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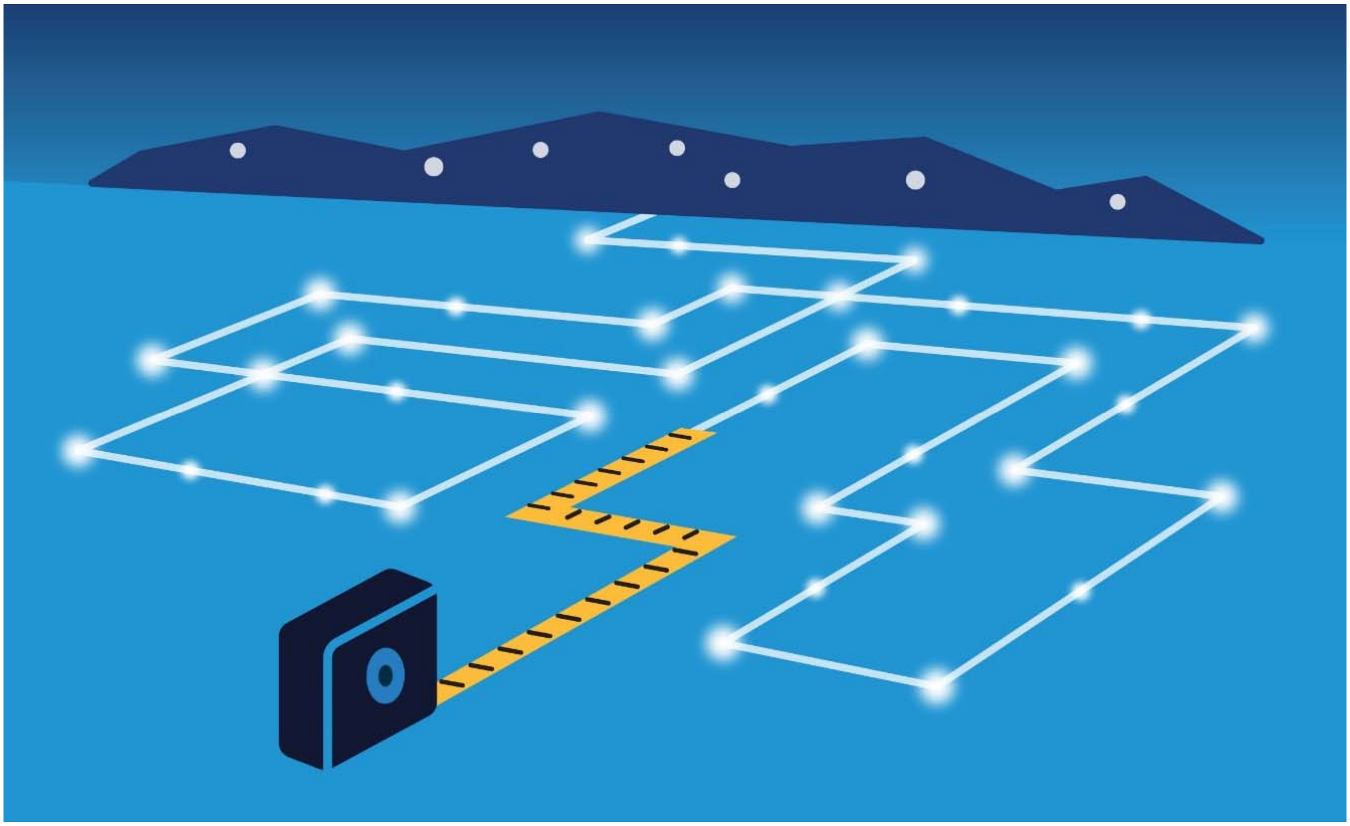


Energy Efficiency and Renewable Energy Portfolios

2016 Annual Evaluation Report
(Volume II – Program Guidance Document)

Prepared for:
PSEG LONG ISLAND
We make things work for you.

Prepared by:
OPINION DYNAMICS CORPORATION

May 30, 2017

With Subcontractors:

Table of Contents

1. Introduction 1
   1.1 Key Definitions 1
   1.2 Summary of Gross and Net Impact Methods 3
   1.3 Summary of Evaluated Demand and Energy Net Impacts 4
   1.4 Summary of Cost-Effectiveness Results 4
   1.5 Summary of Economic Benefits Results 7
2. Commercial Efficiency Programs 10
3. The Energy Efficient Products Program 25
4. The Cool Homes Program 35
5. The Residential Energy Affordability Partnership Program 41
6. The Home Performance Direct Program 46
7. The Home Performance with ENERGY STAR Program 51
8. The Solar Photovoltaic Program 56
9. Detailed Methods 60
   9.1 Overview of Data Collection 60
   9.2 Overview of Analytical Methods 60
   9.3 Commercial Efficiency Programs 60
   9.4 Energy Efficient Products Program 66
   9.5 Cool Homes 66
   9.6 Data Cleaning and Model Development for Billing Analyses of REAP, HPD, and HPwES 66
   9.7 REAP Program Estimation of Savings Using Billing Analysis 70
   9.8 HPD/HPwES Estimation of Savings Using Billing Analysis 76
   9.9 Cost-Effectiveness Method 82
   9.10 Economic Impact Method 84

Appendix A. Ex Ante and Ex Post Net-to-Gross Values by Program and Measure 93

Table of Tables

Table 1-1. Portfolio Evaluated Impacts (Used for Comparison to Goals) 4

Table 1-2. Cost-Effectiveness for the Energy Efficiency and Renewable Energy Portfolios 5

Table 1-3. Levelized Costs for the Energy Efficiency and Renewable Energy Portfolios 6

Table 1-4. Economic Impact of 2016 Energy Efficiency Portfolio Investments 8

Table 1-5. Economic Impact of 2016 Renewable Energy Portfolio Investments 9

Table 2-1. Ex Ante Program Performance against Goals 10

Table 2-2. CEP Savings from Lighting and Non-Lighting Measures 11

Table 2-3. Year-over-Year Participation Rate across Rate Classes 13

Table 2-4. Year-over-Year Per-Project Savings across Rate Classes 13

Table 2-5. CEP Net Impacts for Goal Comparison 16

Table 2-6. CEP Net Impacts for Cost-Effectiveness 17

Table 2-7. Prescriptive Program Component: Comparison of Ex Ante and Evaluated Net Savings 18

Table 2-8. Prescriptive Program Component NTGRs 20

Table 2-9. Prescriptive Program Component: Comparison of Ex Ante and Ex Post Net Savings 20

Table 2-10. Existing Retrofit Program Component: Comparison of Ex Ante and Evaluated Net Savings 21

Table 2-11. Existing Retrofit Program Component: Comparison of Ex Ante and Ex Post Net Savings 22

Table 2-12. Custom Program Component: Comparison of Ex Ante and Evaluated Net Savings 22

Table 2-13. Custom Program Component: Comparison of Ex Ante and Ex Post Net Savings 23

Table 3-1. Energy Efficient Products Program Net Impacts for Goal Comparison 31

Table 3-2. NTGRs for EEP Program 33

Table 3-3. EEP Program Net Impacts for Cost-Effectiveness 34

Table 4-1. Number of Cool Home Program Systems by Measure 35

Table 4-2. Difference in Number of Cool Home Program Measures Installed, 2014–2016 36

Table 4-3. Equipment-Only and Quality-Installation Units by Month in 2016 36

Table 4-4. Cool Homes Program Net Impacts for Goal Comparison 38

Table 4-5. Cool Homes Program Net Impacts for Cost-Effectiveness 40

Table 4-6. Cool Homes Program NTGRs 40

Table 5-1. REAP Program Net Impacts for Comparison to Goals and Cost-Effectiveness 41

Table 5-2. REAP Program Installations by Program Year for Billing Analysis Groups 43

Table 5-3. Savings from the REAP Program Billing Analysis Compared to Ex Ante Savings Estimates 43

Table 5-4. REAP Program Measure-Specific Net Impacts: Engineering Approach 44

Table 6-1. HPD Program Net Impacts for Goal Comparison and Cost-Effectiveness 46

Table 6-2. Comparison of HPD Program Installed Measures for Participants in Billing Analysis 47

Table 6-3. Savings from HPD and HPwES Programs Billing Analysis Compared to Ex Ante Savings Estimates 48

Table 6-4. HPD Program Measure-Specific Net Impacts: Engineering Approach 49

Table 7-1. HPwES Program Net Impacts for Goal Comparison and Cost-Effectiveness 51

Table 7-2. Comparison of HPwES Program Installed Measures for Participants in Billing Analysis 52

Table 7-3. Savings from HPD and HPwES Programs Billing Analysis Compared to Ex Ante Savings Estimates 53

Table 7-4. HPwES Program Measure-Specific Net Impacts: Engineering Approach 53

Table 8-1. NY-Sun MW Block Structure for Long Island 56

Table 8-2. Solar PV Residential and Nonresidential Net Impacts for Goal Comparison 58

Table 8-3. Solar PV Residential and Nonresidential Net Impacts for Cost-Effectiveness 59

Table 9-1. Primary Analytical Methods Used in 2016 Evaluation 60

Table 9-2. CEP Prescriptive Lighting, Existing Retrofit Lighting, and Existing Retrofit Non-Lighting Engineering Review Sample Design 63

Table 9-3. Strata Boundaries for Stratified Sample Design 64

Table 9-4. REAP Program Participation and Billing Data Cleaning Steps 71

Table 9-5. REAP Program Analysis – Average Values of Key Variables by Time Period for 2015 Treatment Group 74

Table 9-6. REAP Program Billing Analysis: Final Model 75

Table 9-7. Adjusted Estimate of Daily Program Savings 76

Table 9-8. Savings from the REAP Program Billing Analysis Compared to Savings Expected from Program-Planning Estimates 76

Table 9-9. HPD/HPwES Participation and Billing Data Cleaning Steps 77

Table 9-10. HPD/HPwES Program Analysis: Average Values of Key Variables by Time Period for 2015 Treatment Group 79

Table 9-11. HPD/HPwES Program Performance Billing Analysis: Final Model....81

Table 9-12. Adjusted Estimate of Daily Program Savings....81

Table 9-13. Savings from HPD/HPwES Program Billing Analysis Compared to Savings Expected from Program-Planning Estimates....82

Table 9-14. UCT Algorithm Inputs....83

Table 9-15. Evaluated Program Effects 85

Table of Figures

Figure 1-1. 2016 PSEG Long Island Expenditures for the Energy Efficiency Portfolio 7

Figure 1-2. 2016 PSEG Long Island Expenditures for the Renewable Energy Portfolio 7

Figure 2-1. CEP Savings from Lighting and Non-Lighting Measures 12

Figure 3-1. Percent of Total Program Bulbs Rebated by Type: 2010–2016 27

Figure 3-2. Percent of Rebated LED Bulbs by Bulb Type and Pack Size 28

Figure 3-3. Percent of Specialty LED Sales by Bulb Shape 29

Figure 3-4. Pool Pumps Rebated by Type: 2010–2016 30

Figure 4-1. Comparison of Installations by Program Offering in 2015 and 2016 37

Figure 8-1. Solar PV Projects and Associated Savings by Sector 57

Figure 8-2. PV Systems Installed per Year by Purchase Type (2012–2016) 57

Figure 9-1. Ratio Adjustment Algorithm 65

Figure 9-2. REAP Program Analysis – Baseline kWh by Sample Group in Analysis 72

Figure 9-3. REAP Program Analysis – HDDs by Sample Group 73

Figure 9-4. REAP Program Analysis – CDDs by Sample Group 73

Figure 9-5. Final Model Equation 74

Figure 9-6. Home Performance Analysis – Baseline kWh by Sample Group 78

Figure 9-7. Home Performance Analysis – HDDs in the Pre-Participation Period by Sample Group 78

Figure 9-8. Home Performance Analysis – CDDs in the Pre-Participation Period by Sample Group 79

Figure 9-9. Final Model Equation 80

Figure 9-10. Visual Model of Economic Impacts of the PSEG Long Island Portfolio 89

1. Introduction

Volume II of the 2016 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 its 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 of 2015, PSEG Long Island transitioned the implementation of the Energy Efficiency Portfolio to its subcontractor, Lockheed Martin. PSEG Long Island continues to implement the Renewable Energy Portfolio. This evaluation covers the period from January 1, 2016 to December 31, 2016.

