:

$$NTGR = 1 - FR + SO$$

- **Ex Ante Net Impacts:** The energy and demand savings expected by the program as found in the program-tracking database. The ex ante net impacts include program planning NTGR values.
- **Verified Ex Ante Savings**: The energy and demand savings calculated by the evaluation team using methods and assumptions consistent with those used by PSEG Long Island to develop annual savings goals. These savings estimates are used to determine if PSEG Long Island achieves its annual scorecard goals.
- **Evaluated Net Savings:** The net savings attributed to the program for purposes of tracking towards the original ELI goal of 520 MW by 2018. Evaluated net savings are determined by applying program planning assumptions for NTGR to the gross impact estimates determined by the evaluation team.
- **Ex Post Net Savings:** The savings realized by the program after independent evaluation determined gross impacts and applied ex post NTGR values. Ex post NTGR values have been determined through primary research by the evaluation team. The evaluation team uses the ex post net impacts in the cost-effectiveness calculation to reflect the current best industry practices.
- **Line Loss Factors:** Line losses of 6.4% on energy consumption (resulting in a multiple of 1.0684 = [1 ÷ (1 − 0.064)]) and of 9.1% on peak demand (resulting in a multiple of 1.1001 = [1 ÷ (1 − 0.091)]) have been applied to estimate energy and demand savings at the power plant.

1.2 Summary of Gross and Net Impact Methods

Below we provide a summary of the methods used to determine evaluated and ex post net savings. Section 9 contains a more detailed discussion of methods.

Gross Impact Methods

We conducted multiple analyses to assess the evaluated gross energy and demand savings associated with PSEG Long Island's programs. The majority of our evaluated gross impacts come from engineering analysis using algorithms and inputs derived from the program-tracking databases. We also performed a consumption analysis[2] for the Residential Energy Affordability Partnership (REAP) program. For the Commercial Efficiency

[2] Previously referred to as "billing analysis," the evaluation team estimates the change in energy consumption resulting from program participation by modeling average daily consumption for a "treatment group" comprised of program participants and compares that consumption against modeled energy usage for a "comparison group" of future participants.

Program (CEP), in the summer of 2012, the evaluation team performed onsite measurement and verification (M&V) on custom projects, which resulted in a gross realization rate, which we applied to the 2017 custom projects.

When conducting engineering analyses, the evaluation team relied upon, where applicable, primary research from the *2016 PSEG Long Island Residential In-Home Study,* which captured the prevalence, location, and hours of use for certain energy efficient technologies. Additionally, the evaluation team referenced several secondary sources, such as, the New York State TRM, other regional TRMs, and the PSEG Long Island prospective TRM,[3] where applicable, to bolster evaluated savings estimates when primary data were unavailable. Currently, both the *PSEG Long Island Residential In-Home Study* and the prospective TRM reflect the most accurate Long Island-specific information available. However, the evaluation team finalized both resources in the third quarter of 2017 and thus results were unavailable to PSEG Long Island prior to the completion of planning for the 2017 program year. As such, throughout the remainder of this report the evaluation team highlights several instances where program staff used different planning assumptions from those outlined in either the In-Home Study or the Prospective TRM. PSEG Long Island has since updated their planning assumptions for 2018 and future program years to reflect findings from both resources.

Net Impact Methods

The evaluation team used net impact estimates as inputs to three separate analyses required by PSEG Long Island: the determination of annual demand and energy savings toward annual goal attainment, long-range energy efficiency portfolio goals, the benefit/cost assessment, and the economic impact assessment. Based on the specific requirements of each assessment, we developed the three separate net savings estimates described below.

Verified Ex Ante Net Savings

PSEG Long Island tracks its performance against annual energy savings goals, which it derives from planning assumptions regarding key inputs to the estimation of expected gross and net savings. To allow for consistency and direct comparison between evaluated program performance and established savings goals, the evaluation team developed “verified ex ante net savings” estimates for each Energy Efficiency and Renewable Energy program. This comparison verifies that the methods and assumptions used by PSEG Long Island to develop their annual plan for program savings, were applied consistently throughout the year in developing the ex ante savings. The verified ex ante savings are used as a comparison to the established annual savings goals and are first reported in a memorandum presented to PSEG Long Island and LIPA at the end of January. The memorandum is presented in Appendix B of this report.

Evaluated Net Savings

An important catalyst in LIPA’s initial decision to invest in the Energy Efficiency and Renewable Energy portfolios was the need to offset approximately 520 MW of generating capacity over ten years required to satisfy energy demand forecasted at that time. As such, in addition to its annual energy and demand savings goals, performance relative to the long-range capacity savings goal was a critically important performance metric for PSEG Long Island’s programs. The evaluation team calculates evaluated savings using detailed measure-level tracking information and applying the best information and methods available at the time of the evaluation to determine evaluated gross savings. We calculate evaluated net savings by applying PSEG

[3] Beginning with 2017, the “Prospective TRM” is a TRM developed by the evaluation team for PSEG Long Island that documents recommended assumptions and algorithms for future program years. The 2018 Prospective TRM is intended for use for the future planning efforts. Therefore, while we leveraged some assumptions from this document in the 2017 evaluation, we did not incorporate code or other changes in the 2017 evaluation that are specific to the future planning efforts.

Long Island's planning assumptions for NTGR to the gross demand and energy savings estimated through our evaluation. The evaluated net savings are also used by PSEG Long Island to refine its savings estimates going forward and help inform its program planning and goal setting process for the next program year. The evaluated net savings and the realization rate of evaluated savings compared to ex ante savings are the primary focus of this report.

Ex Post Net Savings

Among other inputs, the benefit/cost and economic impact assessments require an estimate of net program savings. The best practice approach for both assessments dictates that the net savings used to develop the benefit/cost ratio, or to quantify economic benefits, reflect current levels of FR and SO to provide an accurate estimate of the benefits associated with the current year's investment in the programs. As such, the evaluation team used ex post net savings in both assessments. Ex post net savings is calculated by applying researched NTG ratios in place of program planning NTGs when available. For 2017, we had no new primary data collection or activities with which to update previous NTGR values. However, the evaluation team conducted a review of recent research on NTGRs for residential LED lighting in 2016 and recommended an updated value for use in the upstream residential lighting program, which we began using in our 2017 evaluation. Both the planning NTGR values (applied within the evaluated savings) and ex post NTGR values (applied within the cost-effectiveness savings) are presented in Table 1-1.

1.3 Summary of Evaluated Demand and Energy Net Impacts

The realization rates in Table 1-1 provide a comparison of evaluated net savings and verified ex ante savings to ex ante savings. We discuss reasons why the evaluated values differ from the ex ante values in Sections 2 through 8.

Table 1-1. Portfolio Evaluated Impacts (Used for Comparison to Goals)

Program	Ex Ante Net Savings		Verified Ex Ante Savings		Evaluated Net Savings		Realization Rate	
	MW	MWh	MW	MWh	MW	MWh	MW	MWh
Energy Efficiency Portfolio								
Commercial Efficiency Program	**26.0**	**103,641**	**25.6**	**102,139**	**25.5**	**100,011**	**98%**	**96%**
Residential Efficiency Programs								
Energy Efficient Products (EEP)	18.5	138,463	18.6	138,920	26.7	121,572	145%	88%
Home Energy Management (HEM)	N/A	11,145	N/A	11,104	N/A	7,627	N/A	68%
Home Performance Programs	2.59	3,055	2.59	3,054	0.995	2,872	38%	94%
Cool Homes	2.80	2,703	2.81	2,705	2.81	2,728	100%	101%
REAP	0.277	644	0.276	645	0.380	1,380	137%	215%
Subtotal Residential	**24.1**	**156,010**	**24.3**	**156,427**	**30.9**	**136,180**	**128%**	**87%**
Total Energy Efficiency Portfolio (Commercial and Residential)	**50.2**	**259,651**	**49.9**	**228,566**	**56.4**	**236,191**	**112%**	**91%**
Renewable Energy Portfolio	**11.4**	**28,065**	**11.4**	**27,995**	**11.2**	**26,236**	**98%**	**93%**
Total Energy Efficiency and Renewable Energy Portfolios	**61.6**	**287,716**	**61.3**	**286,561**	**67.6**	**262,427**	**110%**	**91%**

Note: Totals may not sum due to rounding.

1.4 Summary of Cost-Effectiveness Results

Based on an analysis of program- and portfolio-level impacts and costs, the savings generated by the Energy Efficiency and Renewable Energy Portfolios are cost-effective. The evaluation team used two separate tests to establish a benefit/cost ratio for each program: the Utility Cost Test[4] (UCT) and the Societal Cost Test (SCT). The tests are similar in most respects but consider slightly different benefits and costs in determining a benefit/cost ratio. The UCT measures the net costs of an energy efficiency program as a resource option based on the costs incurred by the program administrator, including all program costs and any rebate and incentive costs, but excludes costs incurred by the participant. The SCT considers costs to the participant, but excludes rebate costs, as these are viewed as transfers at the societal level. The SCT also includes the benefits of non-electric (i.e., gas and fuel oil) energy savings where applicable resulting in different benefit totals than the UCT. Consistent with PSEG Long Island's Benefit-Cost Analysis (BCA) Handbook, we applied the SCT test as the primary method of determining cost-effectiveness and used assumptions similar to those used by PSEG Long Island's resource planning team.

Table 1-2 presents the benefit/cost ratios for both UCT and SCT for each program and for each portfolio separately. The portfolio-level SCT values are 1.6 and 0.79 for the Energy Efficiency and Renewable Energy portfolios, respectively. This indicates that from a societal perspective the Energy Efficiency portfolio is cost effective, while the renewable portfolio is not. The UCT test benefit/cost ratio is 1.9 for the Energy Efficiency Portfolio and 8.7 for the Renewable Energy Portfolio, indicating that portfolio benefits exceed program administrator costs in both cases (a benefit/cost ratio greater than 1 indicates that portfolio benefits outweigh costs).

The SCT was less than 1 for five programs in 2017: Cool Homes, REAP, HEM, Home Performance, and Renewables. The cost-effectiveness of the Cool Homes program increased from 0.60 in 2016 to 0.68 in 2017. In its first year as part of the portfolio, the HEM program achieved a cost effectiveness of 0.38 in the SCT test. The REAP program SCT of 0.35 is lower than in 2016 when the program achieved a SCT ratio of 0.62. However, cost ineffectiveness is not unusual for low-income programs, which typically are not required to be cost-effective. The SCT ratio of the Home Performance program increased from 0.21 in 2016 to 0.46 in 2017. The renewables portfolio had a SCT ratio less than 1 largely because this test accounts for the relatively high costs that participants bear for installing renewables.

The UCT was also less than 1 for Cool Homes, REAP, HEM, Home Performance in 2017. The Renewables portfolio had a UCT ratio significantly greater than 1 in 2017, largely due to the low costs incurred by PSEG Long Island to implement this program.

[4] The Utility Cost Test is also commonly known as the Program Administrator (PA) test.

Table 1-2. Cost-Effectiveness for the Energy Efficiency and Renewable Energy Portfolios

Program	Utility Cost Test			Societal Cost Test		
	NPV Benefits	Costs	Benefit/ Cost Ratio	NPV Benefits	Costs	Benefit/ Cost Ratio
Energy Efficiency Portfolio						
Commercial Efficiency Programs	**$40,836,434**	**$36,808,164**	**1.1**	**$54,878,078**	**$50,110,531**	**1.1**
Residential Programs						
EEP	$90,341,735	$14,828,365	6.1	$121,714,574	$37,740,619	3.2
Cool Homes	$6,804,051	$6,991,830	0.97	$7,739,844	$11,408,858	0.68
REAP	$792,270	$3,047,564	0.26	$1,058,262	$3,054,333	0.35
HEM	$270,681	$1,082,167	0.25	$422,337	$1,119,578	0.38
HP	$2,462,417	$13,322,270	0.18	$5,830,518	$12,776,308	0.46
Subtotal Residential	**$100,671,154**	**$39,272,196**	**2.6**	**$136,765,534**	**$66,099,697**	**2.1**
Total Energy Efficiency Portfolio	**$141,507,588**	**$76,080,360**	**1.9**	**$191,643,612**	**$116,210,228**	**1.6**
Renewable Energy Portfolio	**$50,571,000**	**$5,812,346**	**8.7**	**$63,771,098**	**$80,355,973**	**0.79**
Total Energy Efficiency and Renewable Energy Portfolios	**$192,078,588**	**$81,892,706**	**2.3**	**$255,414,710**	**$196,566,201**	**1.3**

A levelized cost analysis is a way to quickly compare the cost of energy efficiency programs with energy or demand savings from other sources. Levelized costs are expressed as $/kW-yr or $/kWh, meaning that the result can readily be compared to the cost of alternative supply additions or the cost of generating electricity. However, this is different from how power is typically purchased, where capacity is purchased first and then the additional cost of energy is added. The levelized costs here are either/or values. That is, the total costs are included in the calculation for levelized costs for kWh, and then the same costs are included in the kW value. Regardless, if the cost of the efficiency investment is less than the cost of capacity additions or generated electricity, efficiency is considered a wise investment.

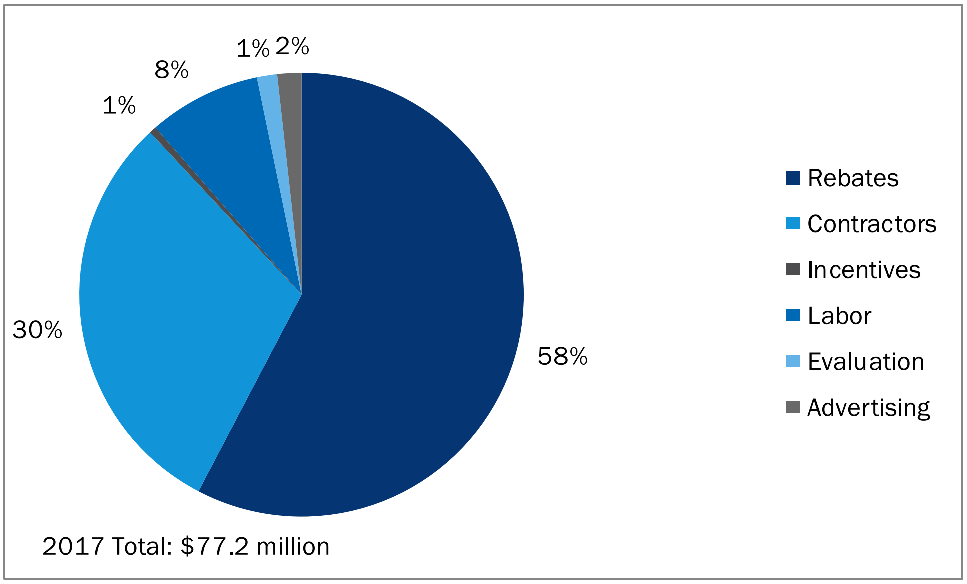
Table 1-3 provides the levelized costs for each program and for each portfolio separately based on the UCT. The levelized costs of capacity and energy for the Energy Efficiency Portfolio savings is $175.86/kW-yr and $0.043/kWh—less than the comparable costs of alternative supply-side resources. Likewise, the levelized costs of capacity and energy associated with PSEG Long Island's investment in the Renewable Energy Portfolio is $38.14/kW-yr and $0.016/kWh, which compares favorably to the cost of alternative supply.

Table 1-3. Levelized Costs for the Energy Efficiency and Renewable Energy Portfolios

Program	Total Program Costs	UCT Levelized Costs $/kWh	UCT Levelized Costs $/kW-yr
Energy Efficiency Portfolio			
Commercial Efficiency Programs	**$37,298,732**	**$0.065**	**$255.22**
Residential Programs			
EEP	$15,401,305	$0.013	$62.05
Cool Homes	$7,005,211	$0.241	$209.92
REAP	$3,054,333	$0.284	$1,030.84
HEM	$1,119,578	$0.147	N/A
HP	$13,336,156	$0.529	$1,586.90
Subtotal Residential Programs	**$39,916,584**	**$0.032**	$136.26
Subtotal Energy Efficiency Portfolio	**$77,215,316**	**$0.043**	$175.86
Renewable Energy Portfolio	**$5,941,037**	**$0.016**	$38.14
Total	**$83,156,354**	**$0.038**	$139.80

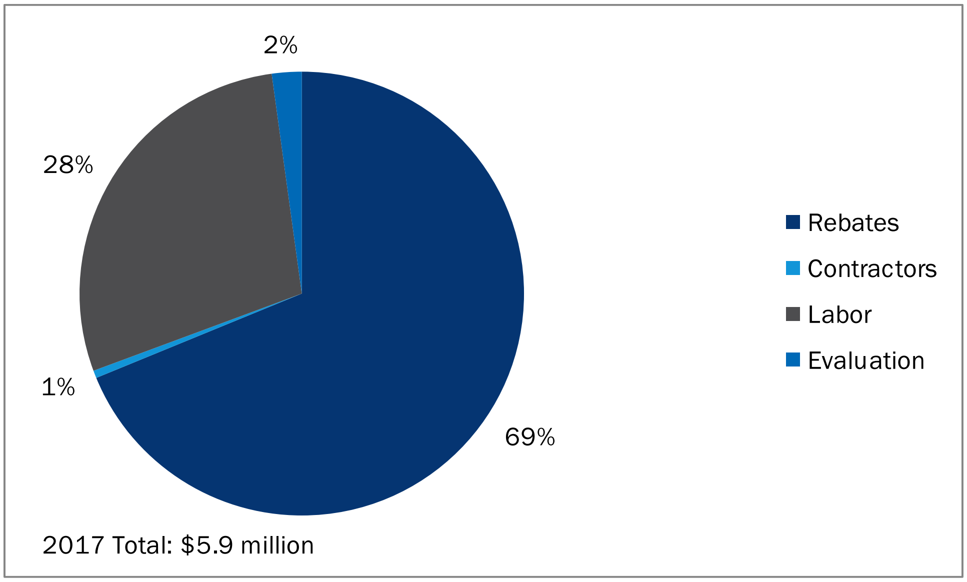
PSEG Long Island's expenditures varied for each program and show the respective breakouts of spending related to the Energy Efficiency and Renewable Energy portfolios by type of expenditure.

Figure 1-1. 2017 PSEG Long Island Expenditures for the Energy Efficiency Portfolio



"Rebates" consists of payments made to participating customers. "Incentives" consists of payments made to participating contractors (e.g., HVAC installers).

Figure 1-2. 2017 PSEG Long Island Expenditures for the Renewable Energy Portfolio



Solar expenditures shown in this figure include $4.1M of Solar PV rebates from NYSERDA funding that were passed through to PSEG Long Island customers.

1.5 Summary of Economic Benefits Results

The evaluation team estimated the expected changes to Long Island's overall economic output and employment resulting from PSEG Long Island's 2017 Energy Efficiency and Renewable Energy portfolios over the next 10 years. Table 1-4 and Table 1-5 present the direct impacts and the combined indirect and induced impacts for 2017 and for the 10-year period of 2017 to 2026. To account for expected inflation and the assumed increasing cost of electricity, the tables show the results as NPV using the discount rate of 5.50% used in PSEG Long Island's supply-side planning and the cost-effectiveness analysis.

Over 10 years, the 2017 investments in the Energy Efficiency Portfolio are expected to return $154.2 million in total economic benefits to the regional economy (in 2017 dollars), with an employment benefit of 1,211 new full-time equivalent employees (FTEs)[5] over that time period.

[5] Full-time equivalents represent the number of total hours worked divided by the number of compensable hours in a full-time schedule. This unit allows for comparison of workloads across various contexts. An FTE of 1.0 means that the workload is equivalent to a full-time employee for 1 year, but could be done, for example, by one person working full-time for a year, two people both working half-time for the year, or two people each working full-time for 6 months.

Table 1-4. Economic Impact of 2017 Energy Efficiency Portfolio Investments

2017 Energy Efficiency Portfolio Investments	2017 Economic Impact	2017-2026 Economic Impact (NPV[a])
Economic Impact		
Total Economic Output (millions)	$73.5	$154.2
Direct Effect	$63.0	$63.0
Indirect & Induced Effects	$10.5	$91.2
Employment (FTE)	557	1,211
Impact per $1M Investment		
2017 Program Investment (millions)	$77.2	$77.2
Total Economic Output in M per $1M Investment	$0.95	$2.0
Employment (FTE) per $1M Investment	7.2	15.7

[a] Using nominal discount rate of 5.50%, based on PSEG Long Island energy-supply cost assumptions.

The investments in the Energy Efficiency Portfolio resulted in a slightly lower total economic output in 2017 ($73.5 million) than in 2016 ($90.4 million), despite program expenditures remaining essentially constant as compared to 2016 and 2015. Several factors contributed to this difference, including:

- Changes to the mix of investments in commercial and residential programs and their related energy and demand savings
- Changes to the implementation of programs in the Energy Efficiency Portfolio, including rebate and incentive levels
- Changes to the Long Island economy and how economic impacts diffuse through different sectors
- Changes in the incremental measure costs and effective useful life of measures, as determined during the cost effectiveness analysis

Over 10 years, the 2017 investments related to the Renewable Energy Portfolio (i.e., program spending plus NY-Sun Initiative funding through the New York State Energy Research and Development Authority [NYSERDA]) are expected to return $50.2 million in total economic benefits to the regional economy (in 2017 dollars), with an employment benefit of 318 new FTEs over that time period. Note that the indirect and induced effect of the portfolio was negative for 2017, but these effects become positive over 10 years as the benefits of the installed systems continue through their 25-year expected life.

Table 1-5. Economic Impact of 2017 Renewable Energy Portfolio Investments

2017 Renewable Energy Portfolio Investments	2017 Economic Impact	2017-2025 Economic Impact (NPV[a])
Economic Impact		
Total Economic Output (millions)	$37.7	$50.2
Direct Effect	$46.2	$46.2
Indirect & Induced Effects	-$8.6	$3.9
Employment (FTE)	216	318
Impact per $1M Investment		
2017 Program Investment (millions)	$1.9	$1.9
Total Economic Output in M per $1M Investment	$20.3	$27.1
Employment (FTE) per $1M Investment	116.6	171.8

[a] Using nominal discount rate of 5.50%, based on PSEG Long Island energy-supply cost assumptions.
[b] Program investment does not include $4.1 million in solar funding from NYSERDA NY-Sun. Economic impacts, however, do include the benefits of these projects.

Similar to the 2016 results, 2017 spending on PSEG Long Island's Renewable Energy Portfolio resulted in greater benefits to the Long Island economy than in earlier program years, however economic impacts have declined since the peak in 2015, due to reduced funding availability through NYSERDA's NY-Sun program. This reduction in funding resulted in fewer systems installed in 2017 compared to the past two years. The renewables portfolio still realized positive economic impacts in 2017 because of the inclusion of $4.1 million in funding from the NY-Sun program, however NY-Sun funding has declined from $20 million in 2015. The NY-Sun funding had a large impact on the results because it positively contributed to the direct impact of the program, but did not incur a corresponding renewables charge to PSEG Long Island ratepayers. In addition, the commercial system cap was raised from 200 MW to 500 MW, which resulted in a few very large solar PV installations in the 2017 program.

2. Commercial Efficiency Program

PSEG Long Island's CEP caters to a wide range of business customers, offering incentives for a variety of energy-efficient equipment options and providing other types of support, such as energy audits and technical assistance studies. In 2017, PSEG Long Island delivered the CEP through the following program components.

- **Comprehensive Lighting:** Includes predefined new construction, as well as replacement and retrofit measures. Only large customers (i.e., customers with accounts billed under rate code 285) may apply for incentives under Comprehensive Lighting. Incentives amounts are fixed for the qualifying measures. All projects require preapproval, pre-inspection (except for new construction), and are subject to post-inspection. Comprehensive Lighting replaces the Existing Retrofit component, which the CEP offered in 2016, although its scope has been expanded to accommodate replacement of all existing lighting systems.

- **Fast Track Lighting:** Aimed at reaching small business customers, this program is limited to the subset of commercial customers with accounts billed under rate codes 280 or 281. Measure offerings and incentives are the same as Comprehensive Lighting. The program participation process is streamlined and is designed to address key barriers to participation among small business customers, namely, lack of time and the hassle factor. Only Prime Efficiency Partners (PEPs), contractors and distributors who have been vetted, trained, and certified by PSEG Long Island, may submit Fast Track Lighting applications. All Fast Track Lighting applications require post-inspection, but no formal preapproval.[6]

- **HVAC:** Includes both prescriptive and retrofit HVAC projects. In 2017, the HVAC program component included high-efficiency air conditioners and heat pumps, including ductless mini-split heat pumps, variable refrigerant flow heat pumps, and geothermal heat pumps.

- **Standard:** All other prescriptive measures are offered under the Standard application. This includes building envelope measures, compressed air, refrigeration, variable frequency drives (VFDs), and thermal energy storage (TES) projects. Standard applications require preapproval and are subject to pre- and post-inspections.

- **Custom/Whole Building Design:** Includes incentives for more-complex and less-common energy-efficient equipment and for new construction projects that integrate energy-efficient building shell and operating systems that result in a building that exceeds standard practice. Custom projects offer a certain degree of flexibility in terms of equipment choices and incentive amounts, thus allowing PSEG Long Island to better meet customer needs and engage customers with the program. Combined heat and power (CHP) projects are considered Custom. All custom projects are preapproved, pre-inspected, and post-inspected.

In addition to these core components, PSEG Long Island's 2017 CEP portfolio included no-cost energy assessments, cost-shared technical assistance studies, building commissioning co-funding, Leadership in Energy and Environmental Design (LEED) certification incentives, and ENERGY STAR® Benchmarking certification.

In 2017, Lockheed Martin oversaw the design and implementation of all CEP components.

Program Performance and Participation Trends

PSEG Long Island's CEP performed well in 2017, with its ex ante savings reaching 109% of the energy savings goal and 113% of the peak demand goal. Table 2-1 provides a summary of the CEP ex ante performance against goals.

Table 2-1. Ex Ante Program Performance against Goals

Metric	MW	MWh
Goal	23.0	95,005
Ex Ante Net Savings	26.0	103,641
% of Goal	113%	109%

Comprehensive Lighting projects account for the largest share of CEP demand and energy savings. As shown in Table 2-2, Comprehensive Lighting projects accounted for 60% of ex ante net demand savings and 59% of ex ante net energy savings from the CEP in 2017, down from 76%[7] in 2016. Fast Track Lighting grew in importance in 2017,[8] accounting for 26% of CEP demand savings compared with 14% in 2016. The CEP

[6] New PEPs are required to undergo a walkthrough in lieu of preapproval.

[7] Since the Comprehensive Lighting track did not exist in 2016, we compared 2017 Comprehensive Lighting performance to the 2016 Existing Retrofit performance for illustrative purposes.

[8] During 2017, CEP program managers updated the method used to calculate savings in the Fast Track Lighting program component. While still prescriptive in nature, the new protocols rely on different prescriptive savings values based on a categorical description of existing conditions.

continued to rely primarily on lighting measures for savings. Lighting measure installations across all program components accounted for 90% of the ex ante net demand savings and 91% of ex ante net energy savings.[9] Table 2-2 shows the distribution of ex ante net energy and demand savings by CEP component[10] and end use.

Table 2-2. CEP Savings from Lighting and Non-Lighting Measures

Program Component	End Use	Ex Ante Net Savings	
		% MW	% MWh
Comprehensive	Lighting	60%	59%
Fast Track	Lighting	26%	27%
Prescriptive Lighting*	Lighting	3%	3%
HVAC	Non-Lighting	6%	2%
Standard	Non-Lighting	2%	3%
Custom/Whole Building Design	Non-Lighting	2%	4%
Custom/Whole Building Design	Lighting	1%	2%
Total		**100%**	**100%**

* Carry over applications from 2016.