This section includes a comparison of the estimated demand and energy impacts determined through our evaluation (evaluated and ex post impacts) to the expected impacts used for program tracking (ex ante impacts). The evaluation team used the most detailed measure-level data available from program-tracking systems as the basis for our estimation of evaluated and ex post impacts and measure-level ex ante estimates. We provide two specific comparisons. The first is between the ex ante net savings and the evaluated net savings calculated by the evaluation team using detailed measure-level tracking information; the ratio of these two numbers is defined as the realization rate. (This information matches the data shown in Volume I and is compared for goal attainment purposes.) The second comparison is between the same ex ante net savings and the ex post net savings; the ratio of these two numbers is defined as the cost-effectiveness realization rate.

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 2016 implementation year. We have also included any measure-specific recommendations for updating the gross energy and demand savings calculations.
- Section 9 provides a summary of the study methodology, 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, coincident factors for demand, and waste-heat factors and installation rate for lighting. Gross impacts are the demand and energy that power plants do not generate due to program-related actions taken by participants.[1]

[1] While this evaluation includes line losses, coincidence factors, and installations rates when estimating gross impacts, PSEG Long Island does not include these in its gross impact estimates.

- **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. 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 the 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 algorithm:

$$NTGR = 1 - FR + SO$$

- **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.
- **Evaluated Net Savings:** The net savings attributed to the program for purposes of comparison to program savings goals. 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.

Within the economic analysis, three key terms are used:

- **Direct Impacts:** Direct impacts are equal to the localized portion of direct spending of the PSEG Long Island programs. For example, direct impacts include money (and associated increases in employment) supplied to contractors to install energy efficiency measures in homes and businesses, such as weatherization contractors installing insulation in homes for the Home Performance with ENERGY STAR® (HPwES) program.
- **Indirect Impacts:** Indirect impacts are determined by the amount of the direct impacts spent within Long Island on supplies, services, labor, and taxes. For example, indirect impacts include money (and associated employment) transferred to local businesses by contractors for supplies needed to install energy efficiency measures, such as if a local wholesaler of HVAC equipment increases sales and adds additional workers to help meet the growing demand for a company's products.
- **Induced Impacts:** Induced impacts are associated with the effects of the direct and indirect impacts on household and business proprietors' income. For example, money expended on Long Island by households or business proprietors benefiting from energy efficiency savings and direct and indirect program spending, such as if an employee of a weatherization contractor uses his or her income (increased by work through the HPwES program) to purchase a car, which stimulates business at the local car dealership.

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 billing analyses for the HPwES program, the Home Performance Direct (HPD) program, and the Residential Energy Affordability Partnership (REAP) program. For the Commercial Efficiency 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 2016 custom projects.

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 goal attainment, the benefit/cost assessment, and the economic impact assessment. Based on the specific requirements of each assessment, we developed the two separate net savings estimates described below.

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 on Long Island required to satisfy energy demand forecasted at that time. As such, performance relative to the annual capacity savings goals is a critically important performance metric for PSEG Long Island's programs. PSEG Long Island derived its annual savings goals 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 "evaluated net savings" estimates for each Energy Efficiency and Renewable Energy program for the purposes of assessing goal attainment. This approach is consistent with the approach applied by utilities in nearly half of all states with energy efficiency program offerings. We calculated evaluated net savings by applying PSEG Long Island's planning assumptions for NTGR to the gross demand and energy savings estimated through our evaluation.

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. We calculated ex post net savings by applying ex post NTGRs to evaluated gross impact estimates. For 2016, we had no new primary data collection or activities with which to update previous NTGR values. As such, all ex post NTGRs are identical to 2015 values. Both the planning NTGR values (applied within the evaluated savings) and ex post NTGR values (applied within the cost-effectiveness savings) are presented in Appendix A.

1.3 Summary of Evaluated Demand and Energy Net Impacts

Overall, our evaluation found that evaluated net savings were closely aligned with program-tracking estimates. The realization rates in Table 1-1 provide a comparison of evaluated net 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		Evaluated Net Savings		Realization Rate	
	MW	MWh	MW	MWh	MW	MWh
Energy Efficiency Portfolio						
Commercial Efficiency Programs	**26.2**	**108,403**	**25.3**	**105,456**	**97%**	**97%**
Residential Programs						
Energy Efficient Products (EEP)	24.7	189,198	25.1	191,172	101%	101%
Cool Homes	3.0	2,458	3.2	2,611	106%	106%
REAP	0.6	1,491	0.6	1,493	102%	100%
HPD	2.8	3,604	1.5	2,459	54%	68%
HPwES	0.5	391	0.3	267	48%	68%
Subtotal Residential	**31.6**	**197,143**	**30.6**	**198,003**	**97%**	**100%**
Total Energy Efficiency Portfolio (Commercial Efficiency and Residential)	**57.8**	**305,546**	**55.9**	**303,459**	**97%**	**99%**
Renewable Energy Portfolio	28.9	69,939	28.4	66,384	98%	95%
Total Energy Efficiency and Renewable Energy Portfolios	**86.7**	**375,485**	**84.27**	**369,843**	**97%**	**98%**

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[2] (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 UCT test benefit/cost ratio is 3.1 for the Energy Efficiency Portfolio and 15.5 for the Renewable Energy Portfolio, indicating that portfolio benefits exceed PA costs in both cases (a benefit/cost ratio greater

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

than 1 indicates that portfolio benefits outweigh costs). The portfolio-level SCT values are 1.7 and 0.89 for the Energy Efficiency and Renewable Energy portfolios, respectively.

The UCT was less than 1 for four programs in 2016: Cool Homes, REAP, HPD, and HPwES. The cost-effectiveness of the Cool Homes program decreased from 2.0 in 2015 to 0.90 in 2016. This change resulted from lower program savings despite costs declining somewhat in 2016. The cost-effectiveness of the HPwES program decreased from 0.86 in 2015 to 0.30 in 2016. This shift resulted from increased costs and decreased savings compared to the prior year. The HPD program achieved a cost effectiveness of 0.96, which was an improvement from the previous year when the program cost effectiveness was 0.63. While the REAP program UCT of 0.62 is below the cost-effectiveness threshold of 1, this ratio is similar to recent years. Cost ineffectiveness is not unusual for low-income programs, which typically are not required to be cost-effective.

The same set of programs, Cool Homes, REAP, HPD, HPwES, showed benefit-cost ratios of less than 1 in the SCT in addition to the UCT. The renewables portfolio also had a SCT benefit-cost ratio of less than 1, largely because this test accounts for the costs that participants bear for installing renewables.

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

	Utility Cost Test			Societal Cost Test		
Program	NPV Benefits	Costs	Benefit/ Cost Ratio	Net Present Value (NPV) Benefits	Costs	Benefit/ Cost Ratio
Energy Efficiency Portfolio						
Commercial Efficiency Programs	$133,741,133	$36,517,897	3.7	$133,741,133	$49,667,294	2.7
Residential Programs						
EEP	$73,407,001	$16,734,335	4.4	$73,407,001	$38,001,435	1.9
Cool Homes	$5,806,840	$6,437,154	0.90	$5,806,840	$9,614,045	0.60
REAP	$1,818,287	$2,925,529	0.62	$1,818,287	$2,949,269	0.62
HPD	$4,139,154	$4,298,636	0.96	$4,171,385	$4,300,482	0.97
HPwES	$1,110,614	$3,760,422	0.30	$1,256,602	$21,441,184	0.06
Subtotal Residential	$86,281,896	$34,156,076	2.5	$86,460,115	$76,306,415	1.1
Total Energy Efficiency Portfolio	$220,023,029	$70,673,974	3.1	$220,201,248	$125,973,709	1.7
Renewable Energy Portfolio	$214,850,043	$13,889,388	15.5	$214,850,043	$242,630,811	0.89
Total Energy Efficiency and Renewable Energy Portfolios	$434,873,072	$84,563,361	5.1	$435,051,291	$368,604,521	1.2

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.

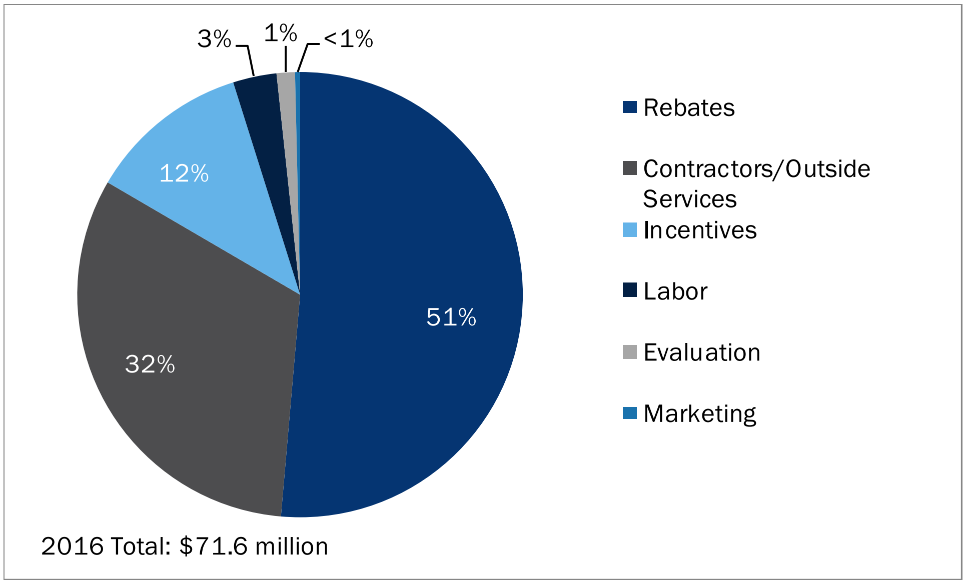
Table 1-3 provides the levelized costs for each program and for each portfolio separately based on the UCT. The levelized costs of capacity and energy for the Energy Efficiency Portfolio savings is $197.48/kW-yr and $0.045/kWh—less than the comparable costs of alternative supply-side resources. Likewise, the levelized costs of capacity and energy associated with PSEG Long Island's investment in the Renewable Energy Portfolio is $33.52/kW-yr and $0.014/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	$/kW-yr
Energy Efficiency Portfolio			
Commercial Efficiency Programs	$36,517,897	$0.040	$167.80
Residential Programs			
EEP	$16,734,335	$0.027	$153.42
Cool Homes	$6,437,154	$0.598	$428.28
REAP	$2,925,529	$0.308	$784.48
HPD	$4,298,636	$0.272	$452.70
HPwES	$3,760,422	$1.360	$1,433.09
Subtotal Residential Programs	$34,156,076	$0.051	$242.86
Subtotal Energy Efficiency Portfolio	$70,673,974	$0.045	$197.48
Renewable Energy Portfolio	$13,889,388	$0.014	$33.52
Total	$84,563,361	$0.033	$109.67

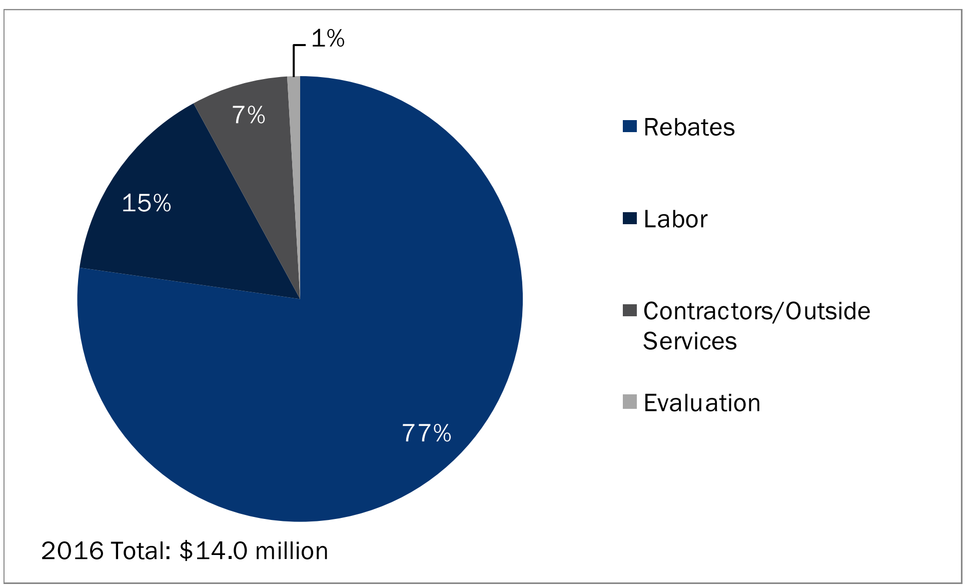
PSEG Long Island's expenditures varied for each program. Figure 1-1 and Figure 1-2 show the respective breakouts of spending related to the Energy Efficiency and Renewable Energy portfolios by type of expenditure.

Figure 1-1. 2016 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. 2016 PSEG Long Island Expenditures for the Renewable Energy Portfolio



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 2016 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 2016 and for the 10-year period of 2016 to 2025. To account for expected inflation and the assumed increasing cost of electricity, the tables show the results as NPV using the discount rate of 4.17% used in PSEG Long Island's supply-side planning and the cost-effectiveness analysis.

Over 10 years, the 2016 investments in the Energy Efficiency Portfolio are expected to return $170.6 million in total economic benefits to the regional economy (in 2016 dollars), with an employment benefit of 1,225 new full-time equivalent employees (FTEs)[3] over that time period.

Table 1-4. Economic Impact of 2016 Energy Efficiency Portfolio Investments

2016 Energy Efficiency Portfolio Investments	2016 Economic Impact	2016-2025 Economic Impact (NPV[a])
Economic Impact		
Total Economic Output (millions)	$90.4	$170.6
Direct Effect	$78.6	$78.6
Indirect & Induced Effects	$11.8	$92.0
Employment (FTE)	642	1,225
Impact per $1M Investment		
2016 Program Investment (millions)	$71.6	$71.6
Total Economic Output in M per $1M Investment	$1.3	$2.4
Employment (FTE) per $1M Investment	9.0	17.1

[a] Using nominal discount rate of 4.17%, based on PSEG Long Island energy-supply cost assumptions.

The investments in the Energy Efficiency Portfolio resulted in a slightly larger total economic output in 2016 ($90.4 million) than in 2015 ($77.5 million), despite program expenditures remaining essentially constant as compared to 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 Efficiency Long Island portfolio, including rebate and incentive levels
- Changes to the Long Island economy and how economic impacts diffuse through different sectors

Over 10 years, the 2016 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 $159.0 million in total economic benefits to the regional economy (in 2016 dollars), with an employment benefit of 1,042 new FTEs over that time period. Note that the indirect and induced effect of the portfolio was negative for 2016, but these effects become positive over 10 years as the benefits of the installed systems continue through their 20- to 25-year expected life.

[3] 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 1-5. Economic Impact of 2016 Renewable Energy Portfolio Investments

2016 Renewable Energy Portfolio Investments	2016 Economic Impact	2016-2025 Economic Impact (NPV[a])
Economic Impact		
Total Economic Output (millions)	$78.4	$159.0
Direct Effect	$139.5	$139.5
Indirect & Induced Effects	-$61.1	$19.5
Employment (FTE)	433	1,042
Impact per $1M Investment		
2016 Program Investment (millions)	$3.2	$3.2
Total Economic Output in M per $1M Investment	$24.3	$49.2
Employment (FTE) per $1M Investment	134.0	322.8

[a] Using nominal discount rate of 4.17%, based on PSEG Long Island energy-supply cost assumptions.
[b] Program investment does not include $10,789,482 in solar funding from NYSERDA NY-Sun. Economic impacts, however, do include the benefits of these projects.

Similar to the 2015 results, 2016 spending on PSEG Long Island's Renewable Energy Portfolio resulted in much greater benefits to the Long Island economy than in earlier program years. This difference is driven primarily by two factors: the higher number of solar PV systems installed compared to the years 2012-2014 and $10.8 million in funding through NYSERDA's NY-Sun Initiative. The effect of NYSERDA's funding was especially pronounced because it positively contributed to the direct impact of the program, but did not incur a corresponding renewables charge to PSEG Long Island ratepayers. Additionally, the portfolio continued to benefit from the falling price of PV modules.

2. Commercial Efficiency Programs

PSEG Long Island's CEP cater 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 2016, PSEG Long Island delivered the CEP through the following avenues:

- Prescriptive: Includes predefined new construction, as well as replacement and retrofit measures. Incentives amounts are fixed for the qualifying measures.
- Existing Retrofit: Includes retrofit measures and relies on a predefined menu of measures installed at the existing site to determine savings. Incentives amounts are fixed for the qualifying measures.
- Fast Track: Aimed at reaching small business customers, this program is limited to a subset of commercial customers.[4] Measure offerings are limited to a select mix of LED lighting products and lighting controls. Rebates are prescriptive and capped at $5,000. The program participation process is easy and streamlined and is designed to address key barriers to participation among small business customers, namely, lack of time and the hassle factor.
- 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.

In addition to these core components, PSEG Long Island's 2016 CEP portfolio also 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 2016, Lockheed Martin oversaw the design and implementation of all CEP components.

Program Performance and Participation Trends

PSEG Long Island's CEP performed well in 2016, achieving 94% of the peak demand goal and 98% of the energy savings 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	28.0	110,580
Ex Ante Net Savings	26.2	108,403
% of Goal	94%	98%

Existing Retrofit projects continued to be the primary source of demand and energy savings. As can be seen in Table 2-2, Existing Retrofit projects accounted for 79% of ex ante net demand savings and 77% of ex ante net energy savings. The CEP continued to rely primarily on lighting measures for savings. Lighting measure

[4] Nonresidential rate 285 customers are excluded from participating under this program.

installations across all program components accounted for 93% of the ex ante net demand savings and 94% of ex ante net energy savings.[5]

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

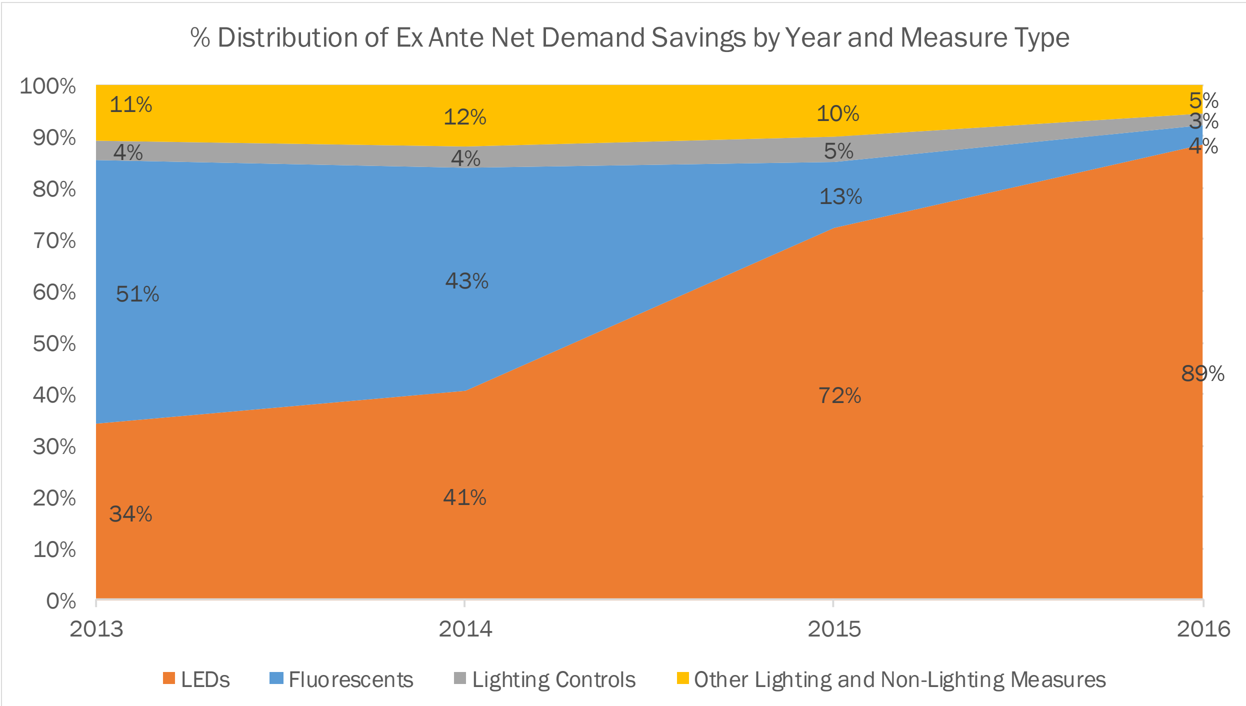
Program Component	End Use	Ex Ante Net Savings	
		% MW	% MWh
Prescriptive	Lighting	14%	15%
	Non-Lighting	3%	4%
Existing Retrofit	Lighting	76%	76%
	Non-Lighting	3%	1%
Custom	Lighting	3%	3%
	Non-Lighting	1%	1%
Total		100%	100%

LED lighting continued to increase in prominence in 2016, primarily at the expense of fluorescent lighting measures. As can be seen in Figure 2-1, LEDs grew from 34% of ex ante net demand savings in 2013 to 89% in 2016.[6] This is, in part, due to changes in the program design (e.g., eliminating incentives for fluorescent fixtures in the Existing Retrofit program, launching the Fast Track lighting program, which rebates LED measures), but also due to the broader market transition towards LEDs as the technology advances and prices decline.