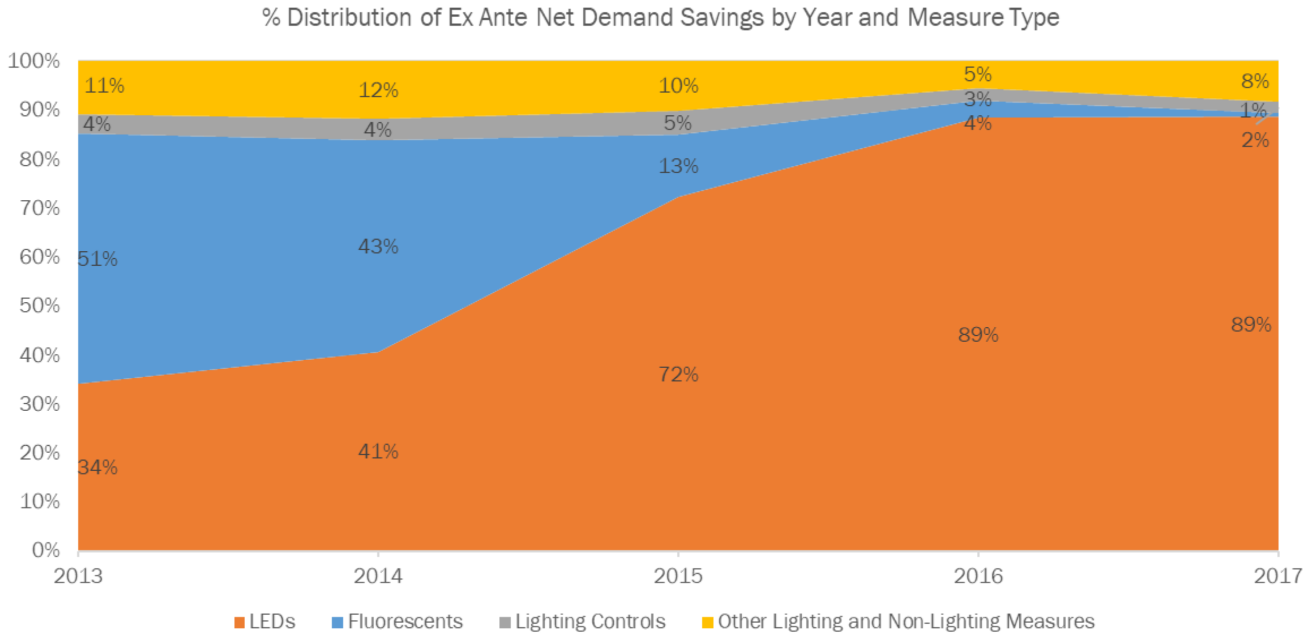
LED lighting continued to be the most prominent source of savings relative to other lighting measures in 2017, accounting for a similar percentage of CEP savings overall when compared to 2016, as shown in Figure 2-1. Non-Lighting measures almost doubled their share of CEP savings in 2017 compared to 2016. LEDs remained constant at 89% of ex ante net demand savings in 2016 and in 2017, while non-lighting savings increased from 5% of ex ante demand savings in 2016 to 8% in 2017.[11]

[9] Note that these measures include lighting controls and refrigeration lighting.

[10] As discussed below, the CEP no longer includes a Prescriptive Lighting program component, but because the program did honor previous commitments made under the 2016 application structure, a small percentage of 2017 CEP savings is classified as Prescriptive Lighting.

[11] Due to the lack of readily available measure detail at the end-use level for Custom projects and this component's relatively small contribution to the CEP savings, we excluded this program component from the analysis.

Figure 2-1. CEP Savings from Lighting and Non-Lighting Measures



Program Design and Delivery

CEP measure offerings and incentive levels underwent several changes in 2017. Noticeable changes included:

- Incentives were reduced for all lighting measures, especially LED low bay fixtures, and high bay fixtures, while rebates for exit signs and fluorescent fixtures and lamps were discontinued altogether.
- The CEP formally added CHP projects to the CEP portfolio.
- The cap on total Fast Track Lighting incentives per account (previously $5,000) was removed.

In 2017, the CEP launched several new initiatives, including:

- PEP program
- Lead Partner Quality Control Evaluation (QCE) Procedures
- New program application structure

Updated Measures and Incentive Offerings for 2017

In 2017, the CEP discontinued all rebates for fluorescent lamps and fixtures and exit signs and reduced the incentives for other lighting measures multiple times.[12] The program first reduced rebates in the Comprehensive and Fast Track Lighting components with targeted reductions to specific technologies, such as high bay and low bay lighting, and then instituted another round of reductions to lighting rebates for almost

[12] Because the 2017 CEP continued to accept some carryover applications from 2016, a very small number of linear fluorescents are included in 2017 savings calculations.

all other lighting measures. According to program managers, these adjustments were driven by the program staff analysis of participation to date and reductions in LED prices throughout the year, as CEP program managers sought to dynamically respond to market changes and avoid oversubscription.

The CEP also reduced its emphasis on TES projects in 2017 and formally added CHP projects to the portfolio of CEP measures. CHP projects involve efficient power generation systems that generate electricity from fuel and that recover excess or waste thermal energy for heating, cooling, or industrial processes. CHP rebates are proportional to the installed CHP system's nameplate capacity and are capped at 70% of the total project cost or $2,000,000, whichever is less. While PSEG Long Island launched a limited CHP offering at the end of 2016, it promoted and refined its approach to CHP projects in 2017. Throughout 2017, the program made updates to its CHP offering by setting a minimum allowable project size of 50 kW, reducing incentives for most project sizes, and allowing for the replacement of nonoperational CHP units only on a case-by-case basis. Since the CEP requires CHP projects to complete an engineering analysis, and CHP projects tend to have a long lag time from initiation to completion due to their higher cost and complexity, no CHP projects were completed in 2017; however, the program-tracking database includes several CHP projects in various stages of completion, collectively representing roughly 11 GWh of potential savings in 2018 and beyond. CEP program managers anticipate continuing to increase their emphasis on CHP projects in 2018.

TES systems allow customers to shift the power associated with conventional chilled water systems from the peak period to the off-peak period. This includes chillers, pumps, fans, cooling towers, and other associated equipment typically in use during the peak period for conventional cooling. While TES projects can result in significant energy savings, their primary purpose is typically to shift cooling loads away from peak periods. The CEP offers $1,000 in rebates for each avoided ton of chiller capacity[13] resulting from TES. As PSEG Long Island shifts toward a focus on energy savings, it expects TES will play a reduced role in the CEP.

The program increased its emphasis on Fast Track Lighting in 2017. According to program staff, after careful analysis, they decided to remove the $5,000 per-account cap on incentives through the Fast Track Lighting program component. This decision coincided with the introduction of the PEP program and enhanced quality control protocols (discussed further below), which, according to program staff, collectively help mitigate the risks associated with removing the incentive cap. In 2017, the Fast Track Lighting program component increased ex ante net savings, number of completed projects, and overall realization rates to levels above its comparable predecessor, Prescriptive Lighting. In fact, the Fast Track Lighting program component achieved an evaluated net demand savings realization rate of 100% in 2017. By comparison, the Prescriptive Lighting program component achieved an evaluated net demand savings realization rate of 88% in 2016.

New Initiatives for 2017

In 2017, the CEP underwent several related programmatic changes to streamline program delivery, capture additional remaining lighting opportunities, and continue to lay foundations for increased non-lighting savings opportunities in the future. To this end, the CEP introduced an enhanced contractor vetting and rewards initiative in the form of the PEP program, a new application structure, and new a QCE procedure for all participating contractors.

Prime Efficiency Partners Program

The CEP introduced the PEP program in 2017; the program allows contractors to apply for an enhanced Efficiency Partner designation. To become a PEP, a contractor must:

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[13] Avoided tons represent the maximum reduction achieved during the peak period, which occurs from 2pm to 6pm on non-holiday weekdays during summer months.

- Read and complete the PEP Agreement and Application
- Attend a PEP training session
- Pass the PEP test
- Obtain a PEP identification number and certificate

There are a variety of benefits that come with the PEP designation. For starters, as of 2017, only PEP contractors are able to submit Fast Track Lighting applications.[14] In addition, PEP contractors are able to co-brand with PSEG Long Island, are allowed to assign rebates electronically, and can market themselves as program-approved PEPs. The CEP allowed PEPs to co-brand their email signatures' letterheads and other marketing materials with the PSEG Long Island logo, provided all materials were explicitly approved by PSEG Long Island in advance. According to program staff, the PEP program was well received by contractors, and 63 contractors received PEP certification in 2017. In fact, although not required by the CEP, some HVAC contractors sought PEP certification, so the program began offering PEP training and certification to HVAC contractors.

Lead Partner Quality Control Evaluation Procedure

In conjunction with the PEP program, the CEP initiated a revised QCE procedure applicable to all participating Lead Partners.[15] This procedure aims to ensure that all participating contractors are adhering to both CEP policies and general industry best practices. Where a contractor has demonstrated noncompliance with program guidelines, industry standards, or best practices in its project work, the CEP may conduct a Lead Contractor QCE of the contractor. As an initial step, the program issues a written warning to Lead Partners who demonstrate such noncompliance. This warning is followed by a pre-QCE meeting between program staff and the contractor, and a follow-up meeting communication. Those contractors who continue to demonstrate the same noncompliant practices then continue through the formal QCE process. During a QCE, a Lead Partner is unable to initiate new projects, and any ongoing projects are placed on hold and subject to QCE audits, which include a review of project documentation and field inspections. In addition, a sample of the Lead Contractor's completed projects are reviewed for program compliance. Once the CEP completes a QCE audit, the contractor either will be allowed to resume project work under the program or will be expelled from the program for 1 year, depending upon the results of the audit.

New Application Structure

In place of the Existing Retrofit, Prescriptive Lighting, Fast Track, and Custom program components, the CEP now rebates measures through five main tracks:

- Comprehensive Lighting
- Fast Track Lighting
- HVAC
- Standard

[14] The Fast Track Lighting application is not available on the CEP website and was provided only to PEP contractors.

[15] The CEP refers to participating contractors, distributors, manufacturers, and other participating entities, collectively, as Lead Partners throughout CEP literature and databases.

- Custom/Whole Building Design

Comprehensive Lighting is available only to large customers (rate code 285) and is intended to be more robust than the previous Existing Retrofit track. For instance, the Comprehensive Lighting application can be used in almost all lighting redesign situations. Comprehensive Lighting applications require preapproval and pre-inspection and are subject to post-inspection. Fast Track Lighting offers the same measures and incentives as Comprehensive Lighting, but is designed to offer a streamlined participation process. In 2017, only PEP contractors were able to submit Fast Track Lighting applications. Offered only to small businesses (rate code 280 or 281), the Fast Track Lighting program component is tailored to their needs by reducing the time and cost burdens associated with multiple approvals and inspections. All Fast Track Lighting applications require post-inspection, but not a formal preapproval.

As of 2017, all HVAC measures are rebated through a separate HVAC application, and all other non-lighting measures are rebated through the Standard application. All Custom, CHP, and whole building projects are included in the Standard application in 2017.

Marketing, Outreach, and Customer Intake

Program marketing and outreach efforts in 2017 remained largely consistent with 2016 and leveraged a wide range of marketing strategies and tactics to broaden customer and trade ally awareness of the CEP and its benefits. Marketing strategies employed in 2017 included continued reliance on trade allies and Lockheed Martin energy consultants to reach and educate customers about program offerings, energy efficiency conferences, testimonials, webinars, and web and radio advertising. There were roughly 400 trade allies who supported direct outreach to customers in 2017, in addition to program energy consultants. The program continued to host open houses once a week to answer trade ally questions, review application forms, provide project preapproval, and address other contractor issues. The annual Energy Efficiency Conference on Long Island continued to be another source of customer and trade ally engagement.

Anticipated Changes in 2018

PSEG Long Island is making several changes to the CEP in 2018. Specifically, they will expand the geothermal offering within CEP as another step toward developing non-lighting savings opportunities. PSEG Long Island will remove CHP projects from the Standard application and will rebate them through a separate application process. In conjunction with these changes, PSEG Long Island will expand the PEP component of the CEP to include geothermal contractors, and likely CHP contractors.

Overall Impacts for the Commercial Efficiency Program

Table 2-3 compares evaluated net savings to ex ante net savings for the CEP by program component, and shows the associated realization rates. The evaluation team calculated evaluated realization rates by dividing evaluated net savings values by ex ante net savings values. Overall, the CEP achieved 98% of its ex ante net demand and 96% of its ex ante net energy savings. Evaluated realization rates for demand savings ranged from 76% for the Prescriptive Lighting program component to 107% for the Standard program component. Evaluated realization rates for energy savings ranged from 54% for the Prescriptive Lighting program component to 123% for the Standard program component. The Comprehensive Lighting and Fast Track Lighting program components make up more than 85% of the overall CEP energy savings; therefore, these components highly influence the overall CEP realization rates. A further discussion of discrepancies seen among all program components is provided in the following sections.

Table 2-3. CEP Net Impacts for Goal Comparison

Program Component	Ex Ante Net Savings		Verified Ex Ante Net Savings		Evaluated Net Savings		Evaluated Net Realization Rate	
	kW	kWh	kW	kWh	kW	kWh	kW	kWh
Comprehensive Lighting	15,513	60,736,456	15,411	60,337,636	15,269	59,542,509	98%	98%
Fast Track Lighting	6,824	28,391,948	6,809	28,425,316	6,801	27,003,826	100%	95%
Custom	968	6,013,626	838	5,794,769	775	5,712,944	80%	95%
Standard	546	3,289,683	583	3,205,923	584	4,041,650	107%	123%
Prescriptive Lighting	686	2,838,711	524	2,167,156	524	1,543,650	76%	54%
HVAC	1,494	2,370,386	1,455	2,207,911	1,575	2,166,005	105%	91%
Total	**26,032**	**103,640,810**	**25,620**	**102,138,711**	**25,527**	**100,010,584**	**98%**	**96%**

Ex post net savings differ from evaluated net savings in that ex post savings are developed using ex post NTGRs, while evaluated net savings are based on program planning NTGR values. Program planning NTGRs differed from evaluated values by program component. The evaluation team did not perform new NTGR research this year and therefore used NTGRs established through previous evaluations. We describe the derivation of ex post NTGRs in detail below and in Appendix A of this report.

Table 2-4 provides a comparison of ex ante and ex post net savings by program component and associated realization rates. The evaluation team developed ex post net impact estimates for use in the benefit/cost and economic impact assessments. Ex post net realization rates were calculated by dividing ex post net savings by ex ante net savings. Overall, the CEP achieved an ex post net realization rate of 77% for demand savings and 76% for energy savings. Ex post realization rates for demand savings ranged from 60% for the Prescriptive Lighting program component to 95% for the Standard program component. Ex post realization rates for energy savings ranged from 42% for the Prescriptive Lighting program component to 113% for the Standard program component.

Table 2-4. CEP Net Impacts for Cost-Effectiveness

Program Component	Ex Ante Net Savings		Ex Post Net Savings		Ex Post Net Realization Rate	
	kW	kWh	kW	kWh	kW	kWh
Comprehensive Lighting	15,513	60,736,456	11,928	46,307,245	77%	76%
Fast Track Lighting	6,824	28,391,948	5,313	21,004,185	78%	74%
Custom	968	6,013,626	619	4,541,791	64%	76%
Standard	546	3,289,683	519	3,712,101	95%	113%
Prescriptive Lighting	686	2,838,711	409	1,200,523	60%	42%
HVAC	1,494	2,370,386	1,257	1,721,974	84%	73%
Total	**26,032**	**103,640,810**	**20,046**	**78,487,819**	**77%**	**76%**

The evaluation team's evaluated and ex post savings estimates relied on a series of engineering analyses. Below we describe the analyses by program component, including reasons for discrepancies between ex ante and evaluated savings. The sections are organized by the CEP categories outlined in Table 2-5.

Table 2-5. CEP Categories and Associated Program Components

Category	Program Component
Lighting	Fast Track Lighting
	Comprehensive Lighting
	Prescriptive Lighting
Non-Lighting	HVAC
	Standard
Custom	Custom

Engineering Analysis Results – Lighting Programs

This section provides the results of the evaluation team's analysis of energy and demand savings associated with lighting measures installed through: Fast Track, Comprehensive, and Prescriptive Lighting program components. Our team used different engineering approaches for the three programs included in CEP Lighting, as described below.

Fast Track Lighting Program Component

The evaluation team's analysis of the Fast Track Lighting program component included a review of the LM Captures data for all 2017 projects. The evaluation team applied engineering algorithms to the measure-level detail provided as part of the program data-tracking extract to arrive at verified ex ante savings, evaluated savings, and ex post savings estimates.

Comprehensive Lighting Program Component

For Comprehensive Lighting measures, the LM Captures database did not contain fully populated details (e.g., building type and lighting controls). Therefore, the evaluation team conducted desk reviews of a representative sample of projects (n=25). This desk review approach is consistent with the approach used in previous evaluations (see Section 9.3 for details on the sampling methodology).

Prescriptive Lighting Program Component

For Prescriptive Lighting measures, the LM Captures database also did not contain fully populated characteristics (e.g., business operating hours of use [HOU], building type). As such, the evaluation team conducted desk reviews of a sample of projects (n=5).

Impact Results for Goal Comparison: Lighting Program Components

Table 2-6 presents evaluated net energy and demand savings associated with the Lighting program components. As both ex ante and evaluated net savings values are calculated using program planning NTGRs, the differences expressed through the realization rates represent differences in the ex ante and evaluated gross savings.

Table 2-6. Lighting Program Components: Comparison of Ex Ante, Verified Ex Ante, and Evaluated Net Savings

Program Component	Number of Units	Ex Ante Net Savings		Verified Ex Ante Net Savings		Evaluated Net Savings		Evaluated Net Realization Rate	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
Comprehensive Lighting	548,099	15,513	60,736,456	15,411	60,337,636	15,269	59,542,509	98%	98%
Fast Track Lighting	230,511	6,824	28,391,948	6,809	28,425,316	6,801	27,003,826	100%	95%
Prescriptive Lighting	14,856	686	2,838,711	524	2,167,156	524	1,543,650	76%	54%
Total	**793,466**	**23,024**	**91,967,116**	**22,745**	**90,930,107**	**22,594**	**88,089,985**	**98%**	**96%**

Note: Totals may not sum due to rounding.

Reasons for Differences in Impacts

Below we describe analysis specifics and reasons for discrepancies in savings.

- For **Comprehensive Lighting** measures, the desk reviews revealed several of discrepancies between ex ante and evaluated savings.
  - For projects that included occupancy sensors, the evaluation team applied a 30% energy savings factor (ESF) per the New York Technical Reference Manual (NY TRM). The ex ante ESF assumption was 25% or 40%, depending on the sensor type.[16] The evaluation team's updates to occupancy sensor savings factors on average decreased evaluated net savings compared to ex ante savings and are the key driver of the 98% realization rate, shown in Table 2-6. The evaluation team recommends PSEG Long Island align its ESF assumptions with those presented in the NY TRM.[17] The team also recommends tracking the lamp controlled by the occupancy sensor to allow for population-level evaluations of the Comprehensive Lighting program component.[18]
  - For one project, calculation errors were discovered in the workbook provided by PSEG Long Island for one measure code.[19] We found that quantities for the existing fixture reflected the number of total lamps not fixtures. This was coupled with an existing wattage assumption associated with the overall fixture, not the number of lamps. This led to a larger ex ante existing energy usage estimate and ultimately an inflated ex ante savings estimate. The individual project realization rate was 70%, which contributed to lowering the overall Comprehensive Lighting realization rate.
  - For one project that included refrigerated case lighting, the evaluation team discovered that ex ante demand savings estimates assumed a CF of 1, whereas the evaluation team assumed the

[16] Within the desk review sample, only two occupancy sensor types were captured (measure codes LC100 and LC300). Other occupancy sensor types are present in the overall comprehensive program. The additional occupancy sensors assume a range from 13% ESF to 50% ESF.

[17] The NY TRM v4 (effective for the 2017 program year) assumes 30% ESF, whereas v5 (effective January 2018) assumes ESF based on install location. Updates to PSEG Long Island inputs should reference v5 of the NY TRM.

[18] For the evaluation team to review the Comprehensive Lighting program component at the population level, each occupancy sensor line item pulled from the LM Captures database must denote the characteristics of the lamp or fixture controlled (such as wattage and quantity of fixtures).

[19] Project ID: 2016-1710617 and measure code L820.

refrigerated case lighting-specific CF from the NY TRMv6 (0.948). This update slightly decreased evaluated net demand savings. In addition, the evaluation team found that ex ante energy and demand savings applied the lighting waste heat factors for all other lighting technologies (i.e., 1.13 for energy and 1.32 for demand). For evaluated net energy savings, the evaluation team applied the waste heat factors specific to refrigerated case lighting (i.e., 1.41 for energy and 1.40 for demand) as prescribed in the NY TRM. This change increased the evaluated net energy and demand savings compared to ex ante energy and demand savings.

  - For several projects, adjustments in measure quantities were made to reflect project-specific documentation. Quantities were increased or decreased only slightly; therefore, these updates did not greatly affect the overall realization rates.

- For **Fast Track Lighting** measures, the population-level analysis revealed the only discrepancy between ex ante and evaluated savings was the operating hours assumption. The implementers applied operating hours from the 2010 LIPA Technical Manual, whereas the evaluation team adhered to the operating hours assumptions provided in the NY TRM. The 2010 LIPA Technical Manual references studies from 1994 to 1996. We believe the NY TRM is the more accurate source and aligns operating hours with other PSEG Long Island commercial programs. Overall, this resulted in lower evaluated savings, as reflected in the 95% kWh realization rate reported in Table 2-6 above. The evaluation team recommends adopting the NY TRM operating hours assumptions for future program years.

- For **Prescriptive Lighting** measures, the evaluation team's desk reviews found two main sources of savings discrepancies responsible for the low realization rates of 76% and 54% for demand and energy savings, respectively.

  - The evaluation team found that all ex ante savings estimates incorrectly applied WHFs twice. The deemed per-measure savings assumptions used in ex ante calculations included WHFs, as did ex ante savings algorithms. The evaluated savings include WHFs only once, which lowered both energy and demand realization rates.

  - The evaluation team also adjusted the operating hours to adhere to the NY TRM, which is consistent with the assumptions for the Fast Track and Comprehensive Lighting measures. Ex ante operating hours again rely on the 2010 LIPA Technical Manual. Because operating hour estimates affect only energy savings, the realization rate for energy savings is significantly lower than that of demand savings.

Impact Results for Cost-Effectiveness: Lighting Program Components

Ex post net impacts are the savings to the grid due to program intervention. As noted previously, the evaluation team develops ex post net impact estimates for use in the benefit/cost and economic impact assessments.

The ex ante NTGR varied from the ex post NTGR, as shown in Table 2-7. We applied the same ex post NTGR as in the previous evaluations. The evaluation team developed an updated NTGR for the CEP in 2011 and performed primary research in 2012 to specifically look for participant SO. SO added approximately 0.02 to the previous NTGR of 0.70. Therefore, we calculated ex post net savings by applying a NTGR of 0.72 to the evaluated gross savings. In contrast, the program calculates ex ante net savings by assigning a NTGR of 0.92 to all lighting measures.

Table 2-7. Lighting Program Component NTGRs

End-Use	Ex Ante NTGR[a]	Ex Post NTGR[b]
Comprehensive Lighting	0.92	0.72
Fast Track Lighting	0.92	0.72
Prescriptive Lighting	0.92	0.72

[a] Ex ante NTGR values are from measure-specific information received from PSEG Long Island staff.
[b] Ex post FR is 30% for both kW and kWh. The specific SO value varies between demand and energy savings. The demand SO is 1.87%, while the energy SO is 1.55%.

Table 2-8 shows a comparison of ex ante and ex post net energy and demand savings associated with CEP Lighting programs by program component.

Table 2-8. Lighting Program Components: Comparison of Ex Ante and Ex Post Net Savings

Program Component	Number of Units	Ex Ante Net Savings		Ex Post Net Savings		Ex Post Net Realization Rate	
		kW	kWh	kW	kWh	kW	kWh
Comprehensive Lighting	548,099	15,513	60,736,456	11,921	46,307,245	77%	76%
Fast Track Lighting	230,511	6,824	28,391,948	5,310	21,004,185	78%	74%
Prescriptive Lighting	14,856	686	2,838,711	409	1,200,523	60%	42%
Total	**793,466**	**23,024**	**91,967,116**	**17,640**	**68,511,954**	**77%**	**74%**

Engineering Analysis Results – Non-Lighting Programs

This section provides the results of the evaluation team's analysis of energy and demand savings associated with non-lighting measures installed through the CEP. The CEP Non-Lighting program components include HVAC and Standard.

HVAC Program Component

The evaluation team's analysis of the HVAC component included a review of the LM Captures data for all 2017 projects. The evaluation team applied engineering algorithms to the average population-level detail provided as part of the program data-tracking extract to arrive at verified ex ante savings, evaluated savings, and ex post savings estimates.

Standard Program Component

The Standard program component includes the following end-uses: compressed air, refrigeration, motors and VFDs, building envelope, and TES. The evaluation team's analysis of the Standard program component included a mix of desk reviews and population-level data analysis similar to the HVAC program component.

Impact Results for Goal Comparison: Non-Lighting Program Components

Table 2-9 presents evaluated net energy and demand savings associated with the Non-Lighting program components by end-use category. As both sets of net savings values were calculated using the same program planning NTGRs, the differences expressed through the realization rates represent differences in the ex ante and evaluated gross savings.

Table 2-9. Non-Lighting Program Components: Comparison of Ex Ante, Verified Ex Ante, and Evaluated Net Savings

End-Use	Number of Units	Ex Ante Net Savings		Verified Ex Ante Savings		Evaluated Net Savings		Evaluated Net Realization Rate	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
HVAC	714	1,494	2,370,386	1,455	2,207,911	1,575	2,166,005	105%	91%
Refrigeration	1,777	79	1,284,211	79	1,284,211	79	1,284,211	100%	100%
Motors and VFDs	143	121	1,153,130	150	1,085,395	60	1,787,041	49%	155%
Compressed Air	49	67	821,311	76	805,286	88	767,449	131%	93%
Building Envelope	31	106	244,121	106	244,121	127	281,670	119%	115%
TES	1	173	−213,090	173	-213,090	231	−78,721	133%	37%a
Total	**2,715**	**2,040**	**5,660,069**	**2,038**	**5,413,835**	**2,158**	**6,207,654**	**106%**	**110%**

Note: Totals may not sum due to rounding.
[a] Ex ante and evaluated net energy savings for the TES end-use are energy penalties and are therefore negative. A smaller realization rate is preferable and indicates that the evaluated net energy penalty is smaller than the ex ante energy penalty by 63%.

Reasons for Differences in Impacts

Below we describe the specific reasons for discrepancies in savings.

- For **HVAC** measures, the engineering analysis led to evaluated net realization rates of 105% for demand and 91% for energy savings. The LM Captures database provided extensive and detailed information for each installation. The evaluation team applied ASHRAE 90.1 2013 to define measure baselines for HVAC installations, because ASHRAE 90.1 2013 had an effective date of October 2016 in New York. The engineering analysis was supplemented with desk reviews of 11 HVAC projects where the evaluation team reviewed ex ante application of TRM algorithms and input assumptions. For new construction or normal replacement installations, evaluated savings were determined by comparing the installed equipment to a code-standard baseline. Our analysis used normalized savings values (i.e., kW/ton or kWh/ton) across the different types of HVAC measures. We multiplied these normalized values by the installed cooling capacity in tons for each measure type to arrive at the evaluated savings.
  - As mentioned above, the evaluation team referenced ASHRAE 90.1 2013 to define measure baselines for HVAC installs in 2017. It appears that the program referenced ASHRAE 90.1 2010 to define baseline efficiencies. This difference in baseline led to lower evaluated demand and energy savings, particularly for the smaller (<5.4 ton) HVAC units, for which the cooling efficiency baseline changes from a seasonal energy efficiency ratio (SEER) of 13 in ASHRAE 90.1 2010 to a SEER of 14 in ASHRAE 90.1 2013.
  - The evaluation team updated the assumed CF from 0.72 to 0.80 to align with the NY TRM. As a result, evaluated net demand savings are greater than ex ante net demand savings.
- For **Refrigeration** measures, the program-tracking data lacked detail on the installed measure information (such as kW rating) behind kW savings. Given this lack of detail, and the fact that refrigeration measures contribute only about 4% of the Non-Lighting ex ante demand savings, the evaluation team assigned a realization rate of 100% for these measures. The evaluation team's previous review of program algorithms and assumptions gives us confidence that the program is characterizing this measure category's savings appropriately. The evaluation team recommends that

the program update its data collection and tracking procedures for this measure to ensure that all data required for evaluation are accurately recorded and available to the evaluation team.

- For **Motors and VFD** measures, the engineering analysis resulted in the evaluated net realization rate of 49% for demand savings and 155% for energy savings. Program-tracking data contained detailed and extensive information for each installation that enabled the evaluation team to conduct engineering analyses by facility and motor type. The evaluation used normalized savings values (i.e., kW/hp or kWh/hp) that the NY TRM recommends based on different building types and VFD application. We multiplied these values by the installed horsepower for each measure provided by PSEG Long Island to arrive at the evaluated savings.[20] The throttle valve measure evaluated demand savings are much lower than that of ex ante, which largely drives the low realization rate for demand savings. The team believes that PSEG Long Island is using the 2010 LIPA Technical Manual planning document for VFD savings factors, resulting in savings differences when compared with the NY TRM. We recommend that the program adopt the savings algorithms and assumptions outlined in the TRM provided by the evaluation team.

- For **Compressed Air** measures, the evaluated net realization rates are 131% for demand savings and 93% for energy savings. The air compressor and compressed air storage end-uses resulted in realization rates for demand above 100%, while all three compressed air end-uses (cycling dryers, compressed air storage, and variable displacement) resulted in realization rates below 100% for energy savings. For evaluated savings, we leveraged the savings calculation methods and assumptions recommended by programs in the Northeast, as well as install-specific data. While we investigated the reason that ex ante savings were higher than evaluated savings, key ex ante savings assumptions were not readily available. The evaluation team recommends that the program adopt the savings algorithms and assumptions outlined in the TRM provided by the evaluation team.