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

[6] Due to the lack of readily available measure detail for Custom projects, 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 remained largely unchanged in 2016 compared to 2015. Noticeable changes included:

- Incentives were reduced for LED measures, lighting controls, low bay fixtures, and high bay fixtures.
- Fluorescent fixtures were removed from Existing Retrofit applications.
- Program incentives for refrigerated case lighting were changed from per linear foot of refrigerated case to per lamp of qualified lighting product.

In 2016, CEP launched several new offerings. They include:

- Fast Track program
- Thermal Energy Storage (TES), through the Custom program
- Combined Heat and Power (CHP), through the Custom program

New Programs for 2016

PSEG Long Island designed the Fast Track program was to drive participation among small business customers. The program is open to commercial customers with rate codes 280 and 281. The program is limited to LED products and lighting controls and sets a participation cap of one application per account and a maximum of $5,000 in rebates. The Existing Retrofit program includes the same LED measures as the Fast Track program, and the incentive levels are the same. The Fast Track program streamlines delivery by not requiring preapprovals or pre-inspections. Based on program staff interviews, customers received the Fast

Track program well and it was delivered successfully, accounting for approximately 24% of overall CEP projects. Our analysis of participation trends among Fast Track program-eligible customers in 2015 and 2016 shows a higher year-over-year participation among 280 and 281 rate classes than other rate classes, which suggests that the Fast Track program may have positively contributed to the influx of small commercial customers into the program. Table 2-3 summarizes the results of this analysis and shows that the number of projects completed by Fast Track-eligible customers increased by 81% between 2015 and 2016, whereas participation among other accounts increased by just 1%.

Table 2-3. Year-over-Year Participation Rate across Rate Classes

Rate Class	# of Projects		% Difference Year-over-Year
	2015	2016	
Fast Track eligible rate codes (280 and 281)	2,177	3,939	+81%
All other rate codes	1,064	1,073	+1%

Furthermore, streamlined delivery mechanisms associated with the Fast Track program resulted in reduced need for staff time to process applications and issue rebates thus allowing staff to spend more time on larger and more complex projects.

While the number of projects completed by small businesses increased significantly between 2015 and 2016, an analysis of demand savings shows that per-project savings among these customers decreased by 19%. At the same time, per-project savings among other participants increased by 46%. A possible explanation for this is that customers who would otherwise pursue larger projects under the Existing Retrofit program are instead attracted by the streamlined delivery of the Fast Track program, but limiting their project scope to comply with the $5,000 rebate cap. Additional research with program participants could be of value in understanding the effects of the Fast Track program on other CEP offerings.

Table 2-4. Year-over-Year Per-Project Savings across Rate Classes

Rate Class	Per-Project Savings (kW)		% Difference Year-over-Year
	2015	2016	
Fast Track eligible rate codes (280 and 281)	3.81	3.09	−19%
All other rate codes	8.94	13.08	+46%

The Custom Program includes TES and CHP measures. 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. For TES projects, the program offers $1,000 in rebates for each avoided ton of chiller capacity.[7] By reducing equipment size and shifting chiller use to non-peak periods, TES can also provide energy savings. CHP includes efficient power generation systems that generate electricity and useful thermal energy from a single fuel and that recover thermal energy for heating, cooling, process thermal energy, or electricity purposes. Program staff determine CHP rebates based on nameplate capacity of the installed CHP system and are capped at 70% of the total project cost or $2,000,000, whichever is less.

[7] Avoided tons represent the maximum reduction achieved during the peak period, which occurs from 1PM to 7PM on weekdays.

Marketing, Outreach, and Customer Intake

Program marketing and outreach efforts in 2016 remained largely consistent with 2015 and leveraged a wide range of marketing strategies and tactics to broaden customer and trade ally awareness of the program and its benefits. Marketing strategies employed in 2016 include 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 568 trade allies and 11 energy consultants who supported direct outreach to customers in 2016. The program continued to host open houses twice a week to answer trade ally questions, review application forms, provide project preapproval, and address any other issues. The Annual Energy Efficiency Conference on Long Island continued to be another source of customer and trade ally engagement. According to program staff, the 2016 conference was very successful and attracted more than 700 attendees. Program staff we interviewed expressed satisfaction with the level of marketing and outreach. However, they anticipate an increased marketing effort with a focus on small business customers in 2017.

Program staff reported several bottlenecks during the beginning of 2016 resulting in a short-term backlog of applications. Several factors contributed to the backlog:

- Backlog of applications from 2015: Spillover of 2015 applications[8] resulted in a backlog of applications from customers rushing to submit their applications for the 2015 incentives. The slight reduction in 2016 incentives also contributed to the influx of applications near the end of 2015.
- Lack of staffing to effectively process applications in the early months of 2016.
- Transition from Siebel data-tracking system to Lockheed Martin's LM Captures database: The learning curve associated with entering and tracking project information in a completely new system resulted in additional time required to process applications.

The program team worked hard to process applications in a timely manner in early 2016, on occasion leveraging staff from other programs (e.g., Residential). Based on the information gathered during the program staff interviews, all bottlenecks were resolved by April 2016, and the program continued "business as usual" operation from then on.

Data tracking

The transition from the Siebel data entry and tracking system to the LM Captures database created a learning curve with data capture and processing. According to program staff, the key challenge impeding the successful initial deployment of the LM Captures database was the difference in the milestone tracking setup between Siebel and LM Captures. To mitigate this challenge, the program staff carefully documented data entry and processing steps, developed quality assurance (QA) protocols, and conducted thorough training on the new system. In addition, program staff implemented a thorough QA/quality control (QC) process with different levels of reviews conducted by various staff to ensure that participants uploaded project documents into LM Captures correctly, projects met program eligibility, and installations were technically feasible.

Despite challenges in the early portion of 2016, the program staff was able to maintain high levels of accuracy and consistency in processing customer applications. The evaluation team's desk reviews of projects completed in the early portion of 2016 and the later portion of the year show little difference in terms of realization rates.

[8] CEP shifted to the 2016 program year applications on November 10, 2015.

CEP staff implemented several technological improvements in 2016. To support accurate and efficient data capture and to promote small business customer participation, staff developed and deployed the Online Energy Analyzer tool to help customers identify energy savings opportunities through the program. In addition, application forms and Excel worksheets featured direct-to-LM Captures import capabilities, which allowed for seamless, accurate, and efficient data capture and transfer.

Program QA/QC processes remained largely similar to 2015, with all Prescriptive and Existing Retrofit projects requiring preapproval and pre-inspection, and all Prescriptive New Construction projects requiring post-inspection. Ten percent of Prescriptive and Existing Retrofit projects under $10,000 in incentives were subject to post-inspection and all projects over $10,000 were post-inspected. Fast Track projects did not require preapproval or pre-inspection but required post-inspection. A team of five Lockheed Martin inspectors completed field inspections.

Anticipated Changes

The program is undergoing several changes in 2017. Trade ally participation in the Fast Track program is limited to Prime Efficiency Partners (PEP)—contractors trained and certified through PSEG Long Island's PEP program.[9] Given that the Fast Track program does not require preapprovals and pre-inspections, having certified contractors perform the installations will ensure high-quality program delivery. In addition, PSEG Long Island is expanding the number of LED measures offered through the Fast Track program to include parking garage fixtures, downlights, low bay and high bay fixtures, and refrigerated case lighting. The program is also discontinuing rebates for exit signs, along with fluorescent fixtures and lamps. Additionally, program staff updated LEED requirements to align with the U.S. Green Building Council's (USGBC) LEED v4 rating system, which is more technically stringent compared to LEED 2009.[10] Program staff also anticipate reanalyzing and classifying lighting rebates into standard and premium tiers to be consistent with Design Light Consortium's (DLC) standards and offering different incentive levels for products in the two tiers to encourage higher-quality measure installations. In addition, Lockheed Martin is upgrading the LM Captures tracking system in early 2017 to a newer version of the current software platform, Microsoft Dynamics, which will require additional training. LM Captures Data QA/QC protocols established in 2016, coupled with a team of experienced staff, will ensure a smoother transition to the updated platform.

[9] To become a PEP, a contractor must submit an application; provide required documentation; including proof of insurance and references; submit and have approved a minimum of five completed program applications over the last 18 months; attend a PEP training session; pass the PEP test; and obtain a PEP identification number and certificate.

[10] LEED v4 also developed new requirements for different building types, such as data centers, warehouse and distribution centers, hotels/motels, multifamily mid-rise, and hospitality.

OVERALL IMPACTS FOR COMMERCIAL EFFICIENCY PROGRAMS

Table 2-5 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 at the program level, the CEP achieved 97% of its ex ante net demand and 97% of its ex ante net energy savings. Evaluated realization rates for demand savings ranged from 80% for the Custom program component to 99% for the Existing Retrofit program. Evaluated realization rates for energy savings ranged from 78% for the Prescriptive Lighting component to 116% for the Prescriptive Non-Lighting component.

Table 2-5. CEP Net Impacts for Goal Comparison

Program	Program Component	Ex Ante Net Savings		Evaluated Net Savings		Evaluated Net Realization Rate	
		kW	kWh	kW	kWh	kW	kWh
Prescriptive	Lighting	3,562	16,536,289	3,128	12,933,261	88%	78%
	Non-Lighting	911	4,554,386	856	5,302,626	94%	116%
	Subtotal	4,473	21,090,675	3,984	18,235,887	89%	86%
Existing Retrofit	Lighting	19,943	82,265,093	19,768	82,381,196	99%	100%
	Non-Lighting	709	1,099,170	703	1,088,360	99%	99%
	Subtotal	20,653	83,364,263	20,471	83,469,556	99%	100%
Custom	Lighting	753	2,998,302	603	2,848,387	80%	95%
	Non-Lighting	329	949,718	263	902,232	80%	95%
	Subtotal	1,082	3,948,020	866	3,750,619	80%	95%
CEP Total		26,208	108,402,958	25,321	105,456,062	97%	97%

Note: Totals may not sum due to rounding.

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 Section 1.2 of this report.

Table 2-6 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 76% for both energy and demand savings. Ex post realization rates for demand savings ranged from 64% for the Custom program component to 81% for the Prescriptive Non-Lighting component (data not shown). Ex post realization rates for energy savings ranged from 61% for the Prescriptive Lighting component to 106% for the Prescriptive Non-Lighting component.

Table 2-6. CEP Net Impacts for Cost-Effectiveness

CEP Component	Ex Ante Net Savings		Ex Post Net Savings		Ex Post Net Realization Rate	
	kW	kWh	kW	kWh	kW	kWh
Existing Retrofit	20,653	83,364,263	16,004	64,934,535	77%	78%
Prescriptive	4,473	21,090,675	3,184	14,874,797	71%	71%
Custom	1,082	3,948,020	691	2,981,742	64%	76%
CEP Total	26,208	108,402,958	19,879	82,791,074	76%	76%

Note: Totals may not sum due to rounding.

Estimation of both evaluated and ex post savings relied on a series of engineering analyses. Sections below provide detailed analysis results by program component.

Engineering Analysis Results – Prescriptive Program Component

This section provides the results of the evaluation team's analysis of energy and demand savings associated with prescriptive measures installed through the CEP. Our team used different engineering approaches for the Prescriptive Non-Lighting measures and Prescriptive Lighting measures, as described below.

Engineering analysis of the Prescriptive Non-Lighting measures included all 2016 projects and consisted of a review of the Siebel and LM Captures data extract and application of engineering algorithms. For the purposes of the engineering analysis, we grouped Prescriptive Non-Lighting measures into six end-use categories: HVAC, commercial kitchen equipment, compressed air, refrigeration, motors and variable-frequency drives (VFDs), and building envelope (i.e., Cool Roofs). As part of the engineering analysis, the evaluation team leveraged measure-level detail provided as part of the program-data tracking extract to tailor the analysis of energy savings to reflect the efficiency standards set by the program over the course of the program year. For example, for HVAC measures, equipment size (in tons) and efficiency (in Seasonal Energy Efficiency Ratio [SEER]/Energy Efficiency Ratio [EER]) were available, and we used these inputs to ensure an "apples to apples" comparison with the ex ante estimates in the program-tracking database.

The LM Captures database did not contain fully populated Prescriptive Lighting measure characteristics (e.g., hours of use, building type). As such, the evaluation team conducted desk reviews of a sample of projects (n=25) within the Lighting and Performance Lighting measure groups. This desk review approach is consistent with the approach used in previous evaluations (see Section 9.3 for details on the sampling methodology).

Table 2-7 presents evaluated net energy and demand savings associated with the Prescriptive program component by end-use 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 2-7. Prescriptive Program Component: Comparison of Ex Ante and Evaluated Net Savings

Category	Number of Units	Ex Ante Net Savings		Evaluated Net Savings		Evaluated Net Realization Rate	
		kW	kWh	kW	kWh	kW	kWh
Lighting	139,533	3,562	16,536,289	3,128	12,933,261	88%	78%
Non-Lighting							
HVAC	395	540	931,120	403	727,513	75%	78%
Building Envelope	52	151	329,286	151	329,286	100%	100%
Compressed Air	53	75	919,441	82	966,969	109%	105%
Motors and VFDs	163	72	1,349,653	91	2,168,262	125%	161%
Refrigeration	1,438	65	990,965	65	990,965	100%	100%
Commercial Kitchen Equipment	10	7	33,921	4	22,018	59%	65%
Total	141,644	4,473	21,090,675	3,923	18,138,274	88%	86%

Note: Totals may not sum due to rounding.

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

Reasons for Differences in Impacts

- For *Lighting* measures (both Prescriptive and Performance Lighting), the desk reviews revealed several types of discrepancies:
  - For all Lighting projects, we adjusted the hours of use to be consistent with the New York (NYTRM), which is also consistent with the assumptions for the Existing Retrofit component. Ex ante hours of use rely on the 2010 LIPA TRM, which references studies from 1994 to 1996. We believe that the NYTRM is the more accurate source and aligns hours of use assumptions with other PSEG Long Island commercial programs. Based on discussions with Lockheed Martin, we did not adjust the hours of use for specific types of facilities where Lockheed Martin uses more recent and Long Island-specific data (e.g., food stores).
  - For 8 of the 25 sampled projects, we confirmed with Lockheed Martin that in estimating ex ante savings, they mistakenly applied waste heat factors twice, thus overestimating savings.
  - We identified an error in the deemed savings value used to calculate ex ante savings for one lighting project.
- For *HVAC* measures, the Siebel and LM Captures database provided extensive per-installation information. The evaluation team applied ASHRAE 90.1 2010 to define measure baselines for HVAC installations in 2016. The engineering analysis led to evaluated net realization rates of 75% for demand and 79% for energy savings. The discrepancy between the ex ante and evaluated savings is due to the changes in measure mix from the previous years. Ex ante per-ton savings appear to be based on deemed savings calculated for a historical measure mix in terms of efficiency and cooling capacity. The evaluation team estimated savings using the 2016 program measure mix, which takes into account the actual characteristics of the measures installed in 2016. However, the database did not contain cooling capacity information for some measures. The evaluation team estimated these values using available data for similar measures. For new construction and end-of-useful-life replacement installations, we determined evaluated savings by comparing the installed equipment to a code-standard baseline. For early replacement installations within the Siebel database, pre-existing equipment data were not available to characterize the full project savings, and therefore evaluated

savings were determined by comparing the installed equipment to a code-standard baseline. This resulted in lower evaluated savings compared to ex ante.

- For *Building Envelope* measures, the evaluation team assigned a realization rate of 100% for this year's analysis, as there was insufficient information to complete a thorough analysis.
- For *Compressed Air* measures, the evaluated net realization rates are 109% for demand savings and 105% for energy savings. The air compressor and cycling dryer measures resulted in realization rates above 100%, while the air receiver resulted in realization rates below 100%. We continue to investigate the specifics around the different realization rates as we currently do not know how ex ante savings were determined. For evaluated savings, we leverage the savings calculation methods and assumptions recommended by programs in the Northeast. We recommend the program adopts the savings algorithms and assumptions outlined in the TRM provided by the evaluation team.
- For *Motors and VFD* measures, the engineering analysis resulted in the evaluated net realization rate of 125% for demand savings and 161% for energy savings. Program-tracking data contained extensive per-installation information that enabled the evaluation team to conduct engineering analysis by facility and motor type. The evaluation used normalized savings values (i.e., kW/hp or kWh/hp) that the NYTRM 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. PSEG Long Island provided the Evaluation Team with ex ante assumptions, however, we were unable to recreate ex ante savings using the provided ex ante assumptions. We recommend the program adopts the savings algorithms and assumptions outlined in the TRM provided by the evaluation team.
- For *Refrigeration* measures, the program-tracking data lacked detail on the installed measure information (such as kW rating) behind kW savings. Given the lack of data, and the fact that refrigeration measures contribute less than 2% of the Prescriptive 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 *Commercial Kitchen Equipment*, the analysis resulted in the evaluated net realization rate of 59% for the demand savings and 65% for energy savings. The "Insulated Holding Cabinet – Full Size" measure is the main contributor to the lower evaluated savings. This measure accounted for approximately 80% of the demand savings and 87% of the energy savings from kitchen equipment measures. Our analysis for commercial kitchen equipment incorporated savings and assumptions methods recommended by the Food Service Technology Center's (FSTC) lifecycle cost calculator tool for holding cabinets and ovens. Over the past year, the FSTC's lifecycle cost calculator was updated with new values for baseline and efficient unit consumptions to reflect current market conditions. Going forward, we recommend that the program update assumptions to reflect the TRM provided by the evaluation team.

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 ex ante NTGR varied from the ex post NTGR by end-use as shown in Table 2-8. 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

0.021 to the previous NTGR of 0.70. We calculated ex post net savings by applying the 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 2-8. Prescriptive Program Component NTGRs

End-Use	Ex Ante NTGR[a]	Ex Post NTGR[b]
General Lighting	0.92	0.72
Performance Lighting	0.92	0.72
HVAC	0.90	0.72
Commercial Kitchen Equipment	0.75	0.72
Compressed Air	0.91	0.72
Refrigeration	1.00	0.72
Refrigeration (vending)	0.99	0.72
Motors and VFDs	0.64	0.72
Building Envelope	1.00	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 2-9 shows a comparison of ex ante and ex post net energy and demand savings associated with the Prescriptive program component by end-use category.

Table 2-9. Prescriptive Program Component: Comparison of Ex Ante and Ex Post Net Savings

Category	Number of Units	Ex Ante Net Savings		Ex Post Net Savings		Ex Post Net Realization Rate	
		kW	kWh	kW	kWh	kW	kWh
Lighting	139,533	3,562	16,536,289	2,444	10,058,422	69%	61%
Non-Lighting							
HVAC	395	540	931,120	370	655,975	68%	70%
Building Envelope	52	151	329,286	147	242,901	97%	74%
Compressed Air	53	75	919,441	65	760,293	86%	83%
Motors and VFDs	163	72	1,349,653	102	2,424,049	140%	180%
Refrigeration	1,438	65	990,965	53	712,152	82%	72%
Commercial Kitchen Equipment	10	7	33,921	4	21,006	57%	62%
Total	141,644	4,473	21,090,675	3,184	14,874,797	71%	71%

Note: Totals may not sum due to rounding.

Engineering Analysis Results – Existing Retrofit Program Component

The engineering analysis of the Existing Retrofit program component relied on a series of desk reviews for a representative sample of projects for both Siebel and LM Captures. The evaluation team drew six independent samples of projects, three for the lighting end-use and three for the HVAC end-use, to identify any potential differences between projects within Siebel and projects within LM Captures. We describe one such difference below. Desk reviews yielded overall evaluated net realization rates of 99% for demand savings and 100% for energy savings.