- For **Building Envelope** measures, the evaluation team used installation-specific building types, installed areas, and normalized savings values (kW/sf or kWh/sf) by building type recommended by the NY TRM. These calculations resulted in realization rates of 119% for kW and 115% for kWh. There were no specific details on how the program team calculated the assumed savings percentage were not available to the evaluation team; therefore, we could not explain the sources of discrepancies. Going forward, we recommend using savings algorithms for these measures based on prospective PSEG Long Island TRM developed by the evaluation team, which is in alignment with the NY TRM.

- For **Thermal Energy Storage** (TES) measures, the evaluated net realization rates are 133% and 37%[21] for demand and energy savings, respectively. The evaluation resulted in a higher peak demand reduction and a lower annual energy penalty compared to the ex-ante analysis results. The ex ante analysis used load estimation based on equipment capacity and full-load rated efficiencies, applied to an estimated annual effective full load hours (EFLH). The evaluation was able to use an hourly model, utilizing all available equipment performance data and post-inspection findings and trends. The most significant factors contributing to the discrepancies include:
  - The evaluation team estimated a design tonnage of 800 tons, and a modeled peak tonnage of 567 tons, for the facility based on a linear model with 800 tons at peak operation and a minimum

[20] Per communications with program staff, one large project completed at Stony Brook University with multiple VFD measures required a custom calculation, as the university is only partially grid reliant.

[21] Ex ante and evaluated net energy savings for the Thermal Energy Storage end use are energy penalties and are therefore negative. A smaller realization rate is preferable and indicates that evaluated net energy penalty is smaller than the ex ante energy penalty by 63%.

of 0 tons corresponding to an outdoor air temperature (OAT) at 45°F[22]. These values are lower than the 1,400 peak tons estimated in the ex ante analysis, which was based on a combination of 400-ton ice burn assumption, existing 800-ton Trane chiller at full load, and a proposed 800-ton dual-duty chiller operating at 200 tons. As a result of the ex post tonnage update, the evaluation team modeled the as-built chiller plant operating only one chiller during the peak hour at a part load that provided more efficient operation. The ex ante analysis assumed two chillers operating during the peak hour, with the dual-duty chiller operating at a more inefficient low part load, to meet the estimated 1,400 tons of load. Thus, the evaluation team modeled the as-built chiller plant at a higher efficiency than the ex ante analysis, resulting in increased peak demand savings.

- The evaluation team's analysis accounted for the glycol pump usage (a small penalty) and the offset of cooling tower load (a large saving). The ex ante savings calculations did not account for the energy use of this equipment, resulting in further peak demand reductions.
- The evaluation team modeled each hourly chiller plant component power based on the ice-burn schedule (10 am to 9pm daily), chilling schedule (12am to 7 am) and outdoor air temperature (OAT). Compared to the ex ante methodology of using full-load efficiencies and EFLHs, the ex post method resulted in overall decreased annual kWh penalty, since the chillers are more efficient at part-load than at full-load.

Impact Results for Cost-Effectiveness: Non-Lighting Program Components

The ex ante NTGR varied from the ex post NTGR by end-use, as shown in Table 2-10. We applied the same ex post NTGR as in the previous evaluations. The evaluation team developed an updated NTGR for the CEP in 2011 and performed primary research in 2012 to specifically look for participant SO. SO added approximately 0.02 to the previous NTGR of 0.70. Therefore, we calculated ex post net savings by applying a NTGR of 0.72 to the evaluated gross savings. In contrast, the program calculates ex ante net savings by assigning multiple deemed NTGRs based on measure type. These deemed NTGRs range from 0.64 to 1.00.

Table 2-10. Non-Lighting Program Component NTGRs

End-Use	Ex Ante NTGR[a]	Ex Post NTGR[b]
HVAC	0.90	0.72
Compressed Air	0.91	0.72
Refrigeration	1.00	0.72
Motors and VFDs	0.64	0.72
Building Envelope	1.00	0.72
TES	1.00	1.00

[a] Ex ante NTGR values are from measure-specific information received from PSEG Long Island staff.
[b] Ex post FR is 30% for both kW and kWh. The specific SO value varies between demand and energy savings. The demand SO is 1.87%, while the energy SO is 1.55%.

Ex post net impacts are the savings to the grid due to program intervention. As noted previously, the evaluation team developed ex post net impact estimates for use in the benefit/cost and economic impact assessments. The Non-Lighting ex post impacts are presented in Table 2-11.

[22] The 800-ton peak tonnage assumption was based on the post inspection. The inspection revealed the tonnage during noon-7 PM at around 700 tons or less for one summer day with a recorded OAT of 86°F.

Table 2-11. Non-Lighting Program Component: Comparison of Ex Ante and Ex Post Net Savings

End-Use	Number of Units	Ex Ante Net Savings		Ex Post Net Savings		Ex Post Net Realization Rate	
		kW	kWh	kW	kWh	kW	kWh
HVAC	714	1,494	2,370,386	1,257	1,721,974	84%	73%
Refrigeration	1,777	79	1,284,211	61	988,014	77%	77%
Motors and VFDs	143	121	1,153,130	67	1,997,856	56%	173%
Compressed Air	49	67	821,311	70	603,418	104%	73%
Building Envelope	31	106	244,121	91	201,535	86%	83%
TES	1	173	−213,090	231	−78,721	133%	37%[a]
Total	**2,715**	**2,040**	**5,660,069**	**1,777**	**5,434,074**	**87%**	**96%**

Note: Totals may not sum due to rounding.
[a] Ex ante and evaluated net energy savings for the Thermal Energy Storage end use are energy penalties and are therefore negative. A smaller realization rate is preferable and indicates that evaluated net energy penalty is smaller than the ex ante energy penalty by 63%.

Engineering Analysis Results – Custom Program

The evaluation team based evaluated and ex post energy and demand savings from the Custom program on the evaluation of 67 sites via engineering M&V during the 2012 impact evaluation. We applied the same realization rates (0.80 for demand savings and 0.95 for energy savings) from this past analysis to the 2017 Custom projects. While the research that informed these realization rates is now several years old, the Custom program has declined in relative importance within the CEP in recent years and now makes up only about 4% of CEP demand savings. Table 2-12 shows ex ante and evaluated net energy and demand savings associated with the Custom program component broken out by Lighting and Non-Lighting end-uses. Both net savings values are calculated using program planning NTGRs, meaning that the differences expressed through the realization rates represent differences in the ex ante and evaluated gross savings.

Table 2-12. Custom Program Component: Comparison of Ex Ante, Verified Ex Ante, and Evaluated Net Savings

Program Component	Number of Projects	Ex Ante Net Savings		Verified Ex Ante Savings		Evaluated Net Savings		Evaluated Net Realization Rate	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
Custom Non-Lighting	37	646	4,131,076	559	3,980,732	517	3,924,522	80%	95%
Custom Lighting	30	322	1,882,550	279	1,814,037	258	1,788,422	80%	95%
Total	**67**	**968**	**6,013,626**	**838**	**5,794,769**	775	**5,712,944**	**80%**	**95%**

Note: Totals may not sum due to rounding.

Table 2-13 presents ex ante and ex post net energy and demand savings associated with the Custom program component. As noted previously, the evaluation team developed ex post net impact estimates for use in the benefit/cost and economic impact assessments. Similar to the Lighting and Non-Lighting program components, we performed no NTGR research this year. The evaluation team developed an updated NTGR for the CEP and Solutions Provider/Large Business program elements in 2011 and performed primary research in 2012 to specifically look for participant spillover (SO). SO added approximately 0.02[23] to the previous NTGR

[23] The specific SO value varies between demand and energy. The demand SO is 1.87%, while the energy SO is 1.55%. When considered at the single level, both are 2%. We applied the specific values shown here in our analysis.

of 0.70. Therefore, we calculated ex post net savings by applying a NTGR of 0.72 to evaluated gross savings. In contrast, the program calculated ex ante net savings using a deemed value of 0.90 for custom projects.

Table 2-13. Custom Program Component: Comparison of Ex Ante and Ex Post Net Savings

Program Component	Number of Projects	Ex Ante Net Savings		Ex Post Net Savings		Ex Post Net Realization Rate	
		kW	kWh	kW	kWh	kW	kWh
Custom Non-Lighting	37	646	4,131,076	413	3,119,995	64%	76%
Custom Lighting	30	322	1,882,550	206	1,421,796	64%	76%
Total	**67**	**968**	**6,013,626**	**619**	**4,541,791**	**64%**	**76%**

Note: Totals may not sum due to rounding.

Net-to-Gross Ratio Estimation

PSEG Long Island uses deemed NTGRs for the CEP that range from 0.64 to 1.00, depending on the measure for the CEP, and uses a NTGR of 0.90 for the Custom program. The 2011 free ridership research found a 0.70 NTGR for the CEP.

In 2012, the evaluation team performed primary research to estimate participant SO. The resulting SO adds approximately 0.02 to the previous NTGR of 0.70. The resulting total NTGR for Custom projects increased to 0.72.

We did not revisit NTGR assessment as part of the 2017 evaluation, but rather relied on the FR estimate developed during the 2011 evaluation and the SO estimate developed as part of the 2012 evaluation.

Conclusions and Considerations

Looking ahead, there are several potential challenges that could affect continued program success. The core challenge is the program's continued and increased reliance on lighting measures, which account for 93% of the ex ante net demand savings and 94% of ex ante net energy savings. In 2017, PSEG Long Island brought in new CEP measures, such as CHP, which are helping to diversify program offerings away from lighting. PSEG Long Island should continue to research the potential energy and demand savings from other end-uses. Diversification will allow the program to ensure stable performance and savings sources moving forward. Another challenge is the rapid transformation of the LED market in terms of pricing, product availability, and prominence. The program should continue to monitor product pricing and adjust incentives accordingly.

While the LM Captures database provides greatly enhanced project-level detail to evaluators, measure-level characteristics across key data fields prevented the evaluation team from conducting an engineering analysis of the population of projects for all program components. Instead, we relied on a sample-based review of individual program applications when necessary. A sample-based approach results in some sampling error around realization rates, while an engineering review of the full population of projects would not. To enhance the rigor associated with the engineering review, the program should consider consistently tracking the following data as part of LM Captures for all applicable projects and allow the data to be easily extractable:

- Comprehensive Lighting:
  - Occupancy sensor watts controlled
  - Building type

- Non-Lighting:
  - All input assumptions for refrigeration and building envelope measures (specifically refrigerated case size and electronically commutated motor size)

3. Energy Efficient Products Program

The objective of the Energy Efficient Products (EEP) program is to increase the purchase and use of energy-efficient appliances and lighting among PSEG Long Island residential customers. In 2017, the program provided rebates on a range of ENERGY STAR products, including solid state lighting (LED) bulbs, fixtures, and appliances.

Overall, 2017 was a successful year for the EEP program. It reached its internal goals (reaching target ex ante savings within budget) by October, approximately 2 months ahead of schedule. As such, PSEG Long Island assigned more budget to the program and extended the savings goals for the year. The program credits its marketing efforts, including store visits, store materials, and staffing at trade shows, for playing an important role in its ability to reach and educate customers.

During 2017, the program once again updated the list of qualifying products to reflect ENERGY STAR's standards and market trends. Notably, the program fully switched to an all-LED offering, and no longer offers CFLs. Product changes also included expanded offerings for refrigerators, pool pumps, clothes washers, clothes dryers, and water heaters. The program reinstated ENERGY STAR dehumidifier rebates at $25 or up to 50% of the retail price, and piloted ENERGY STAR heat pump water heater rebates of up to $750 or up to 50% of the retail price.

Additionally, PSEG Long Island modified incentives for several other products in 2017.

- The lighting program reduced rebates for both standard and specialty LED lights from 2016 levels, initially capping incentives at $2.00 for standard LEDs and $3.25 for specialty LEDs. In mid-July, the incentives for standard and specialty LED lights were reduced to $1.00 and $2.00, respectively.
- Within the ENERGY STAR "most efficient" clothes washer offering, PSEG Long Island reduced the incentive from $75 (or up to 50% of the retail price) to $65 (or up to 50% of the retail price).
- Within the efficient clothes dryers program, PSEG Long Island decreased the incentive on ENERGY STAR clothes dryers from $150 (or up to 50% of the retail price) to $125 (or up to 50% of the retail price).
- In contrast to recent years (i.e., 2015 and 2016), PSEG Long Island did not run a sweepstakes to boost participation in the appliance recycling program, as program participation was doing well without it.

The evaluation team observed several notable trends within the various EEP measure categories. The following sections offer detailed examination of trends in program participation and savings.

Lighting

As is the case throughout the United States, technological advances and falling prices have made high-quality LEDs more accessible to Long Island customers. Additionally, ENERGY STAR 2.0 product certification standards, which went into effect on January 1, 2017, were expected to increase the number of ENERGY STAR LEDs available on the market during the program year.[24] Many non-ENERGY STAR LED lighting products that were on the market in 2016 are now eligible for ENERGY STAR certification due to a reduction in the bulb lifetime requirement, increasing the number of LED products that PSEG Long Island could offer to customers.

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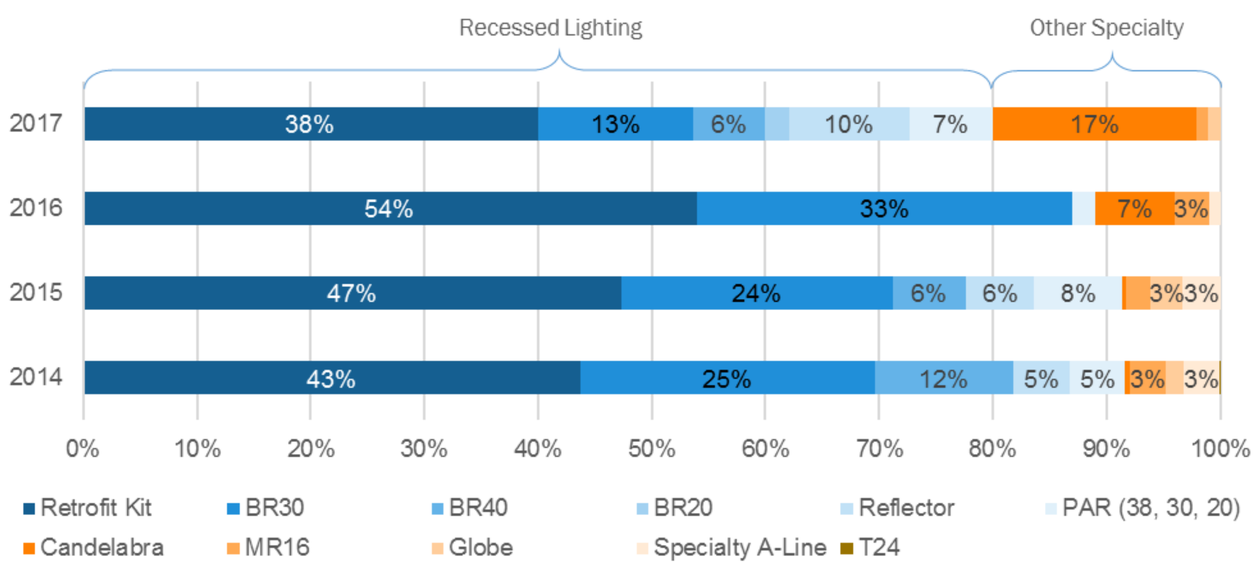
[24] ENERGY STAR Program Requirements, Product Specification for Lamps (Light Bulbs), Eligibility Criteria Version 2.0. https://www.energystar.gov/products/lighting_fans/light_bulbs/.

The ENERGY STAR 2.0 certification standards also require a higher level of bulb efficiency, effectively barring CFLs from certification.

Lighting continues to play a large role in the EEP program: Lighting provided approximately 92% of the EEP program's 2017 evaluated energy savings and 79% of its evaluated demand savings. These savings come from PSEG Long Island's exclusive-LED offering, which as noted above no longer offers discounts on CFLs.[25] Because many participating retailers had already begun to phase out CFLs on their own, PSEG Long Island found that the 2017 transition to LEDs was a natural process.[26] As more retailers enter the lighting business—including Bed, Bath, & Beyond and Best Buy—it is expected that the new retailers will follow the same trend, offering mainly LEDs over CFLs.

The EEP program continued to offer a mix of specialty and standard lighting in 2017. The shift away from CFLs to LEDs also brought a shift in the program's product makeup relative to recent years. In 2016, about 40% of lighting sales were specialty lighting products; in 2017, this had grown to 54%. This is mainly because LEDs are better suited for more specialty applications. Recessed lighting, including retrofit kits, continues to dominate the specialty lighting offering (Figure 3-1). Retrofit kits and BR30 bulbs continued to make up the majority of markdowns (51%), although the margin decreased somewhat relative to previous years (these products were 87% of markdowns in 2016 and 71% in 2015). Candelabras, MR16s, and globe lights are a slowly growing share of the specialty lighting offering, and in 2017 made up the remaining one-fifth (19%) of the program's specialty markdowns.

Figure 3-1. Share of EEP Program Specialty LED Markdowns by Lighting Type, 2014–2017



Source: EEP upstream rebate program-tracking data, 2014–2017.

[25] The evaluation team's review of program-tracking data identified a small quantity of CFL sales in the first 3 months of 2017. Ex post impacts also capture carryover savings from CFLs distributed in past years and assumed to be installed during 2017. Combined, CFLs produced 3% and 5% of the program's ex post kWh and kW lighting savings, respectively.

[26] In the last year, before the transition to all LEDs (i.e., 2016), LEDs had started to outpace CFLs in popularity. Specialty LEDs and standard LEDs each drove a larger share of program-discounted sales (42% and 30%, respectively) than all types of CFLs combined (29%).

Note: Increases in 2017 candelabra sales relative to 2016 may be linked to bulb descriptions that more frequently included bulb base sizes in the 2017 program-tracking data.

The program saw a continued increase in LEDs sold in packages of multiple bulbs (multi-packs), up from 59% in 2016 to 84% in 2017. Additionally, the program's multi-pack sales shifted toward larger package sizes (Figure 3-2). In 2016, 6-, 8-, and 10-packs made up a cumulative 11% of the program's standard LEDs and 7% of specialty LEDs; their share increased in 2017 to 54% of standard LEDs and 22% of specialty LEDs. Though multi-packs get more bulbs into customer homes, sales of large multi-packs may adversely affect installation rates, as customers may not have an immediate need to install all the lights in the package. Notably, other program administrators have observed a correlation between the sale of large pack sizes and reduced first-year installation rates.[27]

Figure 3-2. Distribution of EEP Lighting Measures by Package Size, 2016–2017

	1-Pack	2-Pack	3-Pack	4-Pack	6-Pack	8-Pack	10-Pack
Standard							
2017	4%	5%	<1%	36%	11%	17%	26%
2016	20%	1%	10%	59%	1%	8%	2%
Specialty							
2017	26%	16%	22%	14%	18%	4%	
2016	54%	18%	10%	10%	3%	4%	

Source: EEP program-tracking data, 2016–2017. Excludes bulk lighting and online store rebated lighting products (which account for less than 0.1% of total program sales). The program does not offer package sizes without a percent.

Looking forward to 2020, the second tier of the Energy Independence and Security Act (2007) (EISA Tier 2) goes into effect. This means that lighting equipment efficiency standards will increase again, most notably a new, 45 lumen-per-watt efficiency standard for all general service lamps. The new efficiency standards will be in place as of January 1, 2020. At the same time, the U.S. Department of Energy has expanded its definition of "general service lamp" in anticipation of EISA Tier 2, meaning that more products will be subject to the 45 lumen-per-watt minimum efficiency standard, therefore further reducing the opportunity to save energy beyond the higher baseline efficiency. Several types of lamps will be exempt from EISA Tier 2, although based on our review of the types of lighting currently rebated through the EEP program, PSEG Long Island is already offering an energy-efficient alternative for the one type of product likely to remain exempt from EISA Tier 2, the 3-way lamp (Table 3-1).

[27] In research completed for the South Carolina Electric & Gas residential upstream lighting program in 2013 and 2014, we found that the first-year installation rate decreased from 83% to 66% from 2013 to 2014. We attributed some of this decrease to the sale of larger pack sizes.

Table 3-1. Types of Bulbs Affected by EISA Tier 2 (2020) Regulations

Lighting Regulated under EISA Tier 2, Offering No Opportunity to Promote a More-Efficient Product		Lighting Exempt from EISA Tier 2	
Incentives offered by EEP	**Incentives not offered by EEP**	**Incentives offered by EEP**	**Incentives not offered by EEP**
▪ Standard A-Line ▪ Specialty A-Line ▪ BR30 ▪ BR40 ▪ Candelabra ▪ Globe ▪ MR16 ▪ PAR20; PAR30; PAR38 ▪ Reflector ▪ Retrofit Kit	▪ All other general service lamps	▪ 3-way lamp	▪ Appliance lamp ▪ Black light lamp ▪ Bug lamp ▪ Infrared lamp ▪ Plant light lamp ▪ Colored lamp ▪ Silver bowl lamp ▪ G-shape lamp (diameter ≥ 5in.) ▪ Left-hand thread lamp ▪ Showcase lamp

In determining which lamps would be exempt from the broader definition of "general service lamp" and thereby not subject to the 45 lumen-per-watt backstop, the Department of Energy deliberately excluded lamps with the potential to replace general service lamps and undermine the new standards.[28] The exemptions, therefore, generally fit into two categories: (1) the lamp type is experiencing declining sales or currently makes up less than 1% of lamps sold annually and/or (2) the lamp type is not a risk for "lamp switching" with general service lamps because of its specific function and/or shape. Moreover, while many of the exempt lamp types in Table 3-1 do have LED substitutes, none of those substitutes are currently ENERGY STAR certified.

Altogether, these higher energy-efficiency standards and more-expansive definition of "general service lamps" will reduce the opportunity for PSEG Long Island to achieve savings from the EEP lighting program after 2020. Furthermore, given that the types of lighting expected to remain exempt from EISA Tier 2 represent a small share of the market, and that future ENERGY STAR certification of the available LED alternatives is uncertain, it is unlikely that there are any lighting opportunities for PSEG Long Island to pursue that can offer an impactful opportunity for residential lighting savings after EISA Tier 2 goes into full effect.

Pool Pumps

Pool pumps continued to drive the program's non-lighting savings. The program rebated 2,815 single- and variable-speed pumps, which together comprised 5% of the program's evaluated net kWh savings and contributed more than six times the savings of other key measures like appliance recycling and room air conditioners. The opportunity to promote savings from efficient pool pump options (compared to a single-speed baseline) will continue through the next several years. In July 2021, however, new DOE efficiency standards take effect and raise the minimum pump efficiency.[29] Accordingly, the code change diminishes PSEG Long Island's opportunity to promote above-code savings after that date.[30]

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[28] U.S. Department of Energy (DOE). Energy Efficiency and Renewable Energy Office (EERE). (January 19, 2017). Energy Conservation Program: Energy Conservation Standards for General Service Lamps (Final Rule ed.) (EERE-2013-BT-STD-0051). Regulations.gov: DOE. Available at: https://www.regulations.gov/document?D=EERE-2013-BT-STD-0051-0097.

[29] U.S. Department of Energy (DOE). (August 7, 2017). Energy Conservation Program: Test Procedure for Dedicated-Purpose Pool Pumps (Final Rule). (EERE-2016-BT-TP-0002). Available at: https://www.regulations.gov/document?D=EERE-2016-BT-TP-0002-0015.

[30] The regulation applies to pumps used in both residential and commercial settings and sets performance-based standards by pump size (in hydraulic horsepower, or HHP), and pump type (self-priming, primarily used in in-ground pools, and non-self-priming, primarily used in above-ground pools). Standard size pumps typical of those used in in-ground pools will need to meet performance-based standards equivalent to today's variable-speed pumps. Smaller pumps such as those used in above-ground pools will also face increased efficiency requirements. The 2016 *PSEG Long Island Residential In-Home Study* found that 62% of pools are in-ground and

Heat Pump Water Heaters

As opportunities for efficient lighting savings diminish, the EEP program will increasingly depend on larger appliances to achieve program savings. In 2017, PSEG Long Island piloted a rebate program for ENERGY STAR heat pump water heaters (HPWHs). This offering was designed to provide rebates on up to 100 units and, for the first time, tap into PSEG Long Island's relatively small share of customers with electric water heat. The program assumed that the pilot would rebate a mix of seventy-five 50–60-gallon units and twenty-five 80-gallon units. Year-end counts show that the program achieved 76% of its pilot goal, rebating 76 units in a mix of sizes that was relatively similar to expectation (80% 50–60-gallon units and 20% 80-gallon units).

Including water heaters in the EEP program is an opportunity to add a new, large saving measure. For example, HPWHs can save significantly more per unit (3,058 kWh–3,274 kWh) than pool pumps can (797 kWh–2,437 kWh), which offers the second-highest savings per measure among EEP program products. However, as program staff have cited, the HPWH offering presents a unique set of customer-awareness challenges. According to the program implementer, few retailers are currently marketing water heaters with the attention-grabbing floor displays that attract customers to other appliances, making HPWHs less visible to customers. A 2016 study by the Northwest Energy Efficiency Alliance (NEEA) examined program designs to promote HPWHs sales and installation.[31] That study affirmed and expanded on the barriers cited by PSEG Long Island.

Although most customers replace water heaters on failure, customers who switch from a conventional water heater to a HPWH typically do so on an early-replacement basis, according to NEEA research. This suggests that HPWH purchases are typically planned decisions. Planned purchases of water heaters occur for new construction or in the event that a customer wants to replace his or her water heater before failure.[32] Planned purchases are just 5% of water heater replacements, so one way for PSEG Long Island to expand its ability to reach more HPWH customers would be to find a way to promote HPWHs as part of emergency-replacement installations. The challenge with replace-on-failure situations is that customers have little time for exploring multiple options or doing research on new technologies.[33] Given that barrier, both the customer base and the retailers/installers would need to be educated on the product. According to EEP program staff, the EEP program implementer did not target contractor outreach to market the 2017 program. NEEA recommends expanding installer and retailer education, so that they are more capable of articulating HPWH benefits to customers and making the product more visible to customers in the event that they are shopping in-store.

If PSEG Long Island wishes to expand the HPWH program, it may also be helpful to think of the market in terms of the new construction market versus the small share of existing customer homes with electric heat (homes with electric heat have the existing infrastructure needed to install a HPWH, even if their current water heater is not electric).[34] Effectively targeting these two different types of HPWH opportunities and leveraging these program strategies will help PSEG Long Island compensate for anticipated reductions in savings from lighting measures.

38% are above-ground (n=120). A small sample of on-site audits conducted as part of that study found that most pumps are standard size (n=13).

[31] NEEA. 2018. *2016 Evaluation Findings for the Heat Pump Water Heater Initiative.*

[32] 15% of all water heater replacements are for new construction projects and 5% are for planned purchases. Source: NEEA. 2018. *2016 Evaluation Findings for the Heat Pump Water Heater Initiative.*

[33] 80% of water heater replacements are emergency-replacement scenarios. Source: Ibid.

[34] 7% of all Long Island residents have electric heat, including 6% of single-family homes and 15% of multifamily homes. Source: Opinion Dynamics. October, 2017. *PSEG Long Island Residential In-Home Study.*

Dehumidifiers

In 2017, the EEP program reinstated rebates for ENERGY STAR dehumidifiers, responding to a change in ENERGY STAR specifications in late 2016 that increased the minimum efficiency for ENERGY STAR-rated units.[35] In its first year back, the dehumidifier program performed at 62% of its unit goal, rebating 3,037 of the projected 4,875 units. Most (44%) of these units were rebated in the summer months, peaking in August (21.8% of all rebates). Like the ENERGY STAR HPWHs, a lack of product visibility in stores can be a barrier to program success for dehumidifiers.

Room Air Conditioners

In 2016, the EEP program reinstated rebates for ENERGY STAR room air conditioners (ACs) because changes in ENERGY STAR standards had likely reduced the number of ENERGY STAR models available in retail stores. In their second year back in the program, room ACs performed well, comprising 46% of the program's rebated new appliances. PSEG Long Island offered three size classes of room ACs, with 67% of rebates coming from the largest size class (8,000–13,999 BTU).

Room ACs contributed 6.4% of the EEP program's 2017 summer peak demand savings, a notable share relative to the program's other ENERGY STAR appliances. Moving forward, however, the program will discontinue this offering, as PSEG Long Island and Lockheed Martin shift from a demand reduction focus (kW) to an energy savings focus (kWh). These changes reflect PSEG Long Island's efforts to align with the New York State Energy Plan's commitment to reducing greenhouse gas emissions by 40% from 1990 levels, which carries an increased focus on kWh reductions.

Refrigerators

The number of ENERGY STAR refrigerators rebated increased significantly in 2017. After a successful program year in 2016—exceeding the program unit goal by 444%--PSEG Long Island doubled the number of projected units from 500 in 2016 to 1,000 in 2017. The program still exceeded this increased unit goal halfway through the year and ended the year at 262% of its quantity goal. Just as in 2016, 99% of rebated refrigerators were ENERGY STAR "most efficient" refrigerators.