Table 2-10 presents evaluated net energy and demand savings associated with the Existing Retrofit program component 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 2-10. Existing Retrofit Program Component: Comparison of Ex Ante and Evaluated Net Savings

End-Use	Number of Units	Ex Ante Net Savings		Evaluated Net Savings		Evaluated Net Realization Rate	
		kW	kWh	kW	kWh	kW	kWh
Lighting	705,847	19,943	82,265,093	19,768	82,381,196	99%	100%
HVAC	273	709	1,099,170	703	1,088,360	99%	99%
Total	**706,120**	**20,653**	**83,364,263**	**20,471**	**83,469,556**	**99%**	**100%**

Note: Totals may not sum due to rounding.

Below we describe the specific reasons for discrepancies in savings.

Reasons for Differences in Impacts

For the ***Lighting*** projects, our analysis of 35 projects found three primary reasons for differences in the evaluated net realization rates:

- Ex ante savings for lighting controls varied depending on the control type due to the application of different savings factors (savings factors ranged from 13% to 50%, depending on the control type). The evaluation team applied a 30% savings factor across all control types, as prescribed by the NYTRM. These adjustments affected 10 of the 35 projects in the sample.
- When estimating evaluated net savings for exit signs, the evaluation team applied a coincidence factor of 1.0 and 8,760 hours of operation (which is typical for this measure), while ex ante savings calculations applied hours of use based on building type. These adjustments affected 4 of the 35 projects in the sample[11].
- Two out of the 35 sampled projects resulted in evaluated net savings slightly higher than ex ante (realization rates of 103%–105%). Despite discussions with Lockheed Martin, we were unable to identify the reasons for discrepancies on these two projects.

For HVAC measures, the evaluation team's analysis of a sample of Existing Retrofit projects (n=12) revealed accurate and consistent savings calculations with the exception of one discrepancy for projects in LM Captures. For these projects (n=7), it appears that the ex ante calculations assume a combined SO and FR value of 0.92, rather than 0.90. This error resulted in realization rates of 98% for these projects. We did not observe this discrepancy in the Siebel projects.

The current method for calculating savings for Existing Retrofit projects assumes that the baseline equipment has remaining useful life. During our desk review of HVAC projects, however, we found pre-inspection pictures and email communication with the customers indicating that this may not have been the case for all projects

[11] Of the four projects, one came from Siebel, and three from LM Captures.

(i.e., existing equipment appeared to be at the end of its useful life). Opinion Dynamics recommends collecting the age of the existing equipment to be consistent with Appendix M[12] of the NYTRM, which allows using the existing equipment as baseline only if useful life remains on the equipment.

Table 2-11 shows a comparison of ex ante and ex post net energy and demand savings associated with the Existing Retrofit program component by end-use category. 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 Prescriptive program component, we did not perform new net-to-gross analysis this year. The evaluation team developed an updated NTGR for the CEP elements in 2011 and performed primary research in 2012 specifically to look for participant SO, which added approximately 0.02[13] to the previous NTGR of 0.70. The planning NTGRs are 0.92 for lighting and 0.90 for HVAC. The evaluated NTGR is 0.72 for ex post net savings values.

Table 2-11. Existing Retrofit 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
Lighting	705,847	19,943	82,265,093	15,443	64,069,289	77%	78%
HVAC	273	709	1,099,170	561	865,246	79%	79%
Total	**706,120**	**20,653**	**83,364,263**	**16,004**	**64,934,535**	**77%**	**78%**

Note: Totals may not sum due to rounding.

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 29 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 2016 Custom projects. While the research that informed these realization rates in now several years old, the Custom program has declined in relative importance within the CEP in recent years and now makes up only about 3% of CEP demand savings. Table 2-12 shows ex ante and evaluated net energy and demand savings associated with the Custom program component. Both net savings values are calculated using program-planning NTGRs, meaning 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 and Evaluated Net Savings

Program Component	Number of Projects	Ex Ante Net Savings		Evaluated Net Savings		Evaluated Net Realization Rate	
		kW	kWh	kW	kWh	kW	kWh
Siebel	20	653	2,299,779	523	2,184,790	0.80	0.95
LM Captures	9	429	1,648,241	343	1,565,829	0.80	0.95
Total	**29**	**1,082**	**3,948,020**	**866**	**3,750,619**	**0.80**	**0.95**

Note: Totals may not sum due to rounding.

[12] Appendix M – Guidelines for Early Replacement Conditions. http://www3.dps.ny.gov/.

[13] 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.

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 Prescriptive and Existing Retrofit 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 SO. SO added approximately 0.02[14] to the previous NTGR of 0.70. We calculated ex post net savings by applying the 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	Ex Ante Net Savings		Ex Post Net Savings		Ex Post Net Realization Rate	
	kW	kWh	kW	kWh	kW	kWh
Siebel	653	2,299,779	417	1,736,908	0.64	0.76
LM Captures	429	1,648,241	274	1,244,834	0.64	0.76
Total	1,082	3,948,020	691	2,981,742	0.64	0.76

Note: Totals may not sum due to rounding.

Net-to-Gross Ratio Estimation

Free-Ridership and Participant Spillover

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 program evaluation 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 2016 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. Looking for ways to diversify program offerings away from lighting measures, by researching the potential energy and demand savings from other end-uses, will allow the program to ensure stable performance and savings sources moving forward. The LED market is experiencing dramatic changes in pricing and product availability and prominence. The program should continue to monitor product pricing and adjust incentives accordingly.

[14] 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.

Transition to the new data-tracking platform may bring uncertainty around the quality and completeness of the data. Continuing to develop and implement rigorous data management and QA/QC processes will ensure a high level of data quality.

Within the LM Captures database, a lack of complete measure-level characteristics across key data fields prevented the evaluation team from conducting an engineering analysis of the population of projects. Instead, we relied on a sample-based review of program applications. A sample-based approach results in greater error around realization rates than an engineering review of the full population of projects. To enhance the rigor associated with the engineering review, the program should consider consistently tracking the following data as part of the LM Captures for all applicable projects and allow the data to be easily extractable:

- Prescriptive Lighting:
  - Hours of use
  - Building type
- Existing Retrofit Lighting:
  - Hours of use
  - Building type
  - Pre-/post-wattage
  - Pre-/post-quantity
- Existing Retrofit Non-Lighting:
  - Capacity (tons)
  - Pre-SEER/EER
  - Post-SEER/EER

During its first year of implementation, the Fast Track program appears to be an efficient and cost-effective solution to engaging small commercial customers. Year-over-year participation analysis reveals a positive 81% increase in the number of projects completed by Fast Track-eligible customers. Continuing to build on this program design may be an effective way of continued engagement of the small commercial customer segment. Including measures other than lighting and controls may help further expand the reach of the program.

The Fast Track program offers a streamlined participation process to eligible customers but sets a cap on the size of the project. Having this cap may have a negative impact on the per-project savings. More specifically, small commercial customers who would otherwise participate in the Existing Retrofit program and complete a larger project may favor the Fast Track program's streamlined approach at the expense of the project size. Our analysis of the year-over-year changes in per-project savings revealed a 19% reduction in per-project savings among Fast Track program-eligible customers between 2015 and 2016, while showing a 46% increase in per-project savings for other participants. Program staff should consider monitoring these trends to determine if the potentially detrimental effect of the Fast Track program on savings overshadows an increase in project volume and time savings associated with a more streamlined application process. Additionally, PSEG Long Island may consider conducting additional qualitative research to determine the effect that attributes of the Fast Track program, such as the per-project rebate cap, may have on longer-term savings potential for eligible customers.

3. The Energy Efficient Products Program

The objective of the EEP program is to increase the purchase and use of energy-efficient appliances and lighting among PSEG Long Island residential customers. In 2016, the program provided rebates on a range of ENERGY STAR products, including solid state lighting (LED) bulbs and fixtures, CFL bulbs PSEG Long Island updates the efficiency requirements for EEP program qualifying products whenever these organizations change their standards.

Overall, 2016 was a successful year for the EEP program. The program reached its internal goals (achieving savings within budget) by early September, approximately 3 months ahead of schedule. As such, PSEG Long Island assigned more budget to the program and extended savings goals for the year.

During 2016, the program once again expanded the list of qualifying products for most appliance categories. This includes offerings for air purifiers, refrigerators, pool pumps, clothes washers, and clothes dryers. Additionally, the program reinstated room AC rebates in 2016. The program had previously ended ENERGY STAR room AC rebates in 2014, but in late 2015, new ENERGY STAR certification criteria reduced the number of ENERGY STAR models available in retail stores. EEP program staff determined that rebates would once again be effective in influencing customers to purchase ENERGY STAR models over less-efficient models. The program offered room AC rebates at $25, $30, and $50 based on the cooling capacity of the room AC unit.

Additionally, PSEG Long Island modified incentive levels for several other products in 2016:

- The lighting program reduced incentives for both standard and specialty LED lights from 2015 levels. In 2016, the program capped incentives at $3 for standard LEDs and $4 for specialty LEDs. The average incentive per LED bulb was about $2.10 in 2016 compared to about $4.04 in 2015.
- Within the efficient pool pumps program, PSEG Long Island reduced the incentive on two-speed pool pumps for pool pump dealers or installers from $100 to $75.
- As in past years, to boost participation in the appliance recycling program, the program augmented its per-item incentives with two sweepstakes drawings marketed through targeted mailings and emails. For 2016, the program ran one sweepstakes drawing for two Apple iPads and ran another sweepstakes for a $500 prize.

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

Lighting

Lighting accounted for approximately 81% of the evaluated demand savings and 96% of the evaluated energy savings across the EEP program in 2016. Looking broadly to the market context that surrounds the EEP lighting program, many indicators suggest that the energy-efficient lighting market is reaching full transformation. In our 2016 Residential In-Home study, we found that energy-efficient bulbs comprised more than two-fifths of all bulbs in PSEG Long Island customer homes (42% are either CFL or LED). The LED penetration rate in particular has grown since 2013, from 18% of homes with at least one LED bulb to 63%, suggesting that Long Island customers are quickly adopting LEDs. The Long Island LED penetration rate is now higher than rates reported in other parts of the Northeast United States (42% in CT, 30% in Upstate NY, and 51% in MA).[15] Similarly, LED saturation on Long Island has increased in recent years (from 2% in 2013 to 17% in 2016. The

[15] Opinion Dynamics (2017, February 14). 2016 PSEG Long Island Residential Lighting, Pool Pump, and Dehumidifier Study – Preliminary Results. Table 9.

energy efficiency industry group Northeast Energy Efficiency Partnership (NEEP) has also observed upward trends in efficient lighting penetration and saturation rates, and recently declared that the Northeast region is in the "last stages of market transformation." NEEP estimates that the market will reach full transformation by 2020.[16] However, with 47% of residential sockets on long island containing inefficient bulbs, there remain opportunities to accelerate the adoption of efficient lighting through upstream rebates over the short term, before the EISA 2020 national standards come into effect.