Future Planning

PSEG Long Island has made efforts to diversify away from lighting by bringing in new measures and products in recent years, including heat pump water heaters (2017), dehumidifiers (2017), air conditioners (2016), super-efficient clothes washers (2015), and pool pumps (2010). The program should continue to identify and promote new measures moving forward, adjusting the measure mix to reflect ENERGY STAR product availability and market trends. In 2018, PSEG Long Island will no longer offer room ACs in the EEP program, but the program is adding ENERGY STAR "most efficient" dishwashers.

The evaluation team is currently conducting a Long Island specific Commercial and Residential Potential Study, which will generate a range of information about current market baselines in each sector and will support energy efficiency program planning for EEP and other programs. While results of the baseline study and short- and long-term energy-savings potential forecasts were not yet available as publication of this report, the evaluation team will be providing results in time to facilitate 2019 annual planning as well as 2018's long-

[35] PSEG Long Island had previously offered dehumidifier rebates, but canceled them for 2015 after finding that most dehumidifiers on retail shelves in Long Island were ENERGY STAR certified.

range planning efforts. These results are expected to inform decisions about adding or further modifying the EEP program product lineup in coming years.

Impacts for Goal Comparison

Table 3-2 provides a program-level comparison of evaluated net savings to ex ante savings by measure category.

Table 3-2. Energy Efficient Products Program Net Impacts for Goal Comparison

Category	Ex Ante Net Savings			Verified Ex Ante Savings			Evaluated Net Savings		Realization Rate	
	N[a]	kW	kWh	N[b]	kW	kWh	kW	kWh	kW	kWh
Lighting	4,389,716	12,835	128,043,298	4,389,008	12,838	128,029,106	20,588	111,623,386	160%	87%
Pool Pumps	2,816	3,741	6,024,577	2,815	3,740	6,022,142	3,668	5,826,176	98%	97%
Appliance Recycling	4,420	330	2,158,549	4,420	330	2,158,549	187	920,554	57%	43%
Room ACs	13,282	1,080	524,453	13,282	1,081	524,780	1,859	902,786	172%	172%
ENERGY STAR Dehumidifiers	3,037	290	457,821	3,037	290	457,821	105	572,501	36%	125%
Refrigerators	2,662	48	401,732	2,662	48	401,407	17	146,395	36%	36%
HPWHs	80	31	285,816	80	31	285,816	29	265,550	93%	93%
Air Purifiers	613	40	217,661	613	40	217,661	42	356,297	105%	164%
Clothes Dryers	4,315	31	194,002	4,315	145	665,659	146	670,816	479%	346%
Most Efficient Clothes Washers	4,721	30	143,478	4,721	30	143,478	56	266,785	186%	186%
Power Strips	154	2	12,998	155	2	13,082	3	20,876	102%	161%
Total	**4,425,816**	**18,457**	**138,464,385**	**4,425,108**	**18,574**	**138,919,501**	**26,701**	**121,572,122**	**145%**	**88%**

[a] Source: Individual program-tracking spreadsheets.
[b] Source: Evaluation team analysis of reported savings.
Note: Totals may not sum due to rounding.

Reasons for Differences in Impacts

In 2017, the program and evaluation team updated several measure-specific calculations. The following discussion focuses on discrepancies between ex ante and ex post results. Although not discussed as part of the reasons for differences in impacts, the evaluation team also notes that several measure criteria were adjusted in 2017, and these changes resulted in notable differences in some measure-specific savings relative to 2016. For example, the program and evaluation teams worked together to adjust the NTGR for LED bulbs from 1.20 to 0.55 to reflect market trends, updated the Combined Energy Factor assumed for baseline clothes dryers in accordance with federal standards, and recalculated the efficient refrigerator unit energy consumption based on purchases tracked by the program.

- **Lighting:** Lighting accounted for approximately 77% of the evaluated demand savings and 92% of the evaluated energy savings across the EEP program in 2017. The evaluation team calculated a realization rate of 160% for demand and 87% for energy savings. The differences between ex ante and evaluated savings are mainly due to the following:

- **LED CF:** The program assumed a CF of 11% for LEDs based on prior research in the Northeast,[36] while the evaluation team applied a CF of 23% for interior LEDs, based on the Residential In-Home Lighting Study[37] conducted by the evaluation team and finalized in the third quarter of 2017. For exterior LEDs, the evaluation team assumed a CF of 0%, consistent with the NY TRM. The evaluation team assumed that 89% of bulbs were installed in interior locations, based on the Residential In-Home Study. The difference in coincidence factors was the primary contributor to significantly higher evaluated lighting kW.

- **LED ISR:** The program assumed an in-service rate of 100% for LEDs, while the evaluation team determined an 89% ISR for first-year savings, based on the Residential In-Home Study. This resulted in a decrease in evaluated lighting savings for both demand and energy. The evaluation team will account for additional installations (up to 98% ISR) in future program years.

- **HOU:** The program calculated a weighted average of 1,134 annual operating hours from prior research, which assumed 2.8 and 5.0 hours[38] per day for interior and exterior lighting, respectively, at a mixture of 86% and 14% of interior to exterior sockets, respectively. Applying the findings from the Residential In-Home Study, the evaluation team used 3.1 hours per day for interior LEDs, and 2.1 hours per day for interior CFLs. The evaluation team used 4.2 hours per day for exterior lighting, consistent with secondary research performed by Opinion Dynamics in 2016, for use in 2017 program planning. The evaluation team also applied a mix of 89% interior and 11% exterior sockets, based on the Residential In-Home Study finalized in late 2017. These assumptions resulted in average weighted values of 1,159 annual operating hours for LEDs and 851 annual operating hours for CFLs. These differences resulted in a slight increase to the overall realization rate for lighting energy savings.

- **HVAC Interactivity:** The program planning assumptions did not include HVAC interactivity factors in the savings calculations. The evaluation team applied HVAC interactivity factors based on the NY TRM and the prevalence of CFLs and LEDs in conditioned spaces from the Residential In-Home Study. This resulted in an increase in evaluated lighting savings for both demand and energy.

- **Delta Watts:** Program assumptions applied the measure mix from 2015 installation data to estimate the difference in lighting wattage after installation of the energy-efficient unit. The evaluation team calculated a realized difference in lighting wattage from 2017 tracked data and calculated baseline wattage for standard LED bulbs using EISA minimum requirements. For specialty LED bulbs, not addressed by EISA, the evaluation team used baseline incandescent wattages chosen by the evaluators based on 2017 installed wattage data. This approach resulted in higher baseline watts for 2017 in comparison to 2015, and subsequently a slight increase in the overall lighting realization rate for both demand and energy.

- **Pool Pumps:** Ex ante savings assumptions for pool pumps were based on evaluated 2015 data, whereas the evaluation team used 2017 installation data to determine evaluated savings. On average, customers installed variable speed pool pumps in slightly smaller pools in 2017 than in 2015,

[36] NMR Group, Inc. Northeast Residential Lighting Hours-of-Use Study. 2014. Available at: http://www.neep.org/sites/default/files/resources/Northeast-Residential-Lighting-Hours-of-Use-Study-Final-Report1.pdf.

[37] Opinion Dynamics. October, 2017. *PSEG Long Island Residential In-Home Study.*

[38] In 2016, Opinion Dynamics Corporation conducted secondary research and recommended 5.0 hours per day for exterior lighting to facilitate the 2017 planning efforts.

resulting in slightly lower evaluated savings for both demand and energy; the realization rates for two-speed and variable-speed pool pumps are 98% for kW and 97% for kWh, respectively.

- **Refrigerators:** The evaluation team received detailed tracking information on sizes and models of refrigerators rebated through the program in 2017, which were mapped to the ENERGY STAR Qualified Product List (QPL) to verify refrigerator configuration (e.g., freezer mounting). The evaluation team used the latest federal standards and ENERGY STAR efficiency criteria to determine the baseline and efficient unit energy consumption values, respectively, for the sizes and configurations rebated in 2017. Comparatively, ex ante savings were developed based on evaluation recommendations from the 2015 evaluation, which incorporated data on refrigerator size and configuration from 2012 tracking data, due to limitations in program tracking data at the time. Both federal standards and ENERGY STAR's qualification criteria have evolved since 2015, and these changes are the primary driver for lower evaluated savings. ENERGY STAR formerly required its qualified refrigerators to save at least 20% energy compared to less stringent federal standards, leading to significantly higher savings per refrigerator than current market conditions. ENERGY STAR now requires the refrigerators earning the "most efficient" designation to save 10-15% energy compared to federal standards that are 17% more stringent than those referenced in the 2015 evaluation. These differences in federal standards and subsequent ENERGY STAR qualification criteria are the primary driver of the 36% realization rate for energy and peak demand savings. As the evaluation team has incorporated the most current federal standards and ENERGY STAR qualification criteria in the forward-looking TRMs for PY2018 and beyond, we anticipate that this difference will be significantly reduced in future program evaluations.

- **Room Air Conditioners:** Realization rates for ENERGY STAR-rated room ACs, 172% for kW and kWh, are attributed to differences in Combined Energy Efficiency Ratio (CEER) assumed by the program and evaluation team. The program assumed minimum qualifying ENERGY STAR efficiencies for installed units, whereas the evaluation team calculated the energy use of efficient room ACs by cross-referencing installed model data to the ENERGY STAR QPL, which includes rated CEER factors. This resulted in the evaluation team using higher CEER values than the program planning values for efficient units in the 6 to 8 kBTU/hour and 8 to 14 kBTU/hour categories. Ultimately, this led to higher evaluated savings for both demand and energy compared to ex ante.

- **Appliance Recycling:** The overall realization rates for all recycled appliances were 57% and 43% for demand and energy, respectively. Below is a discussion of individual appliance recycling measures where the evaluation team observed a discrepancy between ex ante and evaluated results.

  - **Dehumidifier Recycling:** The program team adopted the evaluation team's recommendations from the 2015 evaluation of 471 gross kWh savings per recycled dehumidifier and 1.0 coincidence factor. The evaluation team's recommendation for 2015 also included 24 hours of dehumidifier operation for 68 days during the summer, per the ENERGY STAR calculator. However, it appears that the program team assumed 24 hours of dehumidifier operation for 365 days, resulting in annual operating hours of 8,760, to back-calculate the peak demand savings. For the 2017 program year, the evaluation team referenced Long Island-specific research on dehumidifier operation from the Residential In-Home Study[39], completed in the third quarter of 2017, which resulted in dehumidifier operating hours of 1,679 and a CF of 0.3. This Long Island-specific research was not available at the time of 2017 program planning, resulting in 57% higher evaluated demand savings as compared with ex ante. As the program has incorporated the latest

[39] Opinion Dynamics. October, 2017. *PSEG Long Island Residential In-Home Study.*

research for 2018, we anticipate that the evaluated savings will more closely resemble the ex ante savings in future evaluation cycles.

- **Refrigerator/Freezer Recycling:** The 2017 tracking data provided the evaluation team with detailed information on recycled refrigerators and freezers, including size, configuration, and vintage. Using this information, along with ENERGY STAR consumption data on refrigerators by vintage, the evaluation team determined the average savings per recycled refrigerator and freezer. It appears that the program planning assumptions incorporated a weighted average of gross savings for the pre-2001 and post-2001 recycled refrigerators from 2015 evaluation recommendations. The evaluation team believes that the discrepancy between ex ante and evaluated savings for recycled refrigerators and freezers can be partially explained by differences in distribution of pre-2001 and post-2001 recycled unit vintages between 2015 and 2017 program years. As the program's savings documentation and planning assumptions only provide the assumed weighted kWh savings value, evaluators cannot discern additional differences contributing to the lower evaluated savings.

- **Clothes Dryers:** The evaluation team calculated savings for clothes dryers using 2017 tracking data combined with baseline clothes dryer standards used by ENERGY STAR. It appears that the program team considered the 2015 evaluation's recommendation for baseline and installed clothes dryer efficiencies to estimate the energy and demand savings of 0.567 kW/unit and 160 kWh/unit for both super-efficient and electric resistance dryers. However, the 'EEP tracking' spreadsheet that was used to calculate the actual ex ante savings for clothes dryers listed gross savings assumptions of 0.671 kW/unit and 263.06 kWh/unit for super-efficient dryers and 0.115 kW/unit and 45.19 kWh/unit for electric resistance dryers. This discrepancy led to significantly higher evaluated savings, resulting in a realization rate of 479% for demand and 346% for energy savings. Additionally, ENERGY STAR's current eligibility criteria appear to reflect outdated federal standards. The current federal standards went into effect on January 1, 2015, but ENERGY STAR's eligibility criteria reflect the federal standards applicable between 1994 and 2014. While the 2015 evaluation recommendations, as well as 2017 evaluated savings, reflect ENERGY STAR's listed criteria and federal standards, the evaluation team recommends that the program move away from the ENERGY STAR-defined baseline to the current federal standards. The 2019 iteration of the evaluation team's prospective TRM will provide additional guidance for the program to incorporate the latest federal standards.

- **Power Strips**: The realization rates for power strips are 102% for kW and 161% for kWh. Using the deemed savings recommended by the NY TRM v4, the evaluation team used linear regression to estimate savings per number of outlets on the installed power strips. The program maintained the Massachusetts TRM assumptions used in the 2016 evaluation.

- **Air Purifiers**: The ex ante kWh savings were derived from prior evaluation recommendations, which referenced assumptions from the ENERGY STAR calculator. The ENERGY STAR calculator has updated with revised baseline and efficient annual energy consumptions. The evaluation team cross-referenced the 2017 installed model numbers to the ENERGY STAR QPL to determine efficiency factors per unit installed. Additionally, the evaluation team applied a CF of 0.67, as recommended by the NY TRM v5, which had previously not provided a CF for air purifiers. Overall, these differences resulted in realization rates of 105% for kW and 164% for kWh.

- **Clothes Washers:** Both the program and the evaluation team referenced the energy savings algorithms for clothes washers based on the ENERGY STAR savings calculator. However, the evaluation team updated the weighted average efficient unit consumption based on type and size of clothes washers installed from the 2017 tracking data. This resulted in a higher difference between conventional and efficient unit consumption values compared to ex ante assumptions, leading to realization rates of 186% for both kW and kWh.

- **Dehumidifiers:** The program's savings values reflected the 2015 evaluation's recommendations for the gross kWh savings per dehumidifier of 166 kWh, as well as CF and operating hours values of 1.0 and 1,632 hours, respectively. For 2017 EEP installations, the evaluation team cross-referenced the tracking data to the ENERGY STAR QPL to determine individual unit efficiencies and sizes, which resulted in increased capacities and equipment efficiencies compared to the 2015 REAP installation statistics. Additionally, the evaluation team updated the dehumidifier coincidence factor and operating hours to 0.3 and 1,679, respectively, based on the Residential In-Home Study[40], resulting in higher evaluated energy savings but lower evaluated demand savings compared to ex ante.

- **Heat Pump Water Heaters:** This measure was added to the program in 2017. The realization rates for HPWHs are 93% for kW and kWh. Both the evaluation team and the program-referenced savings assumptions are based on the NY TRM v4. However, the evaluation team referenced an average inlet water temperature of 62.5°F for Long Island based on the NY TRM v4, but the program assumed 58°F, resulting in slightly lower evaluated savings compared to ex ante.

Impacts for Cost-Effectiveness

Table 3-3 shows the ex ante and ex post NTGRs by measure. In 2016, Opinion Dynamics performed secondary research on NTGRs for LEDs across other jurisdictions and provided a memo to PSEG Long Island recommending the incorporation into program planning of a 0.55 NTGR for LED lighting. In 2017, the program adopted this NTGR for all lighting, including CFL bulbs. The evaluation team applied the 0.55 NTGR to LED lighting for both evaluated and ex post savings, and maintained previous NTGRs for CFL bulbs, which were discontinued early in the 2017 program year.

[40] Ibid.

Table 3-3. NTGRs for EEP Program

Program Measures	Ex Ante Net Savings			Ex Post Net Savings		
	FR	SO	NTGR	FR	SO	NTGR
CFLs – Standard	45%	0%	0.55	30%	4%	0.74
CFLs – Specialty	45%	0%	0.55	25%	20%	0.95
ENERGY STAR Solid State Lighting	45%	0%	0.55	45%	n/a	0.55
Refrigerators and Freezers	20%	10%	0.90	20%	10%	0.90
Appliance Recycling	43%	0%	0.57	52%	0%	0.48
Pool Pumps	20%	10%	0.90	20%	10%	0.90
Smart Strips	0%	0%	1.00	0%	0%	1.00
Clothes Dryers and Most Efficient Clothes Washers	20%	10%	0.90	20%	10%	0.90
Air Purifiers	30%	0%	0.85	30%	15%	0.85
HPWHs	0%	0%	1.00	n/a	n/a	1.00
Room ACs	30%	25%	0.95	30%	25%	0.95
Dehumidifiers	30%	15%	0.85	67%	0%	0.33

Applying the NTGRs in Table 3-3 to evaluated gross savings provides ex post net savings. Table 3-4 provides a category-by-category comparison of ex ante to ex post net savings. As noted previously, the evaluation team developed ex post net impact estimates for use in the benefit/cost and economic impact assessments.

Table 3-4. EEP Program Net Impacts for Cost-Effectiveness

Category	Ex Ante Net Savings[a]			Ex Post Net Savings			Cost-Effectiveness Realization Rate	
	N	kW	kWh	N[b]	kW	kWh	kW	kWh
Lighting	4,389,716	12,835	128,043,298	4,389,008	20,618	111,846,987	160%	87%
Pool Pumps	2,816	3,741	6,024,577	2,815	3,668	5,826,176	98%	97%
Appliance Recycling	4,420	330	2,158,549	4,420	158	775,203	48%	36%
Room ACs	13,282	1,080	524,453	13,282	1,859	902,786	172%	172%
ENERGY STAR Dehumidifiers	3,037	290	457,821	3,037	41	222,265	14%	49%
Refrigerators	2,662	48	401,732	2,662	17	146,395	36%	36%
HPWHs	80	31	285,816	80	29	265,550	93%	93%
Air Purifiers	613	40	217,661	613	42	356,297	105%	164%
Clothes Dryers	4,315	31	194,002	4,315	146	670,816	479%	346%
Most Efficient Clothes Washers	4,721	30	143,478	4,721	56	266,785	186%	186%
Power Strips	154	2	12,998	155	3	20,876	102%	161%
Total	**4,425,816**	**18,457**	**138,464,385**	**4,425,108**	**26,637**	**121,300,137**	**144%**	**88%**

[a] Source: Evaluation team analysis of reported savings.
[b] Source: Individual program-tracking spreadsheets.
Note: Totals may not sum due to rounding.

Conclusions and Considerations

Looking forward, the evaluation team has outlined a number of conclusions for the EEP program and considerations for future program years.

- For refrigerators, program staff should consider updating the kWh savings assumptions to reflect the most up-to-date ENERGY STAR eligibility criteria, particularly for the "most efficient" designation. We also recommend that program staff continue to collect information on sizes and configurations of rebated refrigerators to ensure that the most accurate savings calculations for each installation.
- Additionally, for refrigerators and freezers rebated through the appliance recycling component of the program, we suggest that program staff update ex ante savings assumptions to match the latest calculations included in the prospective PSEG Long Island TRM. The evaluation team also suggests that program staff revise savings algorithms and assumptions for dehumidifiers to reflect the latest version of the prospective TRM.
- The program team should consider updating the kWh savings algorithms for air purifiers and HPWHs based on the latest version of the ENERGY STAR calculator and the NY TRM v5. Similarly, the evaluation team suggests that program staff update ex ante savings assumptions for Tier 1 and 2 power strips and HPWHs to be consistent with the latest version of the NY TRM (currently v5).

4. Cool Homes Program

The Cool Homes program seeks to improve the energy efficiency of residential HVAC systems throughout Long Island. Through the assistance of a program-approved contractor, residential account holders can apply for rebates for the quality installation (QI) of higher-efficiency HVAC equipment, including split central air conditioners (traditional CACs), ground source and air-source heat pumps, and ductless mini-split systems. QI means that the contractor performs Manual J calculations to install an energy-efficient unit sized appropriately for the space and to ensure that the refrigerant charge and airflow are checked using prescribed tests. Participating Cool Homes contractors receive incentives for each rebated QI.

PSEG Long Island also offers an equipment-only (EO) rebate option that allows a customer to choose any licensed air conditioning (A/C) contractor to install qualifying split CACs, air-source heat pumps (ASHPs), and ductless mini-splits rather than having the work performed only by a Cool Homes program contractor. With the EO rebate, customers receive lower rebate amounts for qualifying split CACs and ASHP equipment and contractors are not eligible for QI incentives. Customers receive the same rebates for ductless mini-split systems in both the EO and QI pathways. Rebate levels for ductless mini-split systems and ground-source heat pumps (GSHPs) did not change from 2016 to 2017, but the 2017 program year brought several updates to rebates for other product categories:

- Rebates for QI ducted CACs decreased from \$700–\$1,000/system to \$300–\$400/system; EO rebates decreased from \$200–\$350/system to \$150–\$250/system.
- Rebates for QI ASHPs decreased from \$700–\$1,000/system to \$500–\$600/system; EO rebates increased from \$200–\$350/system to \$350–\$400/system.

In addition, the program changed the efficiency requirements for several categories of systems:

- Waived the energy efficiency ratio (EER) requirements for split CAC, ASHP, and ductless mini-split systems
- Lowered the minimum ASHP efficiency to 15 SEER

The changes in rebates were designed to shift program resources to promote increased participation through GSHP installations and away from the more traditional split CAC systems. Previously, the program had changed the rebate structure and levels for GSHP systems for the 2016 program year. GSHP systems have been rebated on a per-ton basis as of 2016, compared to a per-system basis in 2015. The same GSHP rebate levels from the 2016 program were carried forward in the 2017 program.

The adjustment of rebates for GSHPs and split CAC systems was part of a larger adjustment of the program's focus toward reducing energy consumption over demand reductions in the 2017 program. Traditionally, the Cool Homes program has focused on reducing peak electric demand among residential customers.

As part of this effort to engage with customers, the program continues to provide incentives to participating contractors to promote the QI option. In the QI pathway, contractors are eligible for incentives of at least \$100 per installation, with \$100 for the first system and \$50 for each additional system. Contractors are also eligible to receive 75% reimbursement on tools used for QI and 50% reimbursement on Manual J software after they have completed 20 approved installations.

In 2017, the program pursued a more targeted marketing approach, focused specifically on geothermal systems, which provide savings of 848–995 kWh/ton, the highest of any measure offered by the Cool Homes program. As the program transitions from being demand-based to focusing on energy savings, measures like GSHPs and ASHPs (118–283 kWh/ton), which can provide significant savings in winter as well as summer, will be increasingly important program components.

Program Performance

In 2017, the Cool Homes program set a demand goal of 1.65 MW and achieved evaluated demand savings of 2.81 MW. Unlike 2016, the program exceeded its 2017 demand goal by 70%, in part because the program lowered its demand goal in 2017, along with the shift in focus to energy savings. The program's energy savings goal in 2017 was 2.69 MWh and it achieved evaluated energy savings of 2.70 MWh. The program rebated 5,197 measures in 2017, of which 70% were split CACs. The remaining rebated measures were ductless mini-split systems (23 %), GSHPs (4 %), and ASHPs (3 %), as seen in Table 4-1.

Table 4-1. Number of Cool Home Program Rebated Systems by Measure

Measure	Quantity	Percent
Split CAC	3,630	70%
Ductless Mini-Split	1,200	23%
GSHP	187	4%
ASHP	181	3%
Total	**5,198**	**100%**

Source: Cool Homes program-tracking data, 2017.

Compared to the 2016 program, the 2017 Cool Homes program rebated 4% fewer total systems (as seen in Table 4-2). This overall decline is due to the program rebating 17% fewer split CAC systems, historically the most frequently rebated product. All other product categories saw an increase in rebated systems, with the largest increase occurring among ASHPs (101%), followed by GSHPs (50%), and ductless mini-splits (47%).

Table 4-2. Difference in Number of Cool Home Program Measures Installed, 2015–2017

Measure	2015	2016	2017	Percent Difference 2016 to 2017
Split CAC	5,114	4,362	3,630	−17%
Ductless Mini-Split	894	814	1,200	47%
GSHP	166	125	187	50%
ASHP	249	90	181	101%
Total	**6,423**	**5,391**	**5,198**	**−4%**

Source: Cool Homes program-tracking data, 2015, 2016, 2017.

The EO option grew from 594 installations in 2016 to 849 units in 2017. Table 4-3 compares installations in the two program pathways for each category of equipment. Systems rebated through the traditional QI pathway continued to represent the largest share of projects.

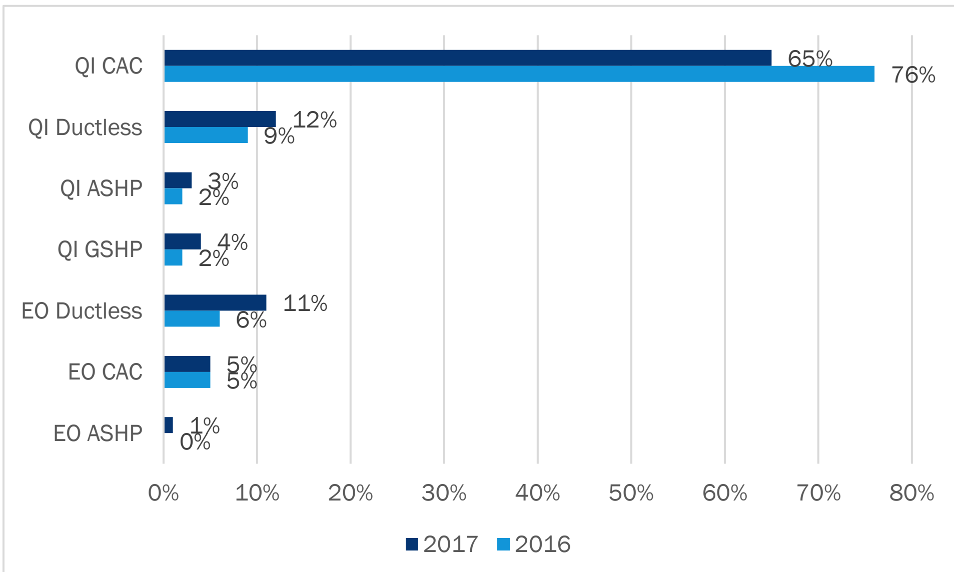
Table 4-3. Equipment-Only and Quality Installation Units in 2017

Equipment-Only Installations			QI Installations by Cool Homes Contractors			
ASHP	CAC	Ductless	ASHP	CAC	Ductless	GSHP
31	254	564	150	3,375	636	187

Source: Cool Homes program-tracking data, 2017.

Figure 4-1 compares the installations of each measure offered by the program in 2016 and 2017 on a percentage basis, including the EO and QI offerings. Within the EO category of installations in 2017, 254 were CAC installations, 564 were ductless systems, and 31 were ASHPs, representing 16% of the total program installations. In comparison, the program rebated 254 CACs, 354 ductless systems, and 1 ASHP through the EO offering in 2016, accounting for 11% of the total program installations. Changes in rebate levels may explain why the installations of ductless systems have increased through the EO pathway in comparison to other measures. In 2017, customer rebates for ductless mini-split systems were the same for both EO and QI options. In comparison, the rebate levels for QI ASHPs and split CACs are $100–$150 higher than comparable EO options.

Figure 4-1. Comparison of Installations by Program Offering in 2016 and 2017



Source: Cool Homes program-tracking data, 2016–2017.

Program Marketing

In 2016, the Cool Homes program substantially increased its marketing in a broad sense, working with MarketSmith to utilize a more diverse mix of channels, including print advertisements in local newspapers, radio and television spots, Google AdWords, and social media. For 2017, this effort evolved into a more targeted marketing approach, focused on educating consumers and contractors about geothermal systems. The marketing efforts for geothermal systems focused on market segments that are most likely to be interested in the installation of such a system, specifically in the Suffolk County market. In addition to geothermal-specific marketing materials, the Cool Homes program initiated a second communication channel aimed at training and educating architects and contractors on the benefits of geothermal systems. The program expects this two-pronged approach to spur GSHP activity in the coming program years. Geothermal systems generally have a longer lead time for project installation, so efforts to market this technology in 2017 may not be fully realized for several years. For 2018, the program plans to continue marketing geothermal systems in the off-season and marketing CACs during the cooling season, making the Cool Homes program's presence year-round, rather than only during the warmer months.

Impacts for Goal Comparison

Table 4-4 provides a program-level comparison of evaluated net savings, verified ex ante savings and ex ante savings by measure category. As both ex ante and evaluated net savings values are calculated using program planning NTGRs, the differences expressed through the realization rates represent differences in the ex ante and evaluated gross savings.

Table 4-4. Cool Homes Program Net Impacts for Goal Comparison

Category	Installs	Ex Ante Net Savings		Verified Ex Ante Savings		Evaluated Net Savings		Realization Rate	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
Split CAC	3,630	2,196	1,474,662	2,199	1,475,347	2,199	1,519,841	100%	103%
GSHP	187	316	686,494	316	686,762	315	564,293	100%	82%
Ductless Mini-Split	1,200	217	430,574	219	430,685	219	542,799	101%	126%
ASHP	181	75	111,655	75	112,114	75	101,471	100%	91%
Total	**5,198**	**2,804**	**2,703,384**	**2,809**	**2,704,908**	**2,808**	**2,728,405**	**100%**	**101%**

Note: Totals may not sum due to rounding.

Reasons for Differences in Impacts

To estimate evaluated energy and demand savings, the evaluation team used installed sizes and efficiency for each unit of rebated equipment, as determined through examination of the program's 2017 tracking data. The evaluation team relied on the 2015 International Energy Conservation Code (IECC) for baseline efficiencies, since the 2015 IECC went into effect on October 1, 2016 in New York and therefore applies to all 2017 projects. The evaluation team adopted a line-by-line savings approach for all installed equipment to obtain the total evaluated savings by measure. Most measure-specific discrepancies between ex ante and evaluated savings are due to differences in assumptions of baseline efficiencies and heating and cooling full load hours between the program and evaluators. The program and the evaluation team used the same CFs for all measures in the Cool Homes portfolio.

The evaluation team has the following comments on the measure-specific savings calculations.

- **Air-Source Heat Pumps:** ASHPs achieved realization rates of 100% for peak demand and 91% for energy savings. The evaluated energy savings are less than ex ante savings due to a difference in equivalent full load heating hours (EFLHH) and equivalent full load cooling hours (EFLCH) between ex ante assumptions and evaluation team recommendations. The program assumed an EFLCH value of 630 based on the NY TRM v3, whereas the evaluation team used 649 EFLCH for average vintage homes per the NY TRM v4, which went into effect on January 1, 2017. Similarly, the program assumed an EFLHH value of 934 based on the NY TRM v3, whereas the evaluation team used 786 EFLHH per the NY TRM v4 for average vintage homes.

- **Split Central Air Conditioners:** Split CACs achieved realization rates of 100% (demand) and 103% (energy). The evaluated energy savings are higher than ex ante savings due to similar differences in EFLCH as described for ASHPs above.

- **Ductless Mini-Split Systems:** The evaluation team observed two types of ductless mini-split installations in the tracking data: (1) "Cooling Only" and (2) "Heating & Cooling." The program's ex ante assumptions for energy considered only the cooling savings for all installations, irrespective of these classifications. The evaluation team treated the “Heating & Cooling” type of units as heat pumps and calculated both heating and cooling energy savings for those units. The addition of heating energy savings, along with the differences in EFLCH and EFLHH as described for ASHPs, resulted in an increase in evaluated energy savings (realization rate equal to 126%) and a slight increase in peak demand savings (101%).

- **Ground-Source Heat Pumps:** GSHPs achieved realization rates of 100% for peak demand savings and 82% for energy savings. The evaluated energy savings are lower than ex ante savings primarily because the evaluation team referenced a baseline heating seasonal performance factor (HSPF) of 8.2 from 2015 IECC recommendations, while the program’s assumption for baseline HSPF was 7.7. Another key contributor to the lower evaluated energy savings is the difference in EFLHH and EFLCH, as discussed for ASHPs.

Impacts for Cost-Effectiveness Calculations

The cost-effectiveness calculations are based on ex post net savings estimates. The evaluation team calculated ex post net savings using NTGRs developed during past research. The ex post NTGR for split CACs was derived from extensive research in 2011 with participating and nonparticipating customers, as well as HVAC market actors, including contractors and equipment distributors (see the 2011 report for details). Table 4-5 shows a categorical breakdown of ex post savings compared with tracked program savings (ex ante).

Table 4-5. Cool Homes Program Net Impacts for Cost-Effectiveness

		Ex Ante Net Savings		Ex Post Net Savings		Cost-Effectiveness Realization Rate	
Category	Installs	kW	kWh	kW	kWh	kW	kWh
Split CAC	3,630	2,196	1,474,662	2,061	1,118,423	94%	76%
GSHP	187	316	686,494	315	564,293	100%	82%
Ductless Mini-Split	1,200	217	430,574	219	542,799	101%	126%
ASHP	181	75	111,655	75	101,471	100%	91%
Total	**5,198**	**2,804**	**2,703,384**	**2,670**	**2,326,987**	**95%**	**86%**

Note: Totals may not sum due to rounding.

The program applied planning, or ex ante, NTGR values of 0.90 for all measures except GSHPs, for which the program applied a NTGR of 1.0. The evaluation team developed an updated NTGR for split CAC installations in 2011, including separate factors for savings associated with QI practices and equipment efficiency, and used those same values this year. We applied the program planning values for all other measures. The ex post NTGR for CAC installations included participant FR and program SO. Table 4-6 shows the NTGR values for the Cool Homes program.

Table 4-6. Cool Homes Program NTGRs

Measure	Ex Ante NTGR		Ex Post NTGR	
	kW	kWh	kW	kWh
CAC Equipment	0.90	0.90	0.52	0.52
CAC QI	0.90	0.90	1.49	1.41
CAC Total	0.90	0.90	0.84	0.65
GSHP	1.00	1.00	1.00	1.00
ASHP	0.90	0.90	0.90	0.90
ASHP QI	0.90	0.90	0.90	0.90
Ductless Mini-Split	0.90	0.90	0.90	0.90

Conclusions and Considerations

Based on interviews with program staff, program data, and an assessment of PSEG Long Island's long-term goals, we have identified a number of considerations for future program years.

- Program installations of traditional split CAC systems declined 17% year-over-year, likely because of the reduction in rebates for these systems, and the reduced focus on marketing this program offering. At the same time, installations of ductless systems, ASHPs, and GSHPs increased significantly over the 2016 installations. These results show progress toward the program's goals of transitioning the program's focus to heat pump technologies, specifically GSHPs, in an effort to generate additional energy savings through the program.

5. Residential Energy Affordability Partnership Program

The REAP program assists low-income households with energy efficiency improvements. The program helps low-income customers save energy, improves overall residential energy efficiency on Long Island, and lowers PSEG Long Island's financial risk associated with bill collection by lowering utility bills for low-income customers. To be eligible to participate in the REAP program, household income must correspond with the United States Department of Housing and Urban Development low-income guidelines.[41]

The REAP program includes a free home energy audit, in addition to free energy-saving measures. In 2017, program measures included LED light bulbs, domestic hot water (DHW) measures, room ACs, dehumidifiers, and refrigerators. While a few participants still received CFLs in 2017 (54 participants), the program made the transition away from CFLs to LEDs in 2017. Additionally, while in previous years some REAP participants received air sealing, duct sealing, and duct insulation measures, in 2017, REAP participants eligible for those measures received them by enrolling in the Home Performance with ENERGY STAR (HPwES) program and going through the subsequent steps to participate in that program (see Section 0). Finally, beginning in 2017, program staff transitioned to tracking all direct installation and follow-up measure information in the LM Captures database.

Impacts for Comparison to Goals and Cost-Effectiveness

As in previous years, the evaluation team used two approaches to estimate savings for the REAP program in 2017: an engineering analysis and a consumption analysis. Because the consumption analysis uses actual customer electric usage to estimate savings, and is therefore more robust than engineering estimates, we based the savings from the program on the results of the consumption analysis. Our consumption analysis uses 2016 participants as the treatment group, since the method requires post-installation electricity usage data for approximately 1 year after participation. The results, presented in Table 5-1, show an overall program energy savings realization rate of 215% and a demand savings realization rate of 137%.

Table 5-1. REAP Program Net Impacts for Comparison to Goals and Cost-Effectiveness

Measure Category	N[a]	Ex Ante Net Savings		Verified Ex ante		Evaluated/Ex Post Net Savings		Realization Rate	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
LED Bulbs	1,788	97	436,657	97	437,864	207	939,194	213%	215%
DHW	214	13	78,337	13	78,448	4	168,494	28%	215%
Refrigerator	196	14	58,810	15	60,397	15	126,493	105%	215%
Room AC	646	124	29,969	122	30,090	139	64,460	112%	215%
Dehumidifier	277	25	21,719	25	20,874	9	46,714	34%	215%
CFL Bulbs	54	4	16,310	4	42,375	6	35,082	164%	215%
Total	**1,873**	**276**	**641,803**	**276**	**670,048**	**380**	**1,380,436**	**137%**	**215%**

[a] Number of REAP program projects with measures in 2017.
Note: 32 REAP participants received duct sealing, duct replacement, and air sealing measures through the HPwES program. Totals may not sum due to rounding.

[41] 2017 HUD Income Limits. https://www.huduser.gov/portal/datasets/il.html#2017

Reasons for Differences in Impacts

The consumption analysis model uses monthly billing data, among other inputs, to quantify post-participation changes in energy use. Because monthly observations of coincident peak demand are not available for participating customers, the consumption analysis does not produce estimates of demand savings. To estimate demand savings, we calculated a ratio between the engineering-based estimates of evaluated demand and energy savings and applied this ratio to the energy savings estimates derived from the consumption analysis.

The combined consumption and engineering analysis found that the REAP program generated approximately 1,380 MWh in energy savings in 2017, or about 215% of the expected net energy savings. Applying the ratio of evaluated demand to energy savings from the engineering analysis within each measure category to the energy savings results in 380 kW in demand savings, or 137% of the expected peak demand savings. The number of treated homes and the average evaluated per-home savings in 2017 were similar to those of 2016. Therefore, these high realization rates are primarily attributable to substantially lower ex ante savings assumptions for 2017.

Over the past several years, REAP program staff have worked with the evaluation team to improve the accuracy of planning estimates, thereby improving realization rates. In 2016, for the first time, the program team applied deemed savings assumptions for each measure installed when calculating ex antes savings for the program. As such, in 2016 REAP realized 99% of ex ante energy savings, compared with 50% in 2015 and 42% in 2014. The 2016 evaluation results were not available before the program team finalized the 2017 planning process. In an effort to reconcile historically higher ex ante savings estimates compared to evaluated results, program staff applied an adjustment to ex ante program savings early in 2017 that lowered the ex ante energy savings to roughly half of the observed savings estimated from the 2017 consumption analysis. As shown in Table 5-2, the 2017 average per-household energy savings from the consumption analysis were about 98% of those observed in 2016. The sections that follow describe the consumption and engineering analyses in more detail.

Table 5-2. Comparison of Per-Household Energy Savings from 2016 to 2017

2016 Observed kWh Savings per Household (Consumption Analysis)	2017 Observed kWh Savings per Household (Consumption Analysis)	2017 Per-Household kWh Savings as a Percent of 2016 Observed kWh Savings
752	737	98%

Consumption Analysis

The evaluation team conducted the consumption analysis with the goal of determining the overall evaluated net energy savings for the REAP program. Our consumption analysis uses 2016 participants as the treatment group, because the method requires post-installation electricity usage data for approximately 1 year after participation.[42] We also included a comparison group consisting of households that participated in 2017. The comparison group acts as the counterfactual or point of comparison for the treatment group (2016 participants) in the post-participation period.

Using future participants as a comparison group gives us some assurance that the treatment and comparison groups are equivalent because the criteria and process for selection into the program is equivalent between early and later participants. However, it is important to do whatever analyses are possible to confirm that the

[42] Note that participants who initiated participation in 2016 and continued participating in 2017 (i.e., through the REAP program) are considered 2016 participants for the purpose of the consumption analysis.

future participants are similar in other ways so that we can be confident in using them as the counterfactual. If the program makes substantial changes in its targeting of customers to recruit for the program, e.g., finding customers with higher usage, then the later participants may not be justifiable as a point of comparison. We show these comparisons in Section 9.7 and confirmed that the groups were similar in consumption and in weather experienced during the same calendar period.

In Table 5-3, we compare the treatment and comparison groups on the types of measures that program staff installed in customer homes during each group's participation period. We can see that the measure mix changes between 2016 and 2017, with the transition to LEDs from CFLs and an increase in refrigerators and DHW measures. According to program staff, these changes were the result of changes made by the program in the measures offered and were not due to changes in the program participants from one year to the next or in the criteria or process used for recruiting or selecting program participants. Further, while replacing inefficient lamps with CFLs or LEDs results in tangible savings for REAP participants, we do not anticipate considerable differences in per-household savings between average participants that received CFLs in 2016 and LEDs in 2017. As such, similar to previous evaluations, the evaluation team is confident in using per-household savings from 2016 as a proxy for 2017 participants.

Table 5-3. REAP Program Installations by Program Year for Consumption Analysis Groups

	Consumption Analysis Treatment Group (2016 Participants) (n=1,795)		Consumption Analysis Comparison Group (2017 Participants) (n=1,873)	
Measure Installed	Participants	Percentage of Gross kWh	Participants	Percentage of Gross kWh
CFL Bulbs	95.6%	79.5%	2.9%	3.1%
LED Bulbs	0.0%	0.0%	94.0%	67.9%
Room AC	40.9%	9.5%	34.5%	4.9%
Refrigerator	0.1%	0.2%	10.5%	8.8%
Dehumidifier	15.5%	5.1%	14.8%	3.5%
DHW	6.7%	5.8%	11.4%	11.8%

The consumption analysis model is a two-way linear fixed effects regression (LFER) conditional demand analysis (CDA) model. The model allows all household factors that do not vary over time to be absorbed by (and therefore controlled for) the individual constant terms in the equation. This would include such things as square footage, appliance stock, habitual behaviors, household size, among other factors. The fixed effect of time (month and year) absorbs the effects of time. We also entered weather terms in the model, as well as interaction terms between weather and the post-participation period for the treatment group, to account for differences in weather across years.

We used the consumption analysis to estimate overall savings and deemed savings to calculate planned savings, using these two calculations to determine the overall program realization rate. We did not attempt to calculate measure-level realization rates in the consumption analysis due to the considerable number of participants who installed multiple measures. Given the overlap in measure installations, it is impossible to estimate individual effects accurately, since parameters in the model are highly collinear, thus greatly increasing uncertainty around the estimates. As such, billing analysis provides results only for the overall program effect.

Table 5-4 presents the overall net program savings for 2017 REAP program participants. As shown below, the 2017 REAP program realized 215% of its expected net savings at the participant level. These results reflect savings attributable to the program and the types of measures installed during 2017.

Table 5-4. Savings from the REAP Program Consumption Analysis Compared to Ex Ante Savings Estimates

End-Use	N (2017 Participants)	Observed Savings*		Program Planning Savings		Realization Rate
		Household Daily Savings	Household Annual Savings	Household Daily Savings	Household Annual Savings	
Program	1,873	2.02	737	0.94	343	215%

* Includes line losses.

Engineering Analysis

The evaluation team also performed a measure-level engineering analysis of ex ante savings to estimate evaluated impacts. Specifically, the evaluation team used program-tracking data and applied either deemed savings estimates or calculated savings based on various parameters described in additional detail below. We used the engineering analysis to determine a ratio between energy and demand savings that we then applied to the consumption analysis energy savings to estimate evaluated demand savings.

Given that the REAP program is a direct installation program serving low-income customers, the evaluation team assumed that this customer segment would not invest in energy efficiency without assistance, as they have limited financial resources and many other competing needs. Therefore, we used a NTGR of 1.0, which is typical for low-income programs. Table 5-5 provides a review of impacts for the program in 2017 by category based on an engineering estimate of savings.

Table 5-5. REAP Program Measure-Specific Net Impacts: Engineering Approach

Measure Category	N[a]	Ex Ante Net Savings		Evaluated Net Savings		Realization Rate	
		kW	kWh	kW	kWh	kW	kWh
LED Bulbs	1,788	97	436,657	315	1,433,352	326%	328%
DHW	214	13	78,337	2	80,435	14%	103%
Refrigerator	196	14	58,810	17	146,314	122%	249%
Room AC	646	124	29,969	124	57,473	100%	192%
Dehumidifier	277	25	21,719	8	42,950	31%	198%
CFL Bulbs	54	4	16,310	4	25,115	117%	154%
Total	**1,873**	**276**	**641,803**	**471**	**1,785,638**	**170%**	**278%**

[a] Number of REAP program projects with measures in 2017.
Note: 32 REAP participants received duct sealing, duct replacement, and air sealing measures through the HPwES program. Totals may not sum due to rounding.

We highlight some of the discrepancies observed in the engineering analysis below.

- **Lighting:** The program tracking database included existing and installed wattages for each lighting measure, which the evaluation team applied to the PSEG Long Island prospective TRM algorithm along with the HVAC interactivity factors, coincidence factor, and operating hours from the Residential In-Home Study[43], finalized in the third quarter of 2017. Since pre-existing lighting wattages were unavailable for REAP planning, the program team applied an assumed wattage difference between the installed bulbs and EISA equivalent bulbs for common and specialty bulbs from the 2015 EEP program evaluation results. The discrepancy between the ex ante and evaluated savings are primarily due to the difference in delta watts from the data available at the time of program planning, and the actual delta watts determined from the 2017 program tracking database. Additionally, the program

[43] Opinion Dynamics. October, 2017. *PSEG Long Island Residential In-Home Study.*

did not include CFLs in its planning assumptions, but did claim savings for the 688 units installed in 2017.

- **Domestic Hot Water:** Shower heads, faucet aerators, pipe insulation, and temperature turndown measures accounted for the DHW savings attributable to the REAP program. The evaluation team determined a realization rate of 14% for demand and 103% for energy savings. The evaluation team's assumptions and savings calculation methodologies are described below.
  - **Shower Head and Faucet Aerator:** Ex ante calculations applied deemed savings for peak demand and energy savings from the 2015 evaluation. The evaluation team used 2017 tracking data, in conjunction with the NY TRM v4, to determine gallon per minute (gpm) flow rate improvements from preexisting to installed efficient fixtures to calculate per-unit peak demand and energy savings. The difference in approaches resulted in a realization rate of 160% for energy savings. Based on 2015 evaluation recommendations, the program claimed demand savings for water fixtures, but demand savings are not applicable for these measures per the NY TRM, leading to a demand savings realization rate of 0% for these measures.
  - **Pipe Insulation:** The evaluated savings for pipe insulation was calculated using DOE 3E Plus software and used 2017 tracked data on insulation length and pipe diameter. The program based its assumptions on 2015 evaluation results.
  - **Temperature Turndown:** The temperature turndown measure reflects reduced skin losses from maintaining the hot water at a lower temperature (i.e., 120°F assumed, as compared with a baseline of 130°F) during standby mode. The ex ante savings assumptions are based on prior evaluation recommendations. The evaluation team updated the recommended savings algorithm and assumptions based on the new research available in the 2017 IL TRM, the 2016 PA TRM, and the NY TRM v4. This updated information resulted in realization rates of 15% for demand and 11% for energy savings for this measure.
- **Refrigerator:** Ex ante calculated savings were based on ENERGY STAR eligibility criteria for the three sizes/configurations offered by the REAP program. Evaluated savings were calculated using 2017 installed refrigerator sizes and configurations (e.g., freezer mounting) along with ENERGY STAR criteria for the installed units. The evaluation team's baseline reflects a weighted average energy consumption based on the vintage of the pre-existing refrigerator, as obtained from the 2014 REAP tracking database, since this information was not tracked by REAP between 2015 and 2017. The evaluation team's use of actual sizes and configurations from REAP tracking data resulted in realization rates of 249% for energy and 122% for peak demand savings.
- **Room Air Conditioner:** The LM Captures database provided extensive information on equipment capacities, baseline EERs, and installed EERs. As such, the evaluation team was able to reference actual 2017 data on the EERs of removed equipment for participating customers, while the program team assumed an existing baseline from the 2015 program evaluation, which was the most appropriate value available at the time of 2017 planning. Another assumption that contributed to the discrepancy in energy savings was unit operating hours. While the program team assumed 400 hours per year based on recommendations from previous program evaluations, the evaluation team assumed 382 hours based on more recent information available in the NY TRM v4.
- **Dehumidifier:** Discrepancies between ex ante and evaluated energy savings are a result of differences in assumptions for input variables. The evaluators applied an annual usage (L/year) and CF from the

Residential In-Home Study[44], which provided PSEG Long Island-specific findings. The ex ante savings calculations utilized ENERGY STAR calculator values. These differences in assumptions resulted in a decrease in peak demand savings and a significant increase in energy savings; realization rates were 31% for kW and 198% for kWh.

[44] Ibid.

6. Home Performance Programs

PSEG Long Island's Home Performance programs are separated into two distinct tracks: Home Performance Direct Install (HPDI) and Home Performance with ENERGY STAR (HPwES). Both programs work in concert to provide homeowners with free and reduced-cost measures and information to encourage greater energy savings. Together, the programs consist of a full-home audit; a Home Energy Score; and possible free or rebated efficient equipment. The Home Performance Programs' design and implementation changed significantly in 2017. These changes are described in detail in the HPDI and HPwES subsections below.

In prior years, the evaluation team estimated energy and demand savings for PSEG Long Island's Home Performance programs by conducting consumption analyses of the previous year's participants and applying those estimates to participants from the program year under evaluation. As both programs underwent substantial changes from 2016 to 2017, described in detail in the remainder of this section, we are unable to use 2016 as an appropriate proxy for 2017 participants. As such, the evaluation team estimated savings for the 2017 Home Performance programs using engineering estimates. Table 6-1 shows the evaluated savings for both Home Performance programs.

Table 6-1. Home Performance Programs Evaluated Net Impacts for Goal Comparison

Program	N[a]	Ex Ante Net Savings		Verified Ex Ante		Evaluated Net Savings		Realization Rate	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
HPDI	580	264	971,558	264	971,558	286	913,149	108%	94%
HPwES	1,206	2,328	2,082,273	2,328	2,082,235	709	1,959,007	30%	94%
Total	**1,786**	**2,592**	**3,053,830**	**2,592**	**3,053,793**	**995**	**2,872,155**	**38%**	**94%**

[a] Number of Home Performance projects with measures in 2017.
Note: Totals may not sum due to rounding.

The evaluation team was unable to perform a comprehensive verification of ex ante savings for Home Performance with Energy Star projects, as well as duct sealing measures within the Home Performance Direct Install (HPDI) program, due to limited visibility into the program contractors' software-based savings estimates. Instead, the evaluation team reviewed the per-project and per-measure savings to ensure they were reasonable and verified that 2017 savings were in line with prior program years. For duct sealing measures under the HPDI program, the evaluation team confirmed that a factor of 0.5 was appropriately applied to the ex ante gross demand and energy savings to reflect billing analysis results from prior evaluation years.

6.1 Home Performance Direct Install Program

The HPDI program conducts free, full-home energy audits by a certified Building Performance Institute (BPI) contractor for homes with electric heat and homes with central air conditioning. During the audit, the contractor checks for moisture problems, assesses insulation and building envelope sealing, and evaluates heating and cooling efficiency (where applicable).[45] The BPI-certified contractor also provides participants with up to 20 free LED bulbs, power strips, and, for customers with central air conditioning, free duct sealing measures. For customers with electric hot water, the program provides efficient faucet aerators and efficient shower heads. Upon completion of the audit, HPDI program staff provide participants with an assessment

[45] The type and extent of HPDI program measure installation depends on which measures will have the greatest savings impact, as determined by household attributes and program software. Air and duct sealing work is limited by the amount of time contractors can spend installing measures during their HPDI program visit.

report that includes an energy efficiency score for the home and suggested improvements, along with estimated energy savings (in dollars).

Implementation of the HPDI program changed from 2016 to 2017, due primarily to the shift in focus to energy savings. First, in 2017, the HPDI program was open to PSEG Long Island customers with electrically heated homes and those with central air conditioning, where in the past the program was available only to those with central air conditioning. Additionally, in 2017, program implementation staff captured all program-tracking data in Lockheed Martin's LM Captures database, as opposed to previous years where data were captured in Real Home Analyzer (RHA). Finally, beginning in June 2016, HPDI participants received LED lighting measures. As such, 2017 marks the first complete program year where HPDI participants received LEDs instead of CFLs.

Impacts for Goal Comparison

Given program changes in 2017, the evaluation team used an engineering analysis to estimate savings for the HPDI program in 2017. Table 6-2 provides a review of impacts for the program in 2017 and comparisons to ex ante savings by measure category.

Table 6-2. HPDI Program Net Impacts for Goal Comparison

Measure Category	N[a]	Ex Ante Net Savings		Evaluated Net Savings		Realization Rate	
		kW	kWh	kW	kWh	kW	kWh
DHW	437	33	476,666	1	241,643	4%	51%
LED Bulbs	569	36	327,603	90	476,158	247%	145%
Duct Sealing	450	186	120,192	186	120,192	100%	100%
Power Strips	566	9	47,096	9	75,155	102%	160%
Total	**580**	**264**	**971,558**	**286**	**913,149**	**108%**	**94%**

[a] Number of HPDI projects with measures in 2017.
Note: Totals may not sum due to rounding.

Reasons for Differences in Impacts

The engineering analysis found that the HPDI program realized 94% of expected net energy savings and 108% of net demand savings. The evaluation team performed a measure-level engineering analysis of ex ante savings to estimate evaluated impacts. Specifically, the evaluation team used program-tracking data and applied either deemed savings estimates or calculated savings based on various parameters described in additional detail below.

We highlight some of the discrepancies observed during the engineering analysis below.

- **Lighting:** Discrepancies in ex ante and evaluated savings are a result of differences in algorithm inputs used by the program and evaluation team. The program assumed a CF of 0.11 based on prior research in the Northeast, while the evaluation team applied a CF of 0.23 from the In-Home Study for interior bulbs, and a CF of 0.0 for exterior bulbs.[46] This was the primary contributor to the significantly higher evaluated lighting peak demand savings; the realization rate was 247%.

  Discrepancies in energy savings are attributed to differences in program and evaluation team delta watts (the difference of preexisting bulb wattage and installed bulb wattage). The program applied the LED delta watts assumed in EEP program planning, which was based on 2015 evaluation results, as

[46] Opinion Dynamics. October, 2017. *PSEG Long Island Residential In-Home Study.*

a proxy for the HPDI program. The evaluation team used 2017 program-tracking data to derive an assessed delta wattage. The higher evaluated energy savings are a result of differences between the program's assumed baseline and the evaluation team's baseline wattages from 2017 tracking data.

- **Domestic Hot Water:** Shower heads, faucet aerators, and temperature turndown measures accounted for the DHW savings attributable to the HPDI program. The evaluation team determined a realization rate of 4% for peak demand and 51% for energy savings. Assumptions and calculation methods are described below.
  - **Shower Heads and Faucet Aerators:** The evaluation team used a comparison between removed and installed shower head and aerator gpm flow rates, tracked by the program, in combination with assumptions specified in the NY TRM v4 to quantify energy savings. The program team applies deemed energy and peak demand savings values based on the 2015 evaluation. The evaluation team's use of actual 2017 data, compared with deemed values from 2015, resulted in a 200% realization rate for 2017 faucet aerator energy savings and 95% for shower heads. For demand savings, the evaluation team applied the NY TRMv4, which specifies that peak demand savings are not available for shower head and faucet aerator measures. This resulted in 75% of the reduction in evaluated peak demand savings from ex ante.
  - **Temperature Turndown:** The temperature turndown measure reflects reduced skin losses from maintaining the hot water at a lower temperature (i.e., 120°F assumed, as compared with a baseline of 130°F) during standby mode. The evaluation team updated the recommended savings algorithm and assumptions based on the new research available in the 2017 IL TRM, the 2016 PA TRM, and the NY TRM v4. The ex ante savings assumptions are based on prior evaluation recommendations, resulting in realization rates of 6% for peak demand and 15% for energy savings.
- **Duct Sealing:** The program-tracking data did not provide enough information to conduct a savings calculation for duct sealing measures. Therefore, the evaluation team assigned a realization rate of 100% for these measures, as claimed savings appeared reasonable compared with prior years.
- **Power Strips:** Using the deemed savings recommended by the NY TRM v4, the evaluation team created a linear regression model to estimate savings per number of outlets on power strips installed, using the EEP program's detailed data as a proxy for the HPDI program. The evaluation team then determined the number of plugs per strip based on model number information and calculated a per-unit kWh and kW savings. The HPDI program applied the same ex ante savings assumptions as the EEP program, which appear to be based on the Massachusetts TRM. This resulted in a realization rate of 102% for peak demand and 160% for energy savings.

Impacts for Cost-Effectiveness Calculations

Similar to other programs, the evaluation team calculated cost-effectiveness using ex post net savings estimates. While program staff applied a planning NTGR of 1.0 for each program measure category to develop the ex ante savings estimates, the evaluation team developed a NTGR for the program in 2011, including FR and SO, for ex post estimates. Table 6-3 provides a review of impacts for the program in 2017 by category based on an engineering estimate of savings.

Table 6-3. HPDI Program Net Impacts for Cost-Effectiveness

Measure Category	N[a]	ExAnte NetSavings		Ex Post Net Savings		Realization Rate	
		kW	kWh	kW	kWh	kW	kWh
DHW	437	33	476,666	1	257,640	4%	54%
LED Bulbs	569	36	327,603	46	264,839	128%	81%
Duct Sealing	450	186	120,192	191	128,149	103%	107%
Power Strips	566	9	47,096	9	80,130	104%	170%
Total	**580**	**264**	**971,558**	**248**	**730,759**	**94%**	**75%**

[a] Number of HPDI projects with measures in 2017.
Note: Totals may not sum due to rounding.