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, may increase the number of ENERGY STAR LEDs available on the market.[17] 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. We expect the number of program-eligible ENERGY STAR LED bulbs to increase in 2017, though it is unclear if ENERGY STAR 2.0 certification criteria will spur a declining market share for non-ENERGY STAR LEDs (i.e., "efficient-ish" LEDs). The newest certification criteria also require a higher level of bulb efficiency and effectively bar CFLs from certification. This change is starting to push CFLs out of many upstream lighting rebate programs throughout the United States. Additionally, several retailers and manufacturers have stopped providing CFL bulbs altogether, leaving LEDs as the only high-efficiency choice in many bulb categories.[18]

Like CFLs, specialty incandescent lighting products may leave retailer shelves in the coming years, which would diminish the program's potential specialty lighting savings. The DOE's Energy Independence and Security Act (EISA) 2020 rule, set to take effect in 2020, will likely provide higher energy efficiency standards for specialty lighting products; as a result, manufacturers may cease producing incandescent specialty lighting, and halogens would become the specialty lighting baseline.[19] This change would affect baseline energy assumptions for many of the current EEP lighting measures. Specifically, under current rules, about 57% of 2016 EEP program rebated lighting products are impacted by earlier iterations of EISA. If, under EISA 2020, specialty incandescent products are effectively removed from the market, we estimate that 70% of all 2016 EEP program rebated lighting measures would be impacted by EISA.[20] In essence, EISA 2020 will likely mean that the program sees reduced savings per product for many of the specialty LED products rebated in 2016.

In-service rates (ISRs) may also affect future savings for LED lighting products. In this evaluation, our analysis assumes that customers installed all LEDs immediately after purchase (an ISR of 100%). This differs from the more mature CFL product category, which breaks down the ISR into an installation rate over 3 years, and assumes that customers install only 83% of CFL bulbs in the first year. During our 2016 In-Home study, we observed LED ISRs that were less than 100%,[21] and we will likely revise the ISR for the 2017 evaluation to

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16 Northeast Energy Efficiency Partnerships (2017, January 11). Goodbye Residential Lighting, Hello New Efficiency Opportunities. http://www.neep.org/blog/goodbye-residential-lighting-hello-new-efficiency-opportunities.

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

18 General Electric ended production of CFL bulbs in 2016, and Walmart shifted away from the sale of CFLs in 2016. Details available at: http://blog.walmart.com/sustainability/20160217/why-led-bulbs-are-stealing-the-spotlight.

19 U.S. Department of Energy (2017, January 19). Energy Conservation Program: Energy Conservation Standards for General Service Lamps. https://www.federalregister.gov/documents/2017/01/19/2016-32012/energy-conservation-program-energy-conservation-standards-for-general-service-lamps.

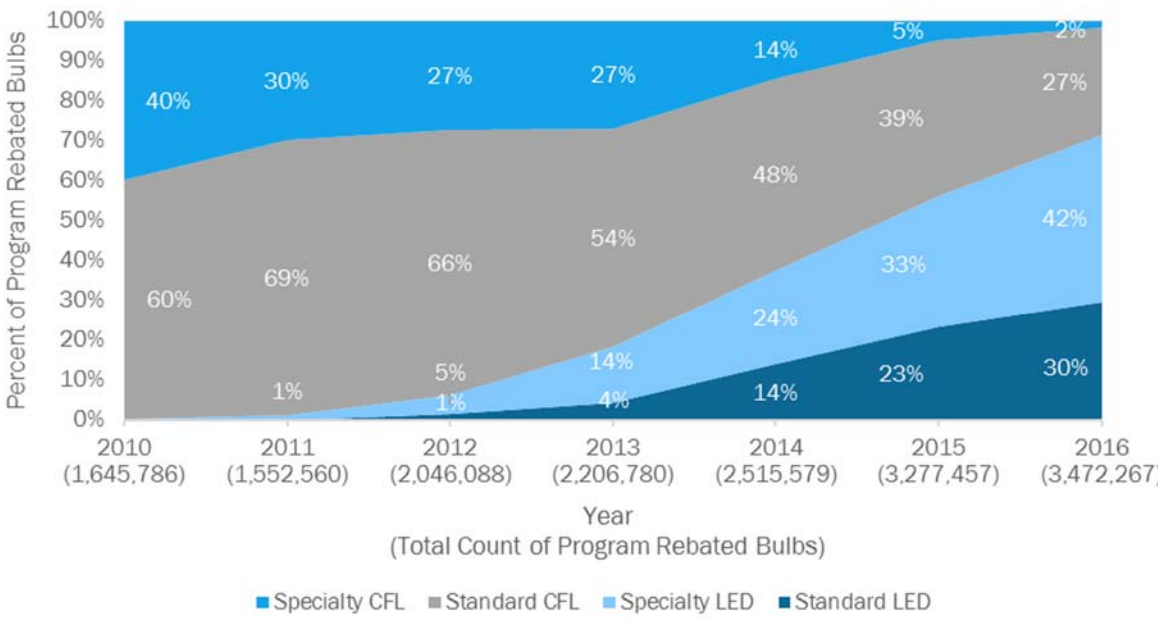
20 Our research indicates that EISA 2020 will affect the following bulb types: BR20, BR30, BR40, Par16, Par20, Par30, Par38, R30, R40, and other reflector bulbs.

21 In our 2016 In-Home study, we observed an ISR of 90% for LEDs overall, 87% for standard LEDs, and 92% for specialty LEDs.

mirror the 3-year algorithm used to calculate CFL ISRs. In effect, the realization rate for LED products will likely be lower in 2017 than in 2016.

Focusing on 2016 program results, lighting products continued to drive much of the EEP program's success. The program rebated almost 3.5 million bulbs in 2016—about 200,000 more bulbs than in 2015 (a 6% increase). For the first time in the program's history, specialty LEDs made up the largest share of rebated bulbs.[22] Both specialty LED sales and standard LED sales grew in 2016, with the share of specialty LEDs increasing by 9% from 2015 (Figure 3-1). Standard LED sales grew at a slightly lower rate (7%) from 2015 to 2016. The program has been shifting away from CFL products over the last several years, in preparation for eliminating CFLs from the program in 2017. Continuing trends seen over the past several program years, CFL sales were replaced by LED lighting products, and CFLs accounted for a smaller share of program sales (29%) than either specialty LEDs or standard LEDs (42% and 30%, respectively).

Figure 3-1. Percent of Total Program Bulbs Rebated by Type: 2010–2016



Source: EEP program-tracking data, 2010–2016.

The program is also seeing a shift within its LED sales toward packages of multiple bulbs (multi-packs). 2016 was the first year in which the program sold most of its rebated LED bulbs as multi-packs (59%). Multipack LED sales increased by about 13% from 2015 to 2016, driven primarily by the sale of standard LED four-packs, which constituted almost a quarter of all 2016 LED sales (23%). Though the program rebated 6-pack, 8-pack, and 10-pack LED products in 2016, bulbs sold in these new pack sizes constitute a smaller share of program sales than the smaller packages, for a cumulative total of 11% of all standard LEDs and 7% of all specialty LEDs (Figure 3-2). Though multi-packs get more bulbs into customer homes, the sale 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 PAs have observed a correlation between the sale of large pack sizes and

[22] Though the program includes many types of specialty LED, BR30 and retrofit kits represented the highest sales amongst specialty LEDs.

reduced first-year installation rates.[23] Because the program introduced larger pack sizes in 2016, our 2016 In-Home study could not establish a clear link between sales of large packs and reduced ISRs in PSEG Long Island territory.

Figure 3-2. Percent of Rebated LED Bulbs by Bulb Type and Pack Size

	1-Pack	2-Pack	3-Pack	4-Pack	6-Pack	8-Pack	10-Pack
Standard							
2016	20%	1%	10%	59%	1%	8%	2%
2015	39%	<1%	38%	23%			
Specialty							
2016	54%	18%	10%	10%	3%	4%	
2015	64%	21%	15%	<1%			

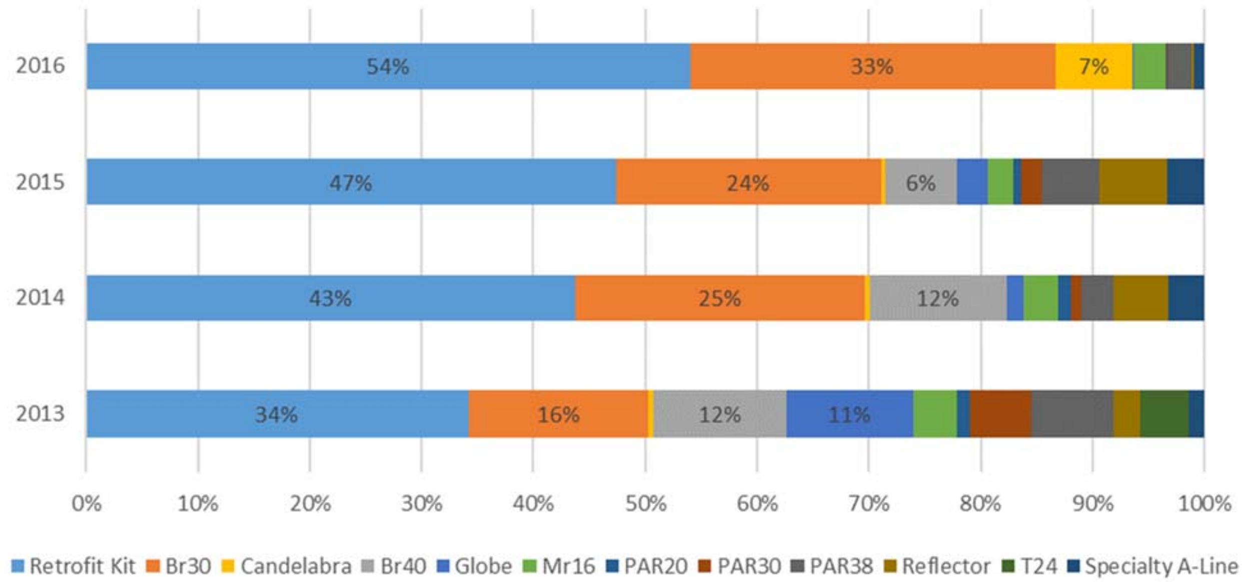
Source: EEP program-tracking data, 2015–2016. Excludes bulk lighting and online store rebated lighting products (which are less than 0.1% of total program sales). The program does not offer package sizes without a percent.

Within the specialty LED bulb category, retrofit kits and BR30 bulbs continued to make up the majority of sales (87%). More than half of all specialty LEDs rebated in 2016 were retrofit kits (54%), and BR30s made up another third of sales (33%), shown in Figure 3-3 below. Over the last 4 years, incentivized LED retrofit kit sales as a share of all specialty LEDs grew by about 20 percentage points, from 34% in 2013 to 54% in 2016. Similarly, incentivized BR30 LED bulbs as a share of all specialty LEDs grew by about 17 percentage points, from 16% in 2013 to 33% in 2016. Customers typically use BR30 bulbs in overhead recessed lighting or in track lighting applications.[24] Similarly, customers use retrofit kits to replace overhead recessed lighting fixtures and should theoretically replace many fixtures using BR30 bulbs.