6.2 Home Performance with ENERGY STAR Program

Similar to HPDI, the HPwES program leverages a home audit by a BPI-accredited contractor to evaluate PSEG Long Island homes. However, in 2017, HPwES participants received a more in-depth Home Energy Assessment (HEA), which evaluated heating and cooling equipment and assessed insulation levels and air leakage. In addition to HVAC and weatherization measures, HPwES customers are eligible to receive free LED bulbs, along with rebates on deeper DHW measures, such as pipe insulation and water heater replacements. Additionally, HPwES participants are eligible to receive rebates on efficient dishwashers and refrigerators.

The HPwES program has three different ways of enrolling PSEG Long Island customers into the program. As in previous years, HPDI customers seeking deeper retrofit opportunities may opt to continue into the HPwES program. However, beginning in 2017, the HPwES program also accepted REAP customers eligible for duct sealing, duct replacement, and air sealing measures, along with those customers enrolling through the New York State Energy Research and Development Authority's (NYSERDA) Home Performance on Long Island program. As with HPDI, program eligibility changed in 2017. With the shift to energy savings and the inclusion of NYSERDA Home Performance customers, all PSEG Long Island customers are now eligible for HPwES measures, with the exception of those with gas heat and no central A/C.

Along with these program changes, PSEG Long Island separated rebate levels into three distinct categories. Participants receiving the standard, or market rate, rebate were eligible to receive up to 15% of HPwES measure costs, capped at $3,000. HPwES participants were also eligible for income-qualified rebates. Those with incomes of 80% of the state's median income level were eligible for Assisted Home Performance rebates at up to 50% of measure costs, and those at 60% of the state's median income level were eligible for up to 100% of measure costs, both capped at $4,000. Contractors also received an additional $200 incentive from PSEG Long Island in 2017 when administering the more in-depth HEA required for HPwES participants. As in previous years, HPwES customers were also eligible to repay the cost of their measure installation through on-bill repayment with PSEG Long Island. In 2017, HPwES participants were also eligible for Green Jobs – Green New York and Smart Energy loans through NYSERDA.

Similar to HPDI, HPwES program staff transitioned away from collecting program-tracking data through RHA.[47] In 2017, HPwES began using software designed by EnergySavvy to track measure level data. The EnergySavvy software accepted four different types of open-source home performance modeling software.

[47] Fifty-five HPwES projects that carried over from 2016 were still captured in RHA.

Impacts for Goal Comparison

Given the substantial program changes in 2017, the evaluation team used an engineering analysis to estimate savings for the HPwES program. Table 6-4 provides a review of impacts for the program in 2017 by category.

Table 6-4. HPwES Program Net Impacts for Goal Comparison

Measure Category	N[a]	Ex Ante Net Savings		Evaluated Net Savings		Realization Rate	
		kW	kWh	kW	kWh	kW	kWh
Building Envelope	1,086	1,634	1,011,131	247	481,628	15%	48%
Lighting*	5,494	45	640,505	131	642,607	294%	100%
Air Sealing	1,088	568	342,078	59	687,310	10%	201%
HVAC	487	62	48,202	259	95,034	420%	197%
DHW	110	20	40,112	5.9	51,359	30%	128%
Dishwasher	1	0	185	6.1	39	N/A	21%
Refrigerator	1	0.03	61	0.13	1,031	442%	1,692%
Total	**6,439**	**2,328**	**2,082,273**	**709**	**1,959,007**	**30%**	**94%**

[a] Number of HPwES projects with measures in 2017.
* Includes 5,233 recipients of LED kits that received HPwES energy audits.
Note: Totals may not sum due to rounding.

Reasons for Differences in Impacts

The engineering analysis found that the HPwES program realized 94% of expected net energy savings and 30% of net demand savings. The evaluation team performed a measure-level engineering analysis of ex ante savings to estimate evaluated impacts. Specifically, the evaluation team used program-tracking data and applied either deemed savings estimates or calculated savings based on various parameters described in additional detail below.

The evaluation team's 2017 evaluation of the HPwES program utilized project-tracking data from several sources, mainly RHA and EnergySavvy. Additionally, the program team tracked all PSEG Long Island customers who received an HEA through the HPwES program and sent those customers a "Thank You" kit that included four free LED bulbs.[48]

The program transitioned its data collection software from RHA to EnergySavvy in early 2017. When this transition took place, the program closed out 55 projects already in the RHA pipeline in January 2017. The remainder of the projects reported in 2017 were processed using the new EnergySavvy system which aggregated results from different open-source home modeling software—CakeSystems, TREAT, Snugg Pro, and OptiMiser. Though algorithms inherent in all software used to model savings for participating homes are approved by NYSERDA, model assumptions used to calculate ex ante savings were unavailable to the evaluation team. We highlight some of the discrepancies observed through our engineering analysis below; however, our lack of insights into the vendor software limits our ability to discuss specific reasons for differences in between evaluated and ex ante savings for some measures.

- **Building Envelope:** The evaluation team observed that the ex ante savings for building envelope measures within the EnergySavvy projects were significantly higher than evaluated savings. Below is

[48] Email from Lockheed Martin program team (1/17/2018) and assumptions tracked via *2017 HP Audit TY Kit LED Calcs.xlsx*

a review of the major themes from the evaluation team's methods for the individual envelope measures.

- **Attic and Roof Insulation:** Evaluated savings calculations applied the PSEG Long Island TRM in coordination with program-tracked data, which included baseline and installed R-values for more than 80% of projects. Attic and roof insulation measures accounted for the overwhelming majority of the discrepancy between the building envelope ex ante and evaluated savings, resulting in realization rates of 5% for peak demand and 39% for energy savings.
- **Basement and Floor Insulation:** Evaluated savings calculations applied the prospective PSEG Long Island TRM in coordination with program-tracked data. The evaluation team did not calculate any summer peak demand savings for floor insulation, consistent with the PSEG Long Island TRM. However, the program did estimate ex ante peak demand savings for floor insulation. This difference accounted for less than 0.5% of the total peak demand savings discrepancy for building envelope measures.
- **Wall and Foundation Wall:** Evaluated savings calculations applied the PSEG Long Island TRM in coordination with program-tracked data.
- **Other Measures:** Doors/windows, rim joist insulation, dryer vent repair, and attic access insulation measures had insufficiently detailed data to perform rigorous evaluation and contributed to less than 0.5% of total program savings. Realization rates of 100% were assigned to these measures.

- **Lighting:** Lighting savings were calculated from the "Thank You" bulb kit[49], EnergySavvy, and RHA data sources.
  - For the "Thank You" bulb kits, the evaluation team utilized the wattage of the LED bulbs provided (10 W) and adopted the EISA-equivalent halogen baseline wattage (43 W) in the evaluated savings calculations. The ex ante calculated savings used deemed LED savings similar to the EEP program's deemed savings. Further, ex ante calculations assumed an in-service rate (ISR) for these LED bulb kits of 100% and a CF of 0.11.[50] The evaluation team adopted the Residential In-Home Lighting Hours-of-Use Study ISR (89%) and CF (0.23) values. This difference in CF was the primary contributor to lighting's overall higher peak demand savings (realization rate of 330%).
  - To estimate the savings for lighting measures from EnergySavvy and RHA, the evaluation team used tracking data in conjunction with the NY TRM v4 specifications. Ex ante calculations and assumptions could not be determined
- **Air Sealing:** The evaluation team calculated estimates using the PSEG Long Island TRM algorithms and applying program-tracking data, including HVAC system data and cubic feet per minute (CFM) air flow rates. Ex ante calculations were performed within the two data sources, RHA and EnergySavvy, and had distinctly different per-project savings. EnergySavvy savings were typically higher by a factor of 10, for both energy and peak demand. Moreover, evaluated per-project energy savings were higher than both RHA and EnergySavvy. This deviation in ex ante calculations, as well as the difference with evaluated savings, led to realization rates of 10% for peak demand and 201% for energy savings.
- **HVAC Measures**

[49] Ibid.
[50] NMR Group, Inc. Northeast Residential Lighting Hours-of-Use Study. 2014.

- **Duct Sealing and Insulation:** The program-tracking data did not differentiate between duct sealing and insulation in all instances, so the evaluation team compared pre- and post-installation conditions for all applicable projects to determine the associated measure. The evaluation team utilized 2016 Connecticut Program Savings Document (PSD)-based algorithms to calculate savings from duct sealing measures, and NY TRM v4-based algorithms to calculate the savings from duct insulation measures.
- **HVAC Equipment:** Due to the format in which data were provided from EnergySavvy for HVAC equipment measures, the evaluation analysis calculates energy savings for cooling and heating per home separately, rather than per equipment type. The evaluation team utilized the heating and cooling capacity of HVAC equipment along with equipment efficiencies (pre- and post-) contained in tracking data to estimate savings from these measures.
- **Programmable Thermostats:** The evaluation team calculated savings using the algorithms from the NY TRM v4. The evaluation team included savings only for projects that upgraded from a manual thermostat to a programmable thermostat. We assumed that if there was an upgraded thermostat in a centrally cooled residence, it applied to the entire home, therefore disregarding the quantity of thermostats installed.

- Domestic Hot Water Measures
  - **Water Heaters:** The evaluation team used algorithms from the NY TRM v4 with program-tracking data, which contained measure-specific hot water temperature set points and energy factors for preexisting and installed equipment to calculate the evaluated energy savings. Details on ex ante calculations and assumptions were not available to the evaluation team.
- **Dishwashers:** There was one dishwasher installed in 2017 under HPwES. Evaluated savings were calculated based on the prospective PSEG Long Island TRM's algorithms. Ex ante calculations and assumptions could not be determined.
- **Refrigerators:** There was one refrigerator installed in 2017 under HPwES. Evaluated savings applied the program-tracking data, including model number, and ENERGY STAR's specified algorithms to calculate savings. Ex ante assumptions could not be determined. Realization rates are 442% for peak demand and 1,692% for energy savings, but total savings for a single refrigerator are negligible in comparison to the overall HPwES program.

Impacts for Cost-Effectiveness Calculations

As with other programs, the evaluation team used ex post net savings to perform cost-effectiveness calculations. While program staff applied a planning NTGR of 1.0 for each program measure category to develop the ex ante savings estimates, the evaluation team developed a NTGR for the program in 2011, including FR and SO, for ex post estimates. Table 6-5 provides a review of ex post impacts for the program in 2017 by category based on an engineering estimate of savings.

Table 6-5. HPwES Program Measure-Specific Net Impacts: Engineering Approach

Measure Category	N[a]	Ex Ante Net Savings		Ex Post Net Savings		Realization Rate	
		kW	kWh	kW	kWh	kW	kWh
Building Envelope	1,085	1,634	1,011,131	182	360,257	11%	36%
Lighting*	261	45	640,505	145	739,932	325%	116%
Air Sealing	1,088	568	342,078	44	514,108	8%	150%
HVAC	322	62	48,202	192	71,085	310%	147%
DHW	314	20	40,112	4.4	38,417	22%	96%
Dishwasher	1	0	185	4.5	29	N/A	16%
Refrigerator	1	0.03	61	0.10	771	326%	1,266%
Total	**1,206**	**2,328**	**2,082,273**	**572**	**1,724,599**	**25%**	**83%**

[a] Number of HPwES projects with measures in 2017.
* Includes 5,233 recipients of LED kits that received HPwES energy audits.
Note: Totals may not sum due to rounding.

7. Home Energy Management Program

The Home Energy Management (HEM) program was launched in 2017, in partnership with Tendril. The program aims to motivate PSEG Long Island customers to increase their understanding of all aspects of their energy needs and to take active control of their energy usage. The objectives of the program are for residential customers to:

- Increase awareness of and participation in energy efficiency programs
- Augment peak hour energy savings
- Lower energy usage
- Consider renewable energy/energy storage and demand response programs
- Increase satisfaction with PSEG Long Island

The program offers a set of intervention strategies to influence customers' energy use behaviors. The primary strategy is a Home Energy Report (HER) plus engagement campaign leveraging a randomized control trial (RCT) design. Beginning in September 2017, Tendril will send periodic HERs for 2 years to 345,000 customers, with the goal of reaching over 30,000 MWh of behavior-based energy savings per year. While most HEM participants began receiving reports in late 2017 and early 2018, PSEG Long Island's savings goals and reporting are based upon the calendar year. Therefore, the savings reflected in the 2017 evaluation cover only the initial rollout of the HEM program. Selection criteria for customers who receive HERs emphasize customers between 55 and 74 years old to improve satisfaction of customers in this segment. In addition, one-third of customers receiving reports are "My Account" participants.[51]

Typically, behavior-based programs use a consumption analysis (conducting regression analyses using monthly billing data) to estimate energy savings. These results reflect the time frame when reports were delivered. This approach requires 1 year of post-participation energy consumption data to produce robust impact estimates. Given the short implementation time frame for 2017, the evaluation team used a deemed savings approach to calculate energy savings associated with the HERs delivered via the HEM program in 2017. The evaluation team will conduct a full consumption analysis for the 2018 program year evaluation.

Program Performance

PSEG Long Island began sending reports to customers in September 2017. As a result, our evaluation captures the 2017 savings associated with customers receiving reports in September through the end of December 2017. The HEM program sent one or more paper reports to 261,747 customers in that period. The program had identified 340,064 customers as the population to target for treatment; however, reports did not go out to all of those customers in 2017, as shown in Table 7-1.

Table 7-1. HEM Program Participation

	Number of Targeted Treatment Customers	Number of Customers Who Received a Paper HER	Start Date
2017 Treatment Group	340,064	261,747	September 2017

[51] "My Account" is an online portal for PSEG Long Island customers to manage their accounts and to access PSEG Long Island's suite of online energy management tools.

The evaluation team's review of program implementation tracking data found that the number of paper reports sent in 2017 was slightly lower than the ex ante number claimed. Table 7-2 shows a breakdown of claimed versus verified reports sent during each month of 2017. Overall, we verified that 441,054 paper HERs were sent during this period. Many of these customers received more than one report in this period.

Table 7-2. HEM Paper HERs Sent by Month

Month	Claimed Report Count	Verified Report Count
September	52,412	52,412
October	124,344	123,929
November	145,097	143,489
December	121,288	121,224
Total	**443,141**	**441,054**

Impacts for Goal Comparison and Cost-Effectiveness

PSEG Long Island indicated that its initial 2017 plan assumed customers would receive six HERs over the course of the year. In consultation with the evaluation team, PSEG Long Island assumed that these reports would yield 1.5% savings relative to total consumption for participants. Evaluations of similar programs have shown that participants achieve on average approximately 1.0%–1.5% net savings over the first year.[52] Because the program had planned to send six paper reports to each participant over the entire 2017 program year, and customers actually received 0–2 reports for the year, PSEG Long Island adjusted this annual savings rate to account for the shortened treatment period in its ex ante savings estimates by applying a deemed savings of 0.25% of average customer usage per report sent. Table 7-3 shows the savings associated with the claimed number of reports sent compared to the verified report count. Ex ante savings per report are applied to the average annual energy consumption for a PSEG long Island customer in 2016.

Table 7-3. HEM Evaluated Savings for Goal Comparison and Cost-Effectiveness

N (Paper Report Count)	Ex Ante Net Savings (MWh)	Verified Ex Ante Savings (MWh)	Evaluated/Ex Post Net Savings (MWh)	Realization Rate
443,141	11,145	11,104	7,627	68%

The evaluation team also applied a deemed savings approach to estimate savings only for the portion of the year after customers received their first report. Whereas ex ante savings were based on average PSEG Long Island residential customer usage in 2016, we based evaluated savings on average HEM control group customer usage specifically for the September–December 2017 period. More specifically, we applied the anticipated first-year monthly savings (1.5%) to the average total energy consumption for control group customers during the September–December 2017 period. We use the following equation to estimate 2017 energy savings resulting from the program.

[52] Behavioral programs are considered an "ongoing treatment" (e.g., customers receive reports on monthly basis for a year or longer), whereas equipment-based programs capture savings from a one-time installation of equipment. As a result, customers who receive reports may not at first recall receiving the report or take energy-savings actions immediately after the program begins. After subsequent months of receiving the reports, customers may be motivated to purchase energy-efficient equipment or habituate recommended behaviors like turning off the lights or setting more-efficient set points on their thermostat. Research suggests that energy savings for behavioral programs ramps up over time, with first-year savings for electric customers typically around 1.0%–1.5% and growing into the second and third years, where they plateau between 2% and 3%.

Equation 7-1. Algorithm for Calculating HEM Program Savings

$$\Delta kWh = \%\, Energy\ Savings * 2017\ Control\ Group\ Usage\ during\ Treatment\ Period * Adjustment\ Factor\ for\ First\ Report\ Date$$

Data on reports sent to each customer showed a wide range of first report dates, with the earliest reports being sent to customers on September 28, 2017. Nearly a quarter of originally targeted treatment customers (81,158) did not receive a report in 2017 according to these data. Based on the date at which a first report was sent, we developed an adjustment factor to account for the actual time that customers were being treated in 2017. We calculated this adjustment factor as the number of days between the first report date and the end of the year divided by the total number of days in the September–December period (122), as shown in Equation 7-2. The adjustment factor was calculated for each customer, with customers who did not receive a report being given a value of zero. The overall adjustment factor applied to the program's evaluated savings is the mean value of all customers' individual adjustment factors.

Equation 7-2. Adjustment Factor

$$Adjustment\ Factor = \frac{Days\ Remaining\ in\ 2017}{122}$$

Using this adjustment factor, we calculate program-level evaluated savings to be 7,627 MWh for the 2017 program year.[53] In 2017, the program achieved a realization rate of 68% (see Table 7-3). In Table 7-4, we show a breakdown of all components used to come to the final evaluated savings estimate.

Table 7-4. HEM Evaluated Savings

N (2017 Customers Targeted for Treatment)	Average Energy Consumption per Household (kWh)	Percent Energy Savings	Average Proportion of Sept–Dec 2017 Period That Targeted Treatment Customers Received Reports	Total Ex Post (MWh)
340,064	3,387	1.5%	0.44	7,627

Equivalency Analysis

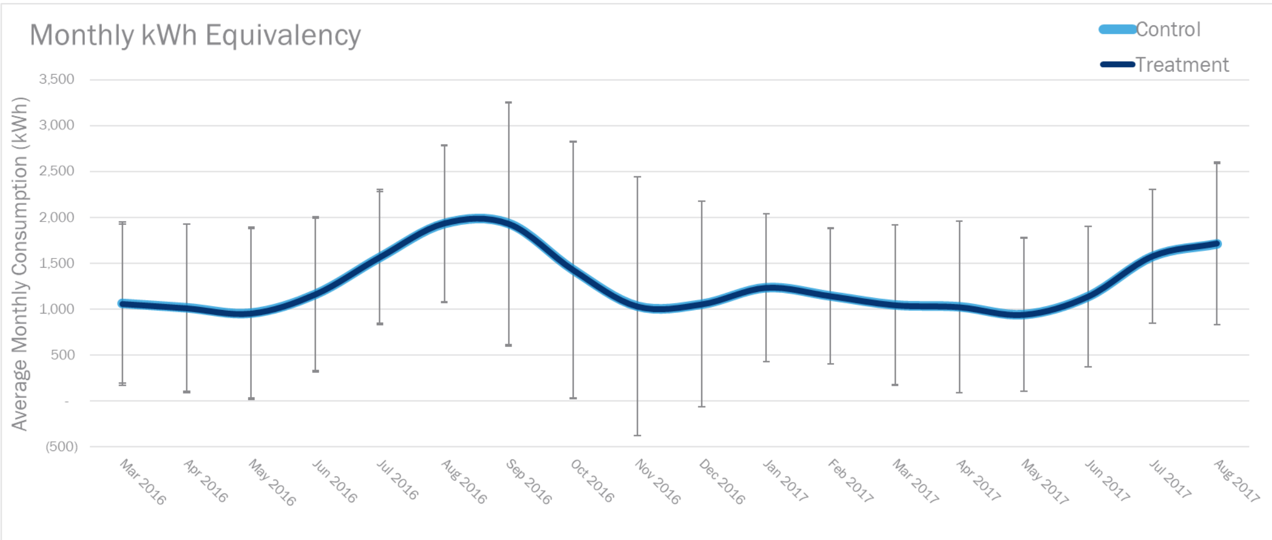
Whereas evaluated savings in 2017 are based on a deemed approach, the evaluation team will calculate evaluated savings in 2018 and 2019 using a consumption analysis comparing energy usage between treatment and control groups. In anticipation of the consumption analysis planned for 2018, the evaluation team performed an equivalency analysis between treatment and control groups to verify that these two groups show equivalent energy consumption overall and monthly, for the 18-month period prior to the start of report delivery for the treatment group. This analysis ensures that the control group provides a reliable counterfactual for the treatment group. In the process, we examined both groups' energy usage and found that the treatment and comparison households are equivalent.

The evaluation team examined the average daily fuel consumption for 18 pre-participation period months for treatment and control group customers used for modeling to ensure that any attrition from the program since the treatment and control groups were established did not compromise their equivalency. In the 18 months before the start of the program, average energy consumption was 1,304 kWh/month for households in both the control group and treatment group. Figure 7-1 presents the pre-participation period energy consumption

[53] Opinion Dynamics notes that, of the 340,064 customers identified for potential program treatment in the RCT program design, 261,747 actually received one or more paper HERs in 2017. Ex post savings totals also reflect removal of 18 customers from the analysis dataset who had originally been in the target population but who opted out from receiving paper HERs.

for both treatment and control groups, for each month leading up to the start of the program. Based on these data, equivalence between these two groups was confirmed.

Figure 7-1. Pre-Participation Period Energy Consumption, Treatment vs. Control

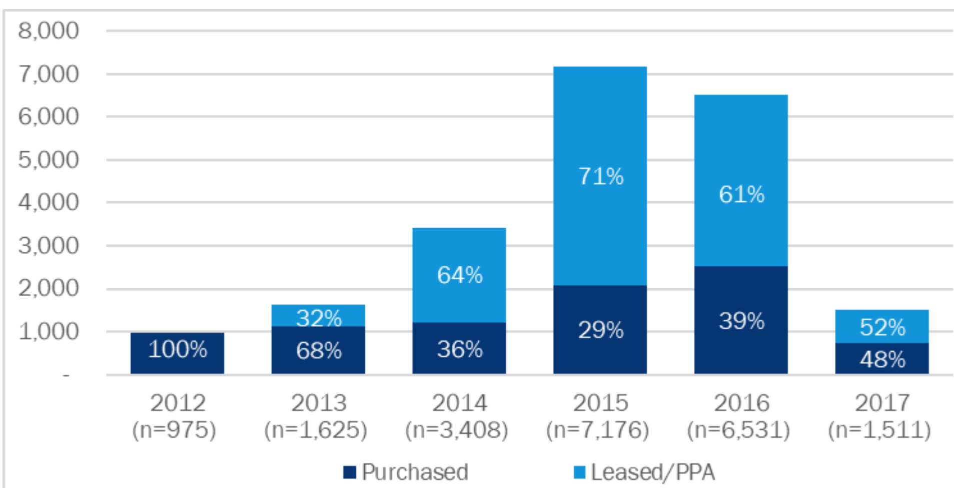


8. Solar Photovoltaic Program

In 2017, PSEG Long Island continued to offer rebates and financing to residential and small commercial customers to promote the installation of solar photovoltaic (PV) systems. These rebates served to encourage customer-sited electric generation, helping customers gain more control over their electric bills and reduce their carbon footprint while also offsetting PSEG Long Island's energy and capacity requirements. Since August 2014, PSEG Long Island has facilitated the NYSERDA-funded NY-Sun Residential and Small Commercial initiative for Long Island customers. The NY-Sun program uses a MW block structure that allots successive tiers of incentive rates so that early adopters receive the highest rebates. Rebates can be offered for residential projects as large as 25 kW and for commercial projects of up to 500 kW. The final block of funding for Long Island residential rebates was fully allocated in April 2016, meaning no new residential rebate applications were accepted in 2017. However, the program continued to accept applications for solar PV installations through the On-Bill Recovery Finance Program offered by Green Jobs – Green New York throughout 2017. NY-Sun funding for nonresidential installations in still currently available.

In 2017, PSEG Long Island provided rebates or financing for 1,512 solar PV systems, amounting to just 23% of the number of projects completed in 2016. The program staff attribute this reduction to the lack of new residential projects following the exhaustion of residential incentive blocks in April 2016. While leasing and power purchase agreements (PPAs) continued to be an important driver of residential participation in 2017, the proportion of leased systems fell significantly in 2017, both in absolute and relative terms. Program staff reported that many leasing companies, including some of the higher producers, began moving their operations out of the region after the exhausting of the residential rebates, and this trend is continuing in 2018. Figure 8-1 illustrates changes in participation over the past 6 years broken out by payment method.

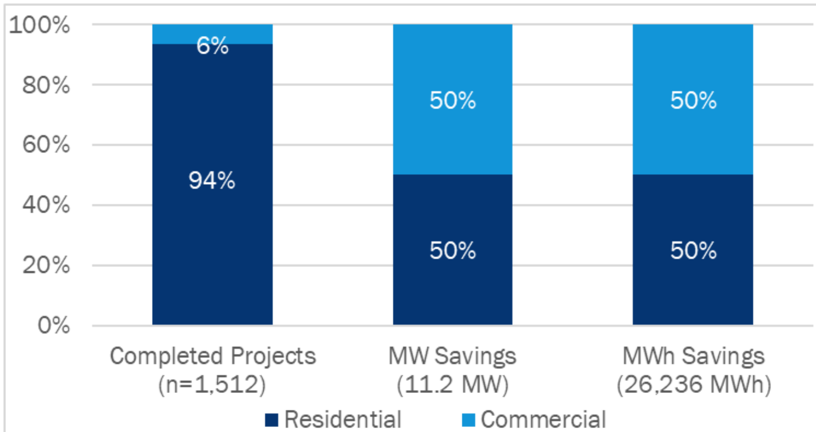
Figure 8-1. PV Systems Installed per Year by Purchase Type (2012–2017)



Note: Excludes six legacy projects completed in 2016 and one completed in 2017 for which purchase type was unavailable.

Figure 8-2 provides the 2017 completed projects and savings broken out by residential and commercial (includes all nonresidential projects) sectors. Despite the overall decline in projects in 2017, residential systems still accounted for 94% of installations, down only slightly from 98% in 2016. However, while commercial projects accounted for only 6% of projects, they accounted for half of both demand and energy savings. By comparison, in 2016, commercial installations accounted for 2% of installations and 10% of MW and MWh savings. The difference between the two years was due to the much larger average size of commercial systems in 2017. In early 2017, the NY-Sun program increased the maximum rebated commercial system size from 200 kW to 500 kW. Nineteen systems rated over 200 kW were installed in 2017, accounting for 62% of commercial installed capacity. As a result, the average system size of residential systems remained the same in 2016 and 2017 (8.1 kW), while the average size of commercial systems doubled from 58.0 kW in 2016 to 117.9 kW in 2017.

Figure 8-2. Solar PV Projects and Associated Savings by Sector



Despite the steep decline in projects in 2017, program managers anticipated this reduction, and lowered the program's 2017 goals substantially in comparison to 2016. Still, the program far exceeded expectations, achieving nearly twice its goals for both energy and demand savings (175% and 188%, respectively). According to program staff, one reason for the higher-than-expected savings was a lower-than-expected attrition rate for residential projects already in the pipeline at the start of 2017. Leasing projects tend to have higher attrition rates and, with leasing firms winding down their business on Long Island, fewer projects were leased in 2017. Additionally, of those leased projects, a higher proportion were seen to completion before the end of the year. Program staff also noted that solar contractors began to shift their focus from residential to commercial markets in 2017, as rebates were still available and maximum system size limits had been raised. As such, PSEG Long Island commercial customers installed more systems than planned in 2017, many of which were larger arrays, which also contributed to higher-than-expected savings.

Notably, about half (48%) of projects completed in 2017 were initiated in 2016. Another 40% were initiated in 2015 or 2014, when residential rebates were still available. Only about one tenth (11%) of projects completed in 2017 were initiated in 2017, which is an indication that even fewer projects will be completed through the program in 2018. Moving forward, program staff expect that commercial participation will remain steady through 2018 and 2019, as the remaining incentive blocks are claimed. In addition, separate incentives will remain available to low-income residential customers, who so far have been completing approximately a dozen projects each month.

Impacts for Goal Comparison

For the 2017 evaluation, the evaluation team completed a desk review of PSEG Long Island's solar PV tracking data to arrive at evaluated net savings. The evaluated net savings resulted in slightly lower demand and energy savings (by 2% and 6%, respectively). Table 8-1 shows the evaluated and ex ante net savings for the PSEG Long Island solar program (including both Salesforce projects and one Seibel legacy project) by program sector.

Table 8-1. Solar PV Residential and Nonresidential Net Impacts for Goal Comparison

Program	Number of Projects	Ex Ante Net Savings		Verified Ex Ante Net Savings		Evaluated Net Savings		Realization Rate	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
Residential	1,417	5,723	13,628,528	5,723	13,628,528	5,626	13,153,920	98%	97%
Commercial	95	5,719	14,366,907	5,719	14,366,907	5,600	13,082,035	98%	91%
Total	**1,512**	**11,442**	**27,995,435**	**11,442**	**27,995,435**	**11,226**	**26,235,955**	**98%**	**94%**

Note: Totals may not sum due to rounding.

Similar to the previous evaluation of the Solar PV program, the evaluation team independently verified the accuracy of program performance test conditions (PTCs) output estimates. For a selection of 624 projects in the 2017 population for which sufficient granular data were available, the evaluation team independently calculated the PTC estimates using inverter efficiencies, panel quantities, and PTC ratings per panel. This verification showed only a slight difference between the program's tracked PTC outputs and the evaluation team's calculations. Therefore, the evaluation team was comfortable using the program's PTC estimates for all 2017 installations to determine evaluated saving for the 1,512 projects completed in 2017.

The evaluated and ex post demand savings differed from ex ante savings for two reasons. First, the evaluation team applied an average rated DC kW to actual AC kW factor of 0.867 based on the interval data of 124 solar PV installations on Long Island in 2012. This value was slightly lower that the value of 0.886 used for ex ante savings estimates. Additionally, the evaluation team applied an averaged rated DC kW to actual AC kWh factor of 1,071, again based on the performance of 124 solar PV projects in 2012. The evaluated savings are lower as a result because ex ante calculations assumed a DC kW to AC kWh factor of 1,119. The program did not provide the evaluation team with the source of this assumption.

Impacts for Cost-Effectiveness

Based on research conducted in 2012 to assess the NTGR for this program, we found that the program had substantially influenced the market for solar PV on Long Island, and the evaluated NTGR was set to 1.0 (equal to the program planning value).[54] Table 8-2 shows the savings by program for the cost-effectiveness calculations. Because the NTGRs for both the evaluated and ex post savings are the same value, this table is identical to Table 8-1 above, as are the reasons for the differences in impacts.

Table 8-2. Solar PV Residential and Nonresidential Net Impacts for Cost-Effectiveness

Program	Number of Projects	Ex Ante Net Savings		Evaluated Net Savings		Realization Rate	
		kW	kWh	kW	kWh	kW	kWh
Residential	1,417	5,723	13,628,528	5,626	13,153,920	98%	97%
Commercial	95	5,719	14,366,907	5,600	13,082,035	98%	91%
Total	**1,512**	**11,442**	**27,995,435**	**11,226**	**26,235,955**	**98%**	**94%**

Note: Totals may not sum due to rounding.

[54] A summary of the primary and secondary research conducted to estimate the effect of LIPA rebates on PV installations on Long Island can be found in the *Program Guidance Document* for 2011.

9. Detailed Methods

9.1 Overview of Data Collection

Our 2017 evaluation of PSEG Long Island's Energy Efficiency and Renewable Energy portfolios relied primarily on reviewing and analyzing program-tracking data, customer billing data, and secondary data sources to assess program impacts. Primary data collection in 2017 was limited mainly to in-depth interviews with program and implementation staff to provide context for our impact evaluation and to assess program processes. The evaluation team also conducted some secondary research to support limited process evaluations for several of the Energy Efficiency programs.

9.2 Overview of Analytical Methods

Table 9-1 provides an overview of the main analytical methods used in the evaluation of each of the PSEG Long Island programs in 2017. The remainder of this section describes key analytic approaches used in our evaluation for each program and for the cost-effectiveness and economic impacts analyses in more detail.

Table 9-1. Primary Analytical Methods Used in 2017 Evaluation

	Qualitative Analysis of In-Depth Interviews	Secondary Data Review	Consumption Analysis	Equivalency Analysis	Engineering Review of Algorithms	Engineering Desk Review of Projects
Program	Process/ Impact	Process/ Impact	Impact	Impact	Impact	Impact
CEP	X	X			X	X
EEP Program	X	X			X	
Cool Homes Program	X				X	
REAP Program	X		X	X	X	
Home Performance Programs	X				X	
HEM Program	X	X		X		
Solar PV Program	X				X	

9.3 Commercial Efficiency Program

We performed two specific data collection activities within the CEP:

- In-depth interviews with program staff to understand programmatic changes and record program implementation processes
- Engineering analysis to assess gross impacts

Below we describe each effort in greater detail.

Program Staff Interviews

As part of the 2017 CEP evaluation, in December 2017, we conducted in-depth interviews with four program staff members at Lockheed Martin who are responsible for the program's implementation. The interviews were designed to understand programmatic changes made in 2017 and planned in 2018, to gather program staff perspectives on program performance and process effectiveness, and to understand any challenges that the program experienced in 2017.

Engineering Analysis

In 2017, the evaluation team performed two types of engineering analysis: a review of LM Captures program-tracking data and calculation of savings using engineering algorithms, and a review of a sample of projects and calculation of savings using detailed information from each sampled project (Table 9-2). We conducted engineering desk reviews of a sample of 76 projects across five program components.[55] We did not perform desk reviews for Custom projects because the small percentage of demand savings attributed to Custom projects did not warrant desk reviews for 2017. Instead, we relied on the realization rates determined through on-site M&V work completed as part of the 2012 evaluation.[56] For projects where we conducted both types of engineering analysis, we did not identify any discrepancies from desk review projects.

Table 9-2. Engineering Analysis by Program Component

Program Component	Database Review	Desk Review	On-Site M&V
Comprehensive Lighting		X	
Fast Track Lighting	X	X	
Prescriptive Lighting		X	
Standard	X	X	
HVAC	X	X	
Custom			X

All evaluations that include sampling have inherent levels of uncertainty in the estimates based solely on the fact that they are assessing only a portion of the population.[57] We can calculate this sampling error using the variability of savings seen from a probability-based sample design. In this type of design, each item in our sample frame has equal probability of being chosen for inclusion in our sample and being further assessed.

[55] Our team conducted engineering desk reviews for a sample of projects (as opposed to the population) as we were unable to extract project-specific information automatically for the entire population of projects.

[56] We are working with PSEG Long Island to update our Custom realization rates for CHP projects in 2018.

[57] We note that all evaluations contain levels of uncertainty, some of which can be calculated (e.g., sampling error, measurement error for engineering instruments) and some of which cannot (e.g., nonresponse in surveys).

However, certain sample designs require larger numbers to be included in the sample to reach the level of certainty desired. The Dalenius-Hodges technique is a statistical technique that provides optimal stratification of a population to enable reduction in sample size while maintaining statistical precision.

We used a simple random and a stratified random sample design to draw samples for the Comprehensive Lighting, Fast Track Lighting, Prescriptive Lighting, Standard, and HVAC projects. For the stratified random sample design, we relied on the Dalenius-Hodges technique to determine appropriate strata for each sample frame, and the Neyman allocation method to obtain optimal samples by stratum. We detail this process below. Following, we provide information on the samples that we drew for each of the CEP components.

Determination of Strata Boundaries

The Dalenius-Hodges method begins with the creation of numerous and narrow strata. Within each stratum, the frequency of coupons, *f(y)*, is calculated. Next, the square root of *f(y)*, $\sqrt{f(y)}$, is calculated and the cumulative of $\sqrt{f(y)}$ is formed. The total of cumulative $\sqrt{f(y)}$ is then divided by the number of desired strata to determine the division points on the cumulative $\sqrt{f(y)}$ scale.

The above rule assumes equal widths, *d*, for the class intervals, and it must be modified when the class intervals have variable widths, d_y. The approach recommended by Kish[58] is to multiply the *f(y)* by the width of the interval, take the square root of this value, and cumulate the values $\sqrt{d_y f(y)}$. Finally, as in the above case, the total of cumulative $\sqrt{d_y f(y)}$ is then divided by the number of desired strata to determine the division points on the cumulative $\sqrt{d_y f(y)}$ scale.

Optimal Allocation

Once strata boundaries have been determined, an allocation scheme is used to estimate the population mean with the lowest variance for a fixed total sample size, *n*, under stratified random sampling. Such a scheme is the Neyman allocation as described in Cochran[59]:

$$n_h = n \frac{N_h s_h}{\sum N_h s_h} \tag{1}$$

where:

N_h = the total number of units in stratum *h*

n_h = the number of units in the sample of stratum *h*

n = the total number of units in the sample across all strata

s_h = the variance within stratum *h*

This formula for optimal allocation may produce an n_h in some stratum that is larger than the corresponding N_h. This problem can arise in the plan for the verification of rebate program savings because the overall sampling fraction is large and some strata are much more variable than others. If the original allocation gives, for example, an n_1 that is greater than N_1, then equation (1) is revised as follows:

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[58] Kish, L. 1995. *Survey Sampling.* Wiley Classics Library Edition.

[59] Cochran, W. G. 1977. *Sampling Techniques.* Hoboken: John Wiley & Sons, Inc.

$$n_h = (n - N_1)\frac{N_h s_h}{\sum_2^L N_h s_h} \tag{2}$$

If the original allocation gives, for example, an n_1 that is greater than N_1 and an n_2 that is greater than N_2, then equation 2 is revised as follows:

$$n_h = (n - N_1 - N_2)\frac{N_h s_h}{\sum_3^L N_h s_h} \tag{3}$$

Using the approach just described, the sample design for all of our samples was expected to provide statistically valid impact results at least at the 90% confidence level ±10% for the projects overall based on demand.

Engineering Review Sample Design

In February 2017, the CEP transitioned to new applications that aligned with the key program components, including Comprehensive Lighting, Fast Track Lighting, Prescriptive Lighting, Standard, HVAC, and Custom. Adjusting to the new applications may present an opportunity for errors and inconsistencies in savings calculations. Those inconsistencies may ultimately lead to differences in realization rates. Recognizing these potential issues and accounting for them as part of the sample design, where participation levels allowed, was important to ensuring accurate and rigorous gross impact analysis. Table 9-3 shows the sample designs for Comprehensive Lighting, Fast Track Lighting, Prescriptive Lighting, Standard, and HVAC. As can be seen in the table, we drew either a simple random or stratified random sample from each program component. We relied on the simple random sample approach in cases with high homogeneity in project sizes and savings. In those cases, stratified random sample does not help improve the efficiency of sample design and is not appropriate to use. We also relied on the simple random sample design in cases where the participant population at the time of the sampling process was too small to allow for a stratified sample design.

Table 9-3. CEP Comprehensive Lighting, Fast Track Lighting, Prescriptive Lighting, Standard, and HVAC Engineering Review Sample Design

Sampling Component	Sample Design	Total Ex Ante Savings (kW)	Projects in Population[a]	Projects in Sample
Comprehensive Lighting	Stratified Random	14,617	1,269	25
Fast Track Lighting	Stratified Random	6,161	2,532	25
Prescriptive Lighting	Simple Random	687	73	5
Standard	Simple Random	546	122	10
HVAC	Stratified Random	1,494	212	11
Total		**23,505**	**4,208**	**76**

[a] At the time of sampling, Comprehensive Lighting and Fast Track Lighting populations included projects completed from January to November 2017, while Prescriptive Lighting, Standard, and HVAC populations included projects completed from January to December 2017.

Table 9-4 provides strata boundaries for program components where we relied on a stratified random sample design.

Table 9-4. Strata Boundaries for Stratified Sample Design

Stratum	Boundaries (kW)	Total Ex Ante Savings (kW)	Projects in Population	Projects in Sample
Comprehensive Lighting				
1	0– <10	3,230	862	8
2	>=10 – <40	6,487	339	9
3	>=40 – <221	4,900	68	8
Subtotal		**14,617**	**1,269**	**25**
Fast Track Lighting				
1	0 – <2	1,741	1,658	8
2	>=2 – <7	2,574	736	9
3	>=7 – <41	1,846	138	8
Subtotal		**6,161**	**2,532**	**25**
HVAC				
1	0 – <11	574	191	6
2	>= 11 – <92	603	20	4
3	>=92 – <318	318	1	1
Subtotal		**1,494**	**212**	**11**

For each desk review, we:

- Checked the data for data entry errors, omissions, or inconsistencies by comparing project documentation, such as invoices, to the program-tracking data extract
- Calculated ex post gross demand and energy savings based on the detailed information in the project files and compared those savings to the program-tracking data
- Calculated gross realization rates for each project in our sample by applying line loss, coincidence, and net-to-gross factors to the ex post gross savings values and dividing the resulting savings by ex ante net savings
- Applied the sample design weighting factors to arrive at a gross realization rate for each program component

For the desk reviews, we used the ratio adjustment method[60] to extrapolate results for the sampled sites back to the overall 2017 component population. The sampling and results calculation approach we took varied by the program component. For the Standard and Prescriptive Lighting projects, we did simple random sampling (SRS) and used a method for calculating estimates, ratios, standard errors, confidence intervals, and precisions appropriate to that sampling approach. For the Comprehensive Lighting, Fast Track Lighting, and HVAC projects, we used a stratified random sampling approach and calculated ratios and associated statistics using a stratified ratio estimator-combined method. Below, we describe the ratio-SRS method first, followed by the stratified ratio-combined method.

$$r = \overline{y} \div \overline{x}$$

[60] Levy, P.S. and Lemeshow, S. 2008. *Sampling of Populations: Methods and Applications* (4th Ed). Hoboken: John Wiley & Sons, Inc.

where:

r = ratio of ex post to ex ante sample estimates, or the realization rate

$\overline{y}$ = sample ex post mean

$\overline{x}$ = sample ex ante mean

The standard error of the ratio estimate is given by:

$$\widehat{SE}(r) = \left(\frac{r}{\sqrt{n}}\right)\left(V_x^2 + V_y^2 - 2\rho_{xy}\hat{V}_x\hat{V}_y\right)^{1/2}\sqrt{\frac{N-n}{N-1}}$$

where:

N = population of participants

n = sample of participants

$\hat{V}_x^2 = \left(\frac{N-1}{N}\right)\left(\frac{s_x^2}{\overline{x}^2}\right)$

$\hat{V}_y^2 = \left(\frac{N-1}{N}\right)\left(\frac{s_y^2}{\overline{y}^2}\right)$

$\hat{\rho}_{xy} = \frac{\sum_{i=1}^{n}(x_i-\overline{x})(y_i-\overline{y})}{(n-1)s_x s_y}$

We followed this method for estimating realization rates for the verified ex ante, evaluated, and ex post net savings for Standard and Prescriptive Lighting projects.

The components of the program that warranted stratified sampling followed the combined method of calculating the realization rate and its standard error. This method was appropriate because there were too few participants in some strata to support separate ratio estimates. The method is as follows:

$$r_{strc} = \frac{\overline{y}_{str}}{\overline{x}_{str}}$$

where:

r_{strc} = stratified-combined ratio of ex post to ex ante sample estimates, or realization rate

$\bar{y}_{str}$ = stratified sample ex post mean

$\bar{x}_{str}$ = stratified sample ex ante mean

The variance of the ratio is given by:

$$Var(r_{strc}) = \left(\frac{1}{N^2X^2}\right)\sum_{h=1}^{L}\frac{N_h^2(N_h - n_h)}{n_h(N_h - 1)}\sigma_{hz}^2$$

where:

N_h = number of participants in population of stratum *h*

X_h = ex ante population mean in stratum *h*

n_h = number of participants in sample of stratum *h*

$\bar{x}_h$ = estimated ex ante sample mean in stratum *h*

and:

$$\sigma_{hz}^2 = \hat{\sigma}_{hy}^2 + R^2\hat{\sigma}_{hx}^2 - 2R\hat{\rho}_{hxy}\sigma_{hy}\sigma_{hx}$$

where:

R = ratio or realization rate

$\hat{\sigma}_{hy}^2$ = estimated variance of the ex post savings in stratum *h*

$\hat{\sigma}_{hx}^2$ = estimated variance of the ex ante savings in stratum *h*

$\hat{\rho}_{hxy}$ = estimated correlation between *x* and *y* in stratum *h*

The standard error is calculated as the square root of the variance. We followed this method for estimating realization rates for the verified ex ante, evaluated, and ex post net savings for Comprehensive Lighting, Fast Track Lighting, and HVAC projects.

9.4 Energy Efficient Products Program

The evaluation team conducted an in-depth interview with the EEP program manager and reviewed program-tracking data for the 2017 EEP program evaluation.

9.5 Cool Homes Program

The evaluation team conducted in-depth interviews with program managers and implementers and reviewed program-tracking data and program application procedures for the Cool Homes program.

9.6 Data Cleaning and Model Development for Consumption Analyses of the REAP Program

Data Preparation and Cleaning

PSEG Long Island provided participation and measure data for all customers who participated in the Home Performance programs or the REAP program in 2016 and 2017. PSEG Long Island also provided a consumption history going back 60 months from January 2013 to December 2017 for both 2016 and 2017 program participants.[61] Prior to carrying out the statistical modeling, we matched, cleaned, and provided quality assurance for all data. We focused primarily on the 2016 participants for analysis purposes, but retained 2017 participants to create a comparison group. We used the same data-cleaning procedures for both 2016 and 2017 participants.

Cleaning Participant Data

We utilized records from program-tracking databases as the basis for our analysis sample, because these records had the PSEG Long Island customer account number associated with each site identifier. Program-tracking records provided in January 2018 included complete 2016 and 2017 participant data.

Our cleaning procedures were consistent with those employed in prior years' evaluations. First, we checked to make sure that all accounts had measure data. In the combined 2016–2017 REAP program-tracking data, we found one 2017 participant account for which we had no participant information and 74 in the 2016 treatment group. Furthermore, we kept only accounts with electric measure (kWh) savings. Measures with gas (therms) savings will naturally have 0 kWh savings, thus including them in the analysis would just be for program-tracking completeness purposes and would not affect our final result. Our team also checked for records with missing savings or zero quantities, but neither was found. One consumption record was removed due to a consumption period with 0 days, but this did not result in removing the whole account. One account was removed from the treatment group due to having no matched weather data. One account in each group was removed due to showing less than 2 kwh usage, on average, per day. Finally, we removed accounts with less than 9 months of data (107 from the treatment group and 11 from the comparison group) and, in the treatment group, we eliminated accounts where there were fewer than 2 summer months covered by the usage data. Since most program effects occur in the summer, it was important to be sure that season was adequately represented in the post-participation period for the treatment group. Of course, in our chosen design, there is no post-participation period for the comparison group.

As part of controlling for energy savings not influenced by the REAP program or influenced by previous REAP program participation, we compiled a list of unique account numbers from REAP (2015), HPDI (2015–2017), HPwES (2015–2017), and Cool Homes (2015–2017). We identified 158 cross-participation accounts and removed them from the analysis (763 in 2016 and 95 in 2017).

After cleaning the measure data, we calculated annual expected savings for each participant based on the sum of gross deemed kWh savings for all of the measures that each participant installed within the REAP program. We used these expected savings as the basis for realization rates. For customers who participated in multiple program years, we used the first installation date as the cutoff for determining whether the customer would be included in the treatment or comparison group.

Matching Participant Information with PSEG Long Island Account Information

The HPDI, HPwES, and REAP programs track PSEG Long Island customer account information with participant records. As a result, we used the customer account numbers provided with participant data to match billing histories to program participants.

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[61] PSEG Long Island provided some of these data to the evaluation team for the 2016 evaluation and some (2017 participants) for the 2017 evaluation.

Cleaning Billing Data

We merged 2016 and 2017 participants' billing data and then took a two-step approach to cleaning the data. This approach is consistent with the approach used in previous evaluations of the program. First, we removed individual billing periods, i.e., meter reads that were duplicative, cancelled, or had 0 billing days. Second, we cleaned the data for customer accounts with anomalous or insufficient data for consumption analysis. We describe each billing data cleaning sub-step below.

- **Cleaning Individual Billing Periods:** We removed billing periods with a duration of 0 days (i.e., same start and end date), and dropped 838 records, but only one comparison group account based on that issue. In the treatment group, we dropped 942 records, but no accounts. We checked for periods with 0a missing date and for those with 0 kWh of energy usage. For participants who participated in 2017 only, we did not include billing periods occurring after their first installation date, as these 2017 participants served as the comparison group.

- **Extremely High or Low Average Daily Consumption:** We checked for customers with entire pre- or post-participation periods having very high (more than 300 kWh daily) or very low usage (less than 2 kWh daily, on average. We dropped two households due to low usage (one from the treatment group and one from the comparison group) but lost no customers due to very high usage. These households are likely to contain odd usage patterns that we cannot easily control for and could bias our results.

- **Inadequate Billing History before or after Program Participation:** Many energy savings measures in these programs are expected to generate energy savings throughout the year. To be able to assess changes in consumption due to program measures before and after installation, we required participants to have a billing history covering, at a minimum, 180 days before the first day of program participation for both the 2016 and 2017 program participants, and 180 days after participation for 2016 participants. We lost 24 treatment customers, but no comparison customers based on the post-participation period criterion and 220 treatment group and 217 comparison customers based on insufficient pre-participation period bills.

- **Inadequate Billing History in the Cooling Season before and after Program Participation:** We also required participants to have a minimum of 60 days in the summer (cooling season), both before and after participation. This is because we expect the measure installations to be generally weather sensitive, both in terms of temperature and in terms of daylight versus night hours. By ensuring that we have enough billing data in the months of June, July, and August, we can provide more-rigorous savings estimates.

Assigning Time Periods to Billing Data

PSEG Long Island provided the billing data in billing cycle format, which means that customers have different read days and different read cycle lengths depending on their meter read cycle. For the analysis to be comparable across customers and time periods, we needed to assign each billing period to a specific calendar month. We first assigned a month to each period based on the midpoint of the billing period, so that the month would refer to the month in which the majority of energy use occurred (e.g., if the read period started on June 20 and ended on July 19, we assigned that period to July). In cases where two shorter read periods occurred within the same billing period, we combined kWh usage for both periods and recalculated average daily consumption (ADC) for the combined period. Many billing periods in the data start and end in the middle of a month, which often causes some consecutive bills to be assigned the same month as a midpoint. In these cases, we combined the two periods.

Incorporating Weather Data

As in previous billing analyses, the evaluation team incorporated weather into the model using daily weather data from numerous weather stations across Long Island, utilizing the site closest to each account's geographic location. By using multiple sites, we increase the accuracy of the weather data that we apply to each account. We obtained these data from the National Climatic Data Center (NCDC).

The daily data are based on hourly temperatures from each day. We calculated cooling degree days (CDDs) and heating degree days (HDDs) for each day (in the evaluated and historical periods) based on daily temperatures using a base temperature of 65°F for HDDs and 75°F for CDDs.[62] We merged daily weather data into the billing data set so that each billing period captures the HDDs and CDDs for each day within that billing period (including start and end dates). For analysis purposes, we then calculated average daily HDDs and average daily CDDs, based on the number of days within each billing period.

Preliminary Analyses

Using a comparison group, including one that comes from future participants, requires the analyst to check for comparability of the comparison group to the treatment group. This should be done even for a true RCT, but it is especially important in designs not based on random assignment. It could be that different demographics, geographical location (and therefore different weather patterns), or usage patterns are the focus of program targeting efforts, or that programs provide rebates for measures that trigger different groups to apply to the program. These scenarios can lead to substantial differences in the composition of the two design groups. Where they are different, the use of the comparison group to represent what the treatment group would have done absent the program is called into question. We describe the analyses that we completed to address these issues in Section 9.7 in the "Assessing Comparison Group Equivalency" subsection, where we conclude that the comparison group is similar enough to the treatment group to use as a valid point of comparison.

Model Development

As mentioned previously, all models included a comparison group consisting of households that participated in 2017 to construct the counterfactual baseline (what 2016 participants would have done during their post-participation period absent the program). Consumption analysis with an appropriate comparison group provides net savings, incorporating the effects of both FR and SO. For example, the energy use patterns of the members of the comparison group during 2016–2017 (up to the point of their participation in 2017) reflect equipment installations and behavioral changes that currently evaluated participants might have performed in the absence of the program. In addition, any measures installed during the evaluation period beyond program measures (SO) would be picked up by increased coefficients for the participation variables.

To improve our estimate of the counterfactual baseline (what the evaluated 2016 participants would have done during the post-participation period absent the program), we added indicator variables for each month of the evaluation period, resulting in a two-way fixed effects model. The monthly indicator variables provide

[62] The evaluation team diverges from the following definition to represent the likely heating and cooling behaviors of customers more closely. In general, degree days are defined as "a unit of measure for recording how hot or how cold it has been over a 24-hour period. The number of degree days applied to any particular day of the week is determined by calculating the mean temperature for the day and then comparing the mean temperature to a base value of 65 degrees F. (The 'mean' temperature is calculated by adding together the high for the day and the low for the day, and then dividing the result by 2.) If the mean temperature for the day is, say, 5 degrees higher than 65, then there have been 5 cooling degree days. On the other hand, if the weather has been cool, and the mean temperature is, say, 55 degrees, then there have been 10 heating degree days (65 minus 55 equals 10)." See http://www.crh.noaa.gov/ffc/?n=degdays.

information on time trends that affect both the comparison and treatment groups. We also entered weather terms in the model, as well as interaction terms between weather and the post-participation period for the treatment group, to account for differences in weather across years and between the design groups.

Our final model needed to meet a number of criteria. Primarily, we looked to use a model that explains as much about changes in the dependent variable, or ADC, as possible. The most direct measure of this is the overall R2, which gives an estimate of how much the model explains. An R2 of 1.0 would represent a model that explains 100% of the variance in the dependent variable, and an R2 of 0.5 would explain 50%. In our quasi-experiment, R2 will appear low because of our use of two fixed effects, but a higher R2 will be a significant factor. We also compare Akaike Information Criterion (AIC) values of different model specifications. AIC is a measure of relative efficiency between models, based on how much information is lost when variables are removed from a model that is meant to capture usage and how it changes over time in response to program interventions and other factors. Given this, a lower value, relative to other models, indicates that the model is more efficient.

In the development of our final model, we tested a series of progressively inclusive specifications. The simplest models were one-way fixed-effects models that took into account only the effect of participation and weather, in the form of total CCDs and HDDs in each period, with the account being a fixed effect. This type of model controls for aspects of the household that remain the same over the period studied. This model is at a high risk of omitted variables bias[63] because of its simplicity. Subsequent models include month-year fixed effects to control for the changes that occur for everyone over time, such as weather, political and economic factors, and others. Because there were differences in usage between the treatment and comparison groups across their common pre-participation periods, average pre-participation usage was interacted with several variables related to time and weather. Finally, we included interaction terms of the treatment variables with both CDDs and HDDs to model how participation effects change with weather, especially at the extremes. The team did not include measure variables, as this has been unprofitable in earlier evaluation years.

Some customers participate in these programs on multiple dates, so we set the treatment or post-participation period to start at the bill in which they participated most recently. The evaluation team excluded months between their primary participation date and their final participation date from the model. For customers with a single date of participation, our team excluded only one billing month from the model as a “deadband.” The treatment effect is the change in energy use that participating in the program causes, and as such cannot overlap with time before their participation in the program.

Final Analysis Data Set

In total, our final REAP program data set includes 2,875 accounts. Approximately 74% of the total participant population was available for analysis after data preparation and cleaning. Table 9-5 presents the results of cleaning the data, integrating clean billing data, and checking for sufficient billing data for each customer.

[63] Omitted variables bias is caused by not including important factors that affect the independent variable. The model compensates for the missing explanatory variables, resulting in misrepresentative estimates of the terms included.

Table 9-5. REAP Program Billing Data Analysis Cleaning Steps

Reasons for Drops	Treatment		Comparison	
	Total Accounts	Percent of Accounts	Total Accounts	Percent of Accounts
Total unique accounts	1,676	100.0%	1,863	100.0%
Records prior to 2014	–		–	
Accounts remaining	1,676	100.0%	1,863	100.0%
Disqualifying read codes	–		–	
Accounts remaining	1,676	100.0%	1,863	100.0%
Billing periods longer than 90 days	–		–	
Accounts remaining	1,676	100.0%	1,863	100.0%
Missing dates	–		–	
Accounts remaining	1,676	100.0%	1,863	100.0%
Usage over 10,000 kWh	–		–	
Accounts remaining	1,676	100.0%	1,863	100.0%
Billing periods with 0 days	–		1	
Accounts remaining	1,676	100.0%	1,862	99.9%
Billing periods under a week	–		–	
Accounts remaining	1,676	100.0%	1,862	99.9%
No participation data	74		1	
Accounts remaining	1,602	95.6%	1,861	99.9%
No weather data	1		–	
Accounts remaining	1,601	95.5%	1,861	99.9%
Too few post-participation period bills (less than 9)	29		–	
Accounts remaining	1,572	93.8%	1,861	99.9%
Too few pre-participation period bills (less than 9)	218		218	
Accounts remaining	1,354	80.8%	1,643	88.2%
Low overall average usage (under 2kWh/day)	2		–	
Accounts remaining	1,352	80.7%	1,643	88.2%
High overall average usage (over 300kWh/day)	–		–	
Accounts remaining	1,352	80.7%	1,643	88.2%
Too few pre-participation period summer bills	107		11	
Accounts remaining	1,245	74.3%	1,632	87.6%
Too few post-participation period summer bills (less than 2)	2		N/A	
Accounts remaining	1,243	74.2%	1,632	87.6%

9.7 REAP Program Estimation of Savings Using Consumption Analysis

In this section, we present the statistical methods and results of a consumption analysis to estimate program savings for the REAP program.

Assessing Comparison Group Equivalency

Before performing any modeling, we assessed the comparability of our treatment and comparison groups. If the comparison group is not very similar to the treatment group on important variables, the comparison group cannot act as an effective counterfactual to the treatment group. To assess the comparability of the groups, we determined the overall average baseline kWh consumption and the average daily CDDs and HDDs for both groups during the same calendar period. We compared the groups only on the months and years where both were in a pre-treatment period. This means that we excluded the years 2016 (as well as 2017) since the evaluated treatment group would have begun their post participation period sometime during 2016.

Graphing average energy consumption during the baseline period makes the similarities and differences between the groups visible. Figure 9-1 shows the ADC for November 2013 through November 2017 to determine how similar households may be in terms of energy consumption patterns. We see similarity in pre-participation program usage patterns between the treatment and comparison groups, with the treatment group sometimes using more and sometimes less than the comparison group.

Our team completed t-tests for the differences between two independent means (for ADC) for the years 2014 and 2015. There were not enough accounts in the 2013 period to justify a test. The comparison of groups in 2014 produced a t-score of 1.81 (statistically significant at 90% confidence, but not 95%), but a nonsignificant t-score of 0.99 in the 2015 year. Our assessment was that the groups were similar enough to warrant use of the comparison group in the analysis, but with statistical controls that model the observed differences across time.

Figure 9-1. REAP Program Analysis: Baseline kWh by Sample Group in Analysis

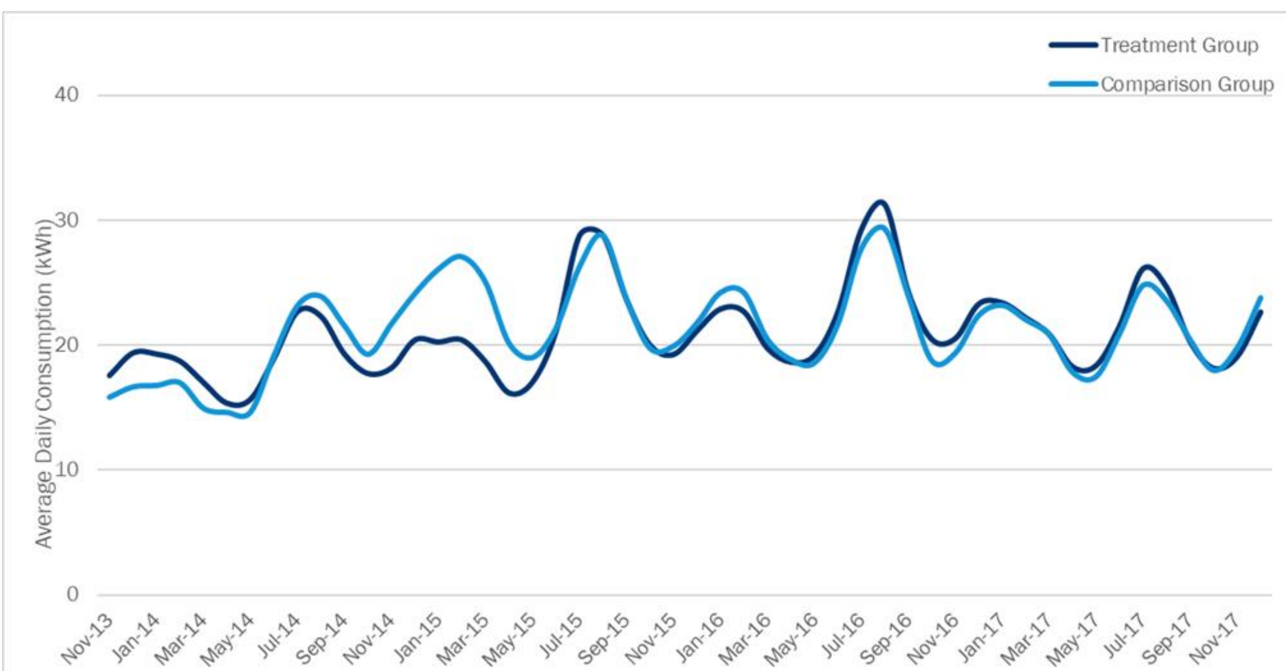


Figure 9-2 and Figure 9-3 demonstrate striking similarities in the weather patterns experienced by both groups over the course of the period covered by the consumption analysis. Thus, the groups likely occupy similar geographic areas and are affected by similar weather.

Figure 9-2. REAP Program Analysis: HDDs by Sample Group

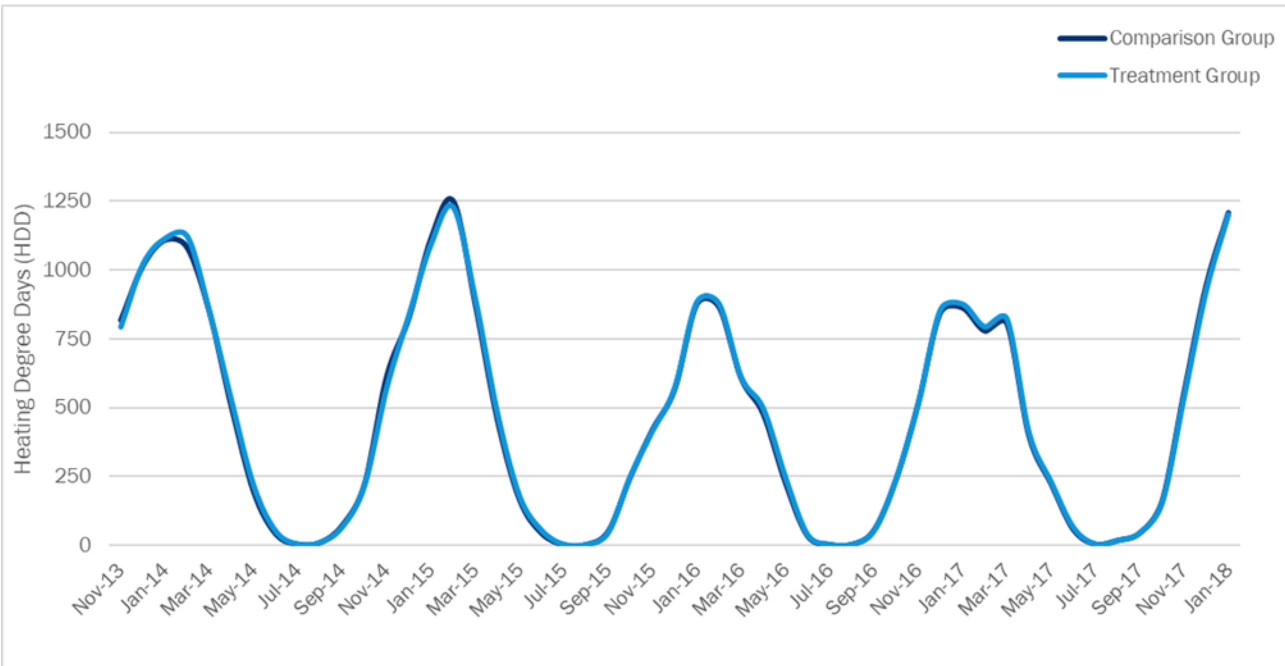
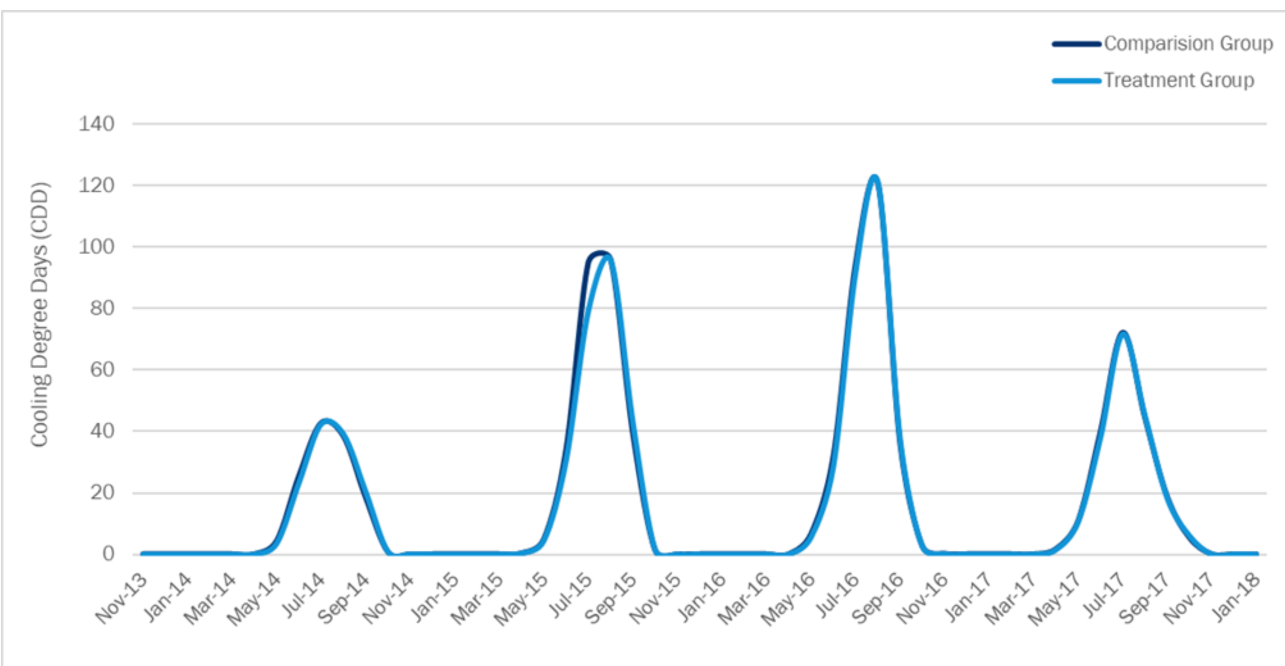


Figure 9-3. REAP Program Analysis: CDDs by Sample Group



Preliminary Assessment of Potential Savings

Before beginning the modeling process, it is useful to view some summary statistics for the pre- and post-participation periods for the treatment group. Specifically, for this type of analysis, we defined the pre- and post-participation periods as they were for the consumption analysis—that is, by ensuring that dividing points were the same for all variables and staggering those points over time. The most important variables in any consumption analysis, beyond the program intervention, are the kWh usage and the weather. These figures provide context for the more detailed analyses shown later. Table 9-6 shows the comparison of the pre- and post-participation kWh and weather variables for the treatment group. It shows that consumption dropped in the post-participation period compared to the pre-participation period. This drop could reflect program impacts, but could also be associated with weather. The post-participation period included a somewhat milder winter and a warmer summer than in the pre-participation period. Billing analysis is necessary to isolate program-related changes from other factors, such as the separate effects of CDDs and HDDs on consumption.

Table 9-6. REAP Program Analysis: Average Values of Key Variables by Time Period for 2015 Treatment Group

Variable	Statistic	Period	
		Pre-Participation	Post-Participation
Daily kWh	Mean	22.6	21.4
	SD	18.7	17.0
HDDs	Mean	435.5	400.0
	SD	395.4	375.2
CDDs	Mean	16.8	19.5
	SD	31.2	32.6

Statistical Method Used

We conducted a consumption analysis to determine ex post net program savings using a two-way LFER CDA model, using future participants as a comparison group during their pre-participation period. The final model includes terms for treatment (which is an indicator variable for participation in the program), time, and weather. The treatment effect is the change in energy use that is associated with participating in the program. We did not include terms for specific measures or end-uses. Most REAP participants received CFLs in 2016, so generating an estimate of the impact of that measure beyond the effect of participation in general was not feasible. The other measures were highly overlapping so that teasing out the effect of one from others installed at the same home was also not feasible.

We fit multiple models, testing the relative efficiency of each using R^2 and AIC to judge the models. Our models included variations of several kinds, including one- or two-way fixed effects, including a cross-participation variable in the model versus removing those who participated in other programs, interacting weather with the treatment and time variables, and interacting pre-participation consumption with weather and with months of the year. The model that performed best by our tests and that we judged most reasonable given weather patterns over time and engineering estimates was the same model that was reported for the last evaluation, which is a two-way fixed effects model, with household and time being fixed.

The following equation represents the final model:

Equation 9-1. Final Model Equation

$$ADC_{it} = B_h + B_{MY} + B_1 Treat_{it} + B_2 HDD_{it} + B_3 CDD_{it} + B_4 Post \cdot HDD_{it} + B_5 Post \cdot CDD_{it} +$$

$$B_{t1}MY \cdot PreADC + \varepsilon_{it}$$

where:

ADC_{it} = ADC (in kWh) for the billing period

$Treat$ = Indicator for treatment group in post-participation period (coded “0” if treatment group in pre-participation period or comparison group in all periods)

HDD = Average daily HDDs from NOAA

CDD = Average daily CDDs from NOAA

MY = Month-year indicator for each time period in the model

$PreADC$ = Pre-participation period ADC

B_h= Average household-specific constant

$B_{MY} = Average\ month - year\ constant$

B_1= Main program effect (change in ADC associated with being a participant in the post-participation period)

B_2= Increment in ADC associated with one unit increase in HDDs

B_3= Increment in ADC associated with one unit increase in CDDs

B_4= Increment in ADC associated with each increment increase of HDDs for participants in the post-participation program period (the additional program effect due to HDD)

B_5= Increment in ADC associated with each increment increase of CDD for participants in the post-participation program period (the additional program effect due to CDD)

B_t= Coefficients for each month-year period

B_{t1}= Coefficients for each month-year period for pre-participation period ADC

ε_{it} = Error term

Electric Savings Results

Table 9-7 shows the final model results. The model is meant to show changes in electricity use after participation in the REAP program, controlling for weather, time (reflected in the time constant), and the household characteristics (reflected in the account or household constant term) in both the treatment and comparison groups. The program effects term (Treatment) is negative, indicating that program participants did reduce energy consumption in the post-participation period (after controlling for time and weather). Because customers who participated in other PSEG Long Island energy efficiency programs were not included in this analysis, we can be confident that this reduced energy consumption is attributable to participation in the REAP program.

Table 9-7. REAP Program Consumption Analysis: Final Model

Predictor	Coefficient	Robust Std. Err.	T	P > |t|	95% Confidence Interval	
					Lower	Upper
Treatment	−2.535	0.3628	−6.99	<0.001	−3.2466	−1.8238
HDD	0.0024	0.0012	1.99	0.047	0.00298	0.00483
CDD	0.0615	0.0077	7.99	<0.001	0.04637	0.07654
Post-Participation Period HDD	0.0020	0.0008	2.5	0.013	0.00043	0.00358
Post-Participation Period CDD	−0.0085	0.0051	−1.67	0.095	−0.01856	0.00149
Constant	30.799	3.7324	8.25	<0.001	23.48075	38.11788

Due to the weather interaction terms in the model, it is necessary to do a post-estimation calculation of the total treatment effect. The terms in the model that interact the treatment variable with heating and cooling degree days capture part of the treatment effect that varies according to the weather. Thus, those terms must be included in the calculation of the total treatment impact. These effects were calculated by multiplying the treatment variable (0 or 1) by the actual mean heating and cooling degree days during the post-participation period.

Table 9-8. Adjusted Estimate of Daily Program Savings

ADC	Estimate	Std. Err.	T	P >|t|	90% Confidence Interval	
					Lower	Upper
(1)	−1.89	0.228153	−8.3	<0.001	−2.27	−1.52

The value of the estimate represents the kWh change in ADC given a one-unit change in the treatment status, i.e., treatment moving from 0 (pre-treatment) to 1 (post-treatment). These results can also be expanded to estimate the decrease in electricity usage over all participants for the evaluation period. There is a 90% probability, or confidence, that overall program savings fall between 1.52 kWh and 2.27 kWh per day per participant.

Consumption Analysis Compared to Expected Savings

Table 9-9 compares the observed (ex post) savings from the consumption analysis to the expected (ex ante) savings for these participants based on PSEG Long Island’s program planning estimates. The results of the comparisons are the associated realization rates. Evaluated participants in the REAP program saved an estimated 737 kWh per year. This compares to 343 expected savings, for a realization rate of 215%.

Table 9-9. Savings from the REAP Program Consumption Analysis Compared to Savings Expected from Program Planning Estimates

End-Use	N[a]	Observed Savings		Program Planning Savings[b]		Realization Rate
		Household Daily Savings	Household Annual Savings	Household Daily Savings	Household Annual Savings	
Overall Program	1,873	2.02	737	0.94	343	215%

[a] Number of program participants in consumption analysis treatment group. In total, our final REAP program data set includes 2,660 accounts. Approximately 67% of the total participant population was available for analysis after data preparation and cleaning. Table 9-5 presents the results of cleaning participation data, integrating clean billing data, and checking for sufficient billing data for each customer.

[b] The line loss factor is not applied to the program planning savings.

Appendix A. Ex Ante and Ex Post Net-to-Gross Values by Program and Measure

Below are the ex ante and ex post values used in the results shown in this report.

Program	Measure	Ex Post – Ex Ante NTGR Differences	Ex Post Values			Ex Ante – Calculated Program Values (all values calculated from gross and net values provided by the program)		
			FR	SO	NTGR	FR	SO	NTGR
Cool Homes	Traditional Split CAC Equipment (kW)	−38%	48%	0%	52%	10%	0%	90%
Cool Homes	Traditional Split CAC Equipment (kWh)	−38%	48%	0%	52%	10%	0%	90%
Cool Homes	Traditional Split CAC – QI (kW)	59%	0%	49%	149%	10%	0%	90%
Cool Homes	Traditional Split CAC – QI (kWh)	51%	0%	41%	141%	10%	0%	90%
Cool Homes	Traditional Split CAC – Total (kW)	−6%	*	*	84%	10%	0%	90%
Cool Homes	Traditional Split CAC – Total (kWh)	−25%	*	*	65%	10%	0%	90%
Cool Homes	GSHP (kW)	0%	0%	0%	100%	0%	0%	100%
Cool Homes	GSHP (kWh)	0%	0%	0%	100%	0%	0%	100%
Cool Homes	ASHP – Equipment (kW)	0%	10%	0%	90%	10%	0%	90%
Cool Homes	ASHP – Equipment (kWh)	0%	10%	0%	90%	10%	0%	90%
Cool Homes	ASHP – Quality Installation	0%	10%	0%	90%	10%	0%	90%
Cool Homes	Ductless Mini-Split (kW)	0%	10%	0%	90%	10%	0%	90%
Cool Homes	Ductless Mini-Split (kWh)	0%	10%	0%	90%	10%	0%	90%
HPDI	Lighting (kW)	−48%	*	*	52%	0%	0%	100%
HPDI	Lighting (kWh)	−44%	*	*	56%	0%	0%	100%
HPDI	Non-Lighting (kW)	3%	*	*	103%	0%	0%	100%
HPDI	Non-Lighting (kWh)	7%	*	*	107%	0%	0%	100%
HPwES	All Measures (kW)	-26%	*	*	74%	0%	0%	100%
HPwES	All Measures (kWh)	-25%	*	*	75%	0%	0%	100%
EEP	ENERGY STAR Refrigerator	0%	20%	10%	90%	20%	10%	90%
EEP	ENERGY STAR Dehumidifier	−52%	67%	0%	33%	30%	15%	85%
EEP	Room A/C	0%	30%	25%	95%	30%	25%	95%
EEP	ENERGY STAR Standard CFLs	0%	30%	4%	74%	45%	0%	55%
EEP	ENERGY STAR Specialty CFLs	0%	25%	20%	95%	45%	0%	55%
EEP	Solid State Lighting	0%	*	*	55%	45%	0%	55%
EEP	Refrigerator Recycle	−9%	52%	0%	48%	43%	0%	57%
EEP	Pool Pumps	0%	20%	10%	90%	20%	10%	90%
EEP	Smart Power Strips	0%	0%	0%	100%	0%	0%	100%
EEP	Room A/C Recycle	−9%	52%	0%	48%	43%	0%	57%

Program	Measure	Ex Post – Ex Ante NTGR Differences	Ex Post Values			Ex Ante – Calculated Program Values (all values calculated from gross and net values provided by the program)		
			FR	SO	NTGR	FR	SO	NTGR
EEP	Dehumidifier Recycle	−9%	52%	0%	48%	43%	0%	57%
EEP	Ceiling Fans	0%	30%	0%	70%	30%	0%	70%
EEP	Super-Efficient Dryer	0%	20%	10%	90%	20%	10%	90%
EEP	ENERGY STAR Room Air Purifiers	0%	30%	15%	85%	30%	0%	70%
CEP - Lighting	Comprehensive Lighting (kW)	-20.13%	30%	1.87%	71.87%	*	*	92%
CEP - Lighting	Comprehensive Lighting (kWh)	-20.45%	30%	1.55%	71.55%	*	*	92%
CEP - Lighting	Fast Track Lighting (kW)	-20.13%	30%	1.87%	71.87%	*	*	92%
CEP - Lighting	Fast Track Lighting (kWh)	-20.45%	30%	1.55%	71.55%	*	*	92%
CEP - Lighting	Prescriptive Lighting (kW)	-20.13%	30%	1.87%	71.87%	*	*	92%
CEP - Lighting	Prescriptive Lighting (kWh)	-20.45%	30%	1.55%	71.55%	*	*	92%
CEP - Non-Lighting	HVAC (kW)	-18.13%	30%	1.87%	71.87%	*	*	90%
CEP - Non-Lighting	HVAC (kWh)	-18.45%	30%	1.55%	71.55%	*	*	90%
CEP - Non-Lighting	Compressed Air (kW)	-19%	30%	1.87%	71.87%	*	*	91%
CEP - Non-Lighting	Compressed Air (kWh)	-19%	30%	1.55%	71.55%	*	*	91%
CEP - Non-Lighting	Refrigeration (kW)	-28%	30%	1.87%	71.87%	*	*	100%
CEP - Non-Lighting	Refrigeration (kWh)	-28%	30%	1.55%	71.55%	*	*	100%
CEP - Non-Lighting	Refrigeration (vending) (kW)	-27%	30%	1.87%	71.87%	*	*	99%
CEP - Non-Lighting	Refrigeration (vending) (kWh)	-27%	30%	1.55%	71.55%	*	*	99%
CEP - Non-Lighting	Motors and VFDs (kW)	8%	30%	1.87%	71.87%	*	*	64%
CEP - Non-Lighting	Motors and VFDs (kWh)	8%	30%	1.55%	71.55%	*	*	64%
CEP - Non-Lighting	Building Envelope (kW)	-28%	30%	1.87%	71.87%	*	*	100%
CEP - Non-Lighting	Building Envelope (kWh)	-28%	30%	1.55%	71.55%	*	*	100%
CEP - Non-Lighting	Thermal Energy Storage (kW)	0%	*	*	100%	*	*	100%
CEP - Non-Lighting	Thermal Energy Storage (kWh)	0%	*	*	100%	*	*	100%
CEP - Custom	(kW)	-18.13%	30%	1.87%	71.87%	*	*	90%
CEP - Custom	(kWh)	-18.45%	30%	1.55%	71.55%	*	*	90%
REAP	All Measures (kW)	+37%	*	*	137%**	0%	0%	100%
REAP	All Measures (kWh)	+115%	*	*	215%**	0%	0%	100%

* FR and SO are unknown or not applicable, usually because NTGR was back-calculated, calculated through billing analysis, or came from PSEG Long Island's program planning numbers.
** These numbers are realization rates calculated through billing analysis.

Appendix B. 2017 Verified Ex ante Savings

The evaluation team presented the following to PSEG Long Island in a memorandum on January 31st, 2018 describing the initial approach to validating 2017 ex ante savings estimates.

Background

PSEG Long Island has requested that the Opinion Dynamics evaluation team provide "verified ex ante" demand savings as part of its evaluation of PSEG Long Island's 2017 energy efficiency and renewable energy programs. This memo defines "verified ex ante" savings and presents the 2017 verified ex ante savings for each program.

Definition of Verified Ex Ante

Beginning with program year 2015, PSEG Long Island has requested annually that Opinion Dynamics and ERS to develop a verified ex ante savings metric as a comparison to the established annual savings goals. To allow for direct comparison, the methods and assumptions used to develop the verified ex ante savings values are consistent with the methods and assumptions used by PSEG Long Island to develop their annual plan for program savings, which are the basis of the annual savings goals. In other words, for each program measure documented in PSEG Long Island's tracking data in 2017, Opinion Dynamics and ERS estimated the associated savings using the same methods and assumptions used by PSEG Long Island in its program planning and goal setting process for the 2017 program year.

It should be noted that the *verified ex ante* savings presented below are not equivalent to the *evaluated net savings* and *ex post net savings* developed each year as part of the evaluation team's annual impact evaluation of the PSEG Long Island's efficiency and renewable energy programs, which we will be delivering by June 1st. The evaluation team's efforts to develop 2017 *evaluated* and *ex post* savings estimates for the 2017 program year are ongoing. The reported verified ex ante savings result from the evaluation team's efforts to verify that the ex ante savings claimed by each program are developed using methods (i.e., calculations, assumptions, and net-to-gross factors) that are consistent with those used in the planning and goal setting process.

Table B-10 below summarizes our 2017 verified ex ante savings.

Table B-10. Summary of 2017 Verified Ex Ante Savings Goals

Program	2017 Net Savings Goals		Ex Ante Net Savings		Verified Ex Ante Savings		Verified Ex Ante RR	
	MWh	MW	MWh	MW	MWh	MW	MWh	MW
Total Commercial[1]	*95,005*	*23.0*	*103,641*	*26.0*	*101,985*	*25.6*	*98%*	*98%*
Energy Efficient Products[2]	112,884	15.3	138,464	18.5	138,917	18.6	100%	101%
Cool Homes	2,693	1.65	2,703	2.80	2,705	2.81	100%	100%
Residential Energy Affordability Partnership	905	0.337	644	0.277	645	0.276	100%	100%
Home Performance[3]	1,619	0.540	3,055	2.59	3,054	2.59	100%	100%
Home Energy Management[4]	30,179	N/A	11,145	N/A	11,104	N/A	100%	N/A
Total Residential	*148,280*	*17.8*	*156,010*	*24.1*	*156,425*	*24.3*	*100%*	*100%*
Energy Efficiency Total	*243,285*	*40.8*	*259,651*	*50.2*	*258,410*	*49.8*	*100%*	*99%*
Renewable Total	*15,000*	*5.98*	*28,065*	*11.4*	*27,995*	*11.4*	*100%*	*100%*
Total Portfolio	*258,285*	*46.8*	*287,716*	*61.6*	*286,405*	*61.3*	*100%*	*99%*

Note: numbers may not sum due to rounding

1) **Commercial Efficiency Program (CEP):** The evaluation team performed desk reviews for CEP lighting projects and found minor discrepancies with one Comprehensive lighting project where the calculation for measure code L820 overstated energy savings Additionally, we noted several prescriptive deemed savings values in LM Captures that incorrectly applied waste heat factors twice. We also found that the net-to-gross ratio of compressed air measures in LM Captures database (93%) was higher than the CEP planning net-to-gross ratio (91%). Each of these discrepancies led to slightly lower verified ex ante savings for both MWh and MW. Based on a review of claimed savings and tracked inputs, the evaluation team verified the ex ante savings for refrigeration and building envelope measures. These measures featured limited planning documentation and contribute to a relatively small portion of the overall CEP savings, and therefore were assigned a 100% verified ex ante RR. Verified savings for CEP custom projects utilize a realization rate from desk reviews of a sample of custom projects developed for the 2014 evaluation. The evaluation team did not perform any verification of 2017 custom projects.
2) **Energy Efficient Products (EEP):** The slight increase in verified ex ante MW savings for the EEP program is due to a discrepancy in savings assumptions for the efficient clothes dryer measures. Verified ex ante savings rely on the gross savings assumptions for heat pump dryers and electric resistance dryers from the 2017 EEP Goals spreadsheet. Ex ante savings were calculated using the gross savings assumptions from the 2017 Year-End EEP Tracking spreadsheet. The deemed savings assumptions from the EEP Goals spreadsheet (used for verified ex ante) were larger than the deemed savings assumptions from the EEP Tracking Spreadsheet (used for ex ante) resulting in the increase in verified ex ante savings for this measure. Savings assumptions in the EEP Tracking and Goals files were identical for all other measures.
3) **Home Performance Programs:** The evaluation team was unable to perform a comprehensive verification of ex ante savings for Home Performance with Energy Star projects, as well as duct sealing measures within the Home Performance Direct Install (HPDI) program, due to limited visibility into the program contractors' software-based savings estimates. Instead, the evaluation team reviewed the per-project and per-measure savings to ensure they were reasonable and verified that 2017 savings were in line with prior program years. For duct sealing measures under the HPDI program, the evaluation team confirmed that a factor of 0.5 was appropriately applied to the ex ante gross demand and energy savings to reflect billing analysis results from prior evaluation years.
4) **Home Energy Management (HEM) Program:** The evaluation team used the same methodology to calculate verified ex ante savings that PSEG Long Island used for claimed ex ante savings. However, the evaluation team's review of participation data provided by the program vendor showed slightly fewer customers receiving one or two paper reports than the number used for ex ante calculations. This difference in the number of reports led to the lower verified ex ante energy savings.

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