[23] 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.

[24] Conservation Mart (2016, October 21). Understanding the Difference Between a PAR 30 v BR 30 Bulb. http://www.conservationmart.com/blog/index.php/understanding-the-difference-between-a-par-30-and-br-30-bulb/.

Figure 3-3. Percent of Specialty LED Sales by Bulb Shape



Source: EEP upstream rebate program-tracking data, 2013–2016. Excludes bulk rebates and online store tracking data.
Note: Increases in 2016 candelabra sales may be linked to bulb descriptions that more frequently included bulb base sizes in the 2016 program-tracking data.

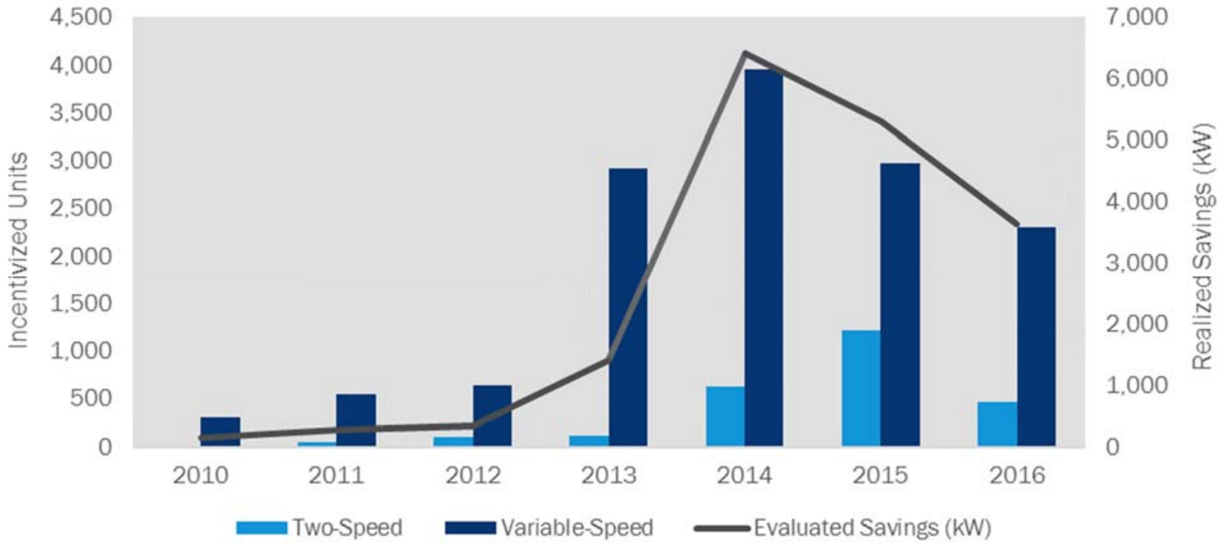
Pool Pumps

The number of rebated pool pumps fell by almost 40% from peak sales in 2014, though pool pumps yielded the second-highest savings of all EEP appliance categories in 2016. The decrease may result from reduced incentives over the last 3 years, with variable-speed pump sales declining after incentive reductions from 2014 to 2015 and two-speed pump sales declining after incentives reductions from 2015 to 2016 (see Figure 3-4).

Despite recent declines, the evaluation team believes that there is potential for ENERGY STAR pool pump savings to compensate for some of the anticipated reductions in savings from lighting measures in the coming years. Though ex post per-unit savings for pool pumps have decreased over the last 3 years (due to revised engineering assumptions), the pool pump market appears to continue to offer a large opportunity for savings. Based on our 2016 Residential In-Home study, we estimate that there are approximately 175,000 resident-maintained pools on Long Island. Of those pools, the program-rebated pool pumps made up only about 16% of the total yearly pool pump replacement market.[25] Optimizing program rebates and marketing efforts may help the program capture an even greater share of the pool pump market. To inform program design, the evaluation team recommends that PSEG Long Island conduct research with pool pump customers, distributors, and contractors to characterize this market fully.

[25] Based on an estimated 18% of homes on Long Island with resident-maintained pools, 995,106 homes served by PSEG Long Island, and a 10-year effective useful life, we estimate about 17,500 pool pumps replaced each year (assuming one pump per pool). The EEP program currently incentivizes 2,782 pumps per year.

Figure 3-4. Pool Pumps Rebated by Type: 2010–2016



Source: EEP program-tracking data, 2010–2016.

Clothes Washers and Dryers

The number of rebated clothes washers and dryers increased dramatically from 2015 to 2016. For example, clothes dryer rebate quantities (5,330 rebated) more than doubled from 2015 to 2016 (127% increase), while clothes washer rebate quantities (4,869 rebated) increased by almost 50% from 2015. We estimate that the program captured about 10% of the annual market share of clothes washer replacements amongst homeowners.[26] This represents a 4% increase from the portion of the market captured in 2015 and leaves ample room for program growth. The program reintroduced ENERGY STAR super-efficient clothes washers in 2015 to capture paired clothes washer and dryer purchases. During 2016, about one-fifth of all program-rebated clothes washers and dryers were purchased as a pair (21%), which was similar to yearly paired sales in 2015 (24%).[27]

Room Air Conditioners

In 2016, the program reinstated rebates for ENERGY STAR room ACs on the assumption that changes in ENERGY STAR standards have reduced the number of ENERGY STAR models available in retail stores. The program previously stopped offering room AC rebates in 2014 after the evaluation team's research showed that most units for sale at retail stores were ENERGY STAR qualified.[28] In late 2015, ENERGY STAR 4.0 specifications for room ACs set a higher minimum combined energy efficiency ratio (CEER) base rating across all room ACs, which was expected to result in the reintroduction of some non- ENERGY STAR® qualified models

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[26] The evaluation team estimated the percent of homes with clothes washers and the percent of homeowners on Long Island based on the U.S. Census 2013 American Housing Survey.

[27] We defined paired purchases as a single customer purchasing both a clothes washer and clothes dryer rebated by the program within 2 days of one another.

[28] Opinion Dynamics (2014, February 4). 2013 Room Air Conditioner and Dehumidifier Shelf Survey and Retailer Interviews Memo.

and again open an opportunity for the program to promote efficient products.[29] The evaluation team performed a shelf study in June 2016 to verify that the number of ENERGY STAR room AC models had indeed decreased since the rollout of ENERGY STAR 4.0.[30] We found that only 35% of room AC models available in retail stores were ENERGY STAR-certified. This represented a 55% percentage point decrease from our 2013 shelf study findings.

In their first year back in the program, room ACs were the second most commonly rebated EEP appliance and constituted about 1% of ex ante EEP program demand savings (kW). Predictably, the program rebated most of the room ACs during the summer months (70% from June to August). We estimate that the program incentivized almost one-quarter of the room ACs (24%) sold on Long Island in 2016.[31]

Impacts for Goal Comparison

Table 3-1 provides a program-level comparison of evaluated net savings to ex ante savings by measure category.

Table 3-1. Energy Efficient Products Program Net Impacts for Goal Comparison

Category	Ex Ante Net Savings[a]			Evaluated Net Savings			Realization Rate	
	N	kW	kWh	N[b]	kW	kWh	kW	kWh
Lighting	3,472,267	20,134	181,669,993	3,472,267	20,837	181,974,101	103%	100%
Pool Pumps	2,782	3,568	3,940,701	2,782	3,636	5,727,478	102%	145%
Clothes Dryers	5,330	309	179,269	5,330	179	821,197	58%	458%
Appliance Recycling	4,136	302	1,873,168	4,133	326	2,066,181	108%	110%
Clothes Washers Most Efficient	4,869	204	1,060,880	4,869	32	154,286	16%	15%
Room ACs	9,330	154	74,761	9,330	548	266,082	356%	356%
Refrigerators	2,220	40	335,028	2,221	34	290,767	87%	87%
Air Purifiers	356	23	52,696	356	23	126,407	100%	240%
Power Strips	140	2	11,816	140	2	11,816	100%	100%
Total	**3,501,430**	**24,736**	**189,198,313**	**3,501,428**	**25,070**	**191,172,233**	**101%**	**101%**

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

Reasons for Differences in Impacts

- **Lighting:** The evaluation team determined a realization rate of 103% for demand and 100% for energy savings. The slight difference between ex ante and ex post are mainly due to the following:
  - **HVAC interactivity:** The evaluators included HVAC interactivity factors in the savings calculations based on the Residential Lighting Study conducted by the evaluation team in 2016. In prior

[29] ENERGY STAR® Program Requirements Product Specification for Room Air Conditioners, Eligibility Criteria Version 4.0, effective October 26, 2015.

[30] Opinion Dynamics (2016, June 8). 2016 Room Air Conditioner Shelf Survey Memo.

[31] Based on an estimated 995,106 homes served by PSEG Long Island, a 9-year effective useful life, and results from the 2015 PSEG Long Island Residential Potential Study conducted by AEG. We estimate that 35% of homes on Long Island have room air conditioners.

evaluations, HVAC interactivity was not included, as the installed location of rebated lamps is unknown for an upstream program. However, with the 2016 study, the evaluation team collected information on the prevalence of CFLs and LEDs in conditioned spaces in 144 sampled homes across Long Island and leveraged these data to estimate HVAC interactivity factors for 2016.

- Specialty LED delta watts: The program assumed a wattage mix based on 2014 data, whereas the evaluation team used actual 2016 data. The average installed wattage in 2014 was 15.51 watts, but it was 13.96 watts in 2016. Mapping the baseline watts to these two installed wattages results in ex post savings that, relative to ex ante savings, are based on lower baseline watts and lower overall delta watts.
- CFL in-storage: The program's ex ante savings estimates for in-storage bulbs from 2015 relied on goals rather than actual installation counts from 2015 (actual installation counts were not available at the time of 2016 EEP planning). The actual 2015 installation counts were 11% lower than the 2015 goal value, which resulted in a slight overestimate of ex ante savings.

- Pool Pumps: The realization rates for two-speed and variable-speed pool pumps was 102% for demand savings and 145% for energy savings. It appears that ex ante calculations relied on assumptions from the Consortium for Energy Efficiency (CEE) Residential Swimming Pool Initiative. Because PSEG Long Island bases pool pump efficiency requirements on ENERGY STAR standards, the evaluation team estimated savings using ENERGY STAR savings calculations with New York default runtime hours (hours per day). However, the evaluation team does recommend augmenting these savings calculations with Long Island-specific data on actual hours of use and pump settings for both efficient and baseline equipment.
- Clothes Dryers: In 2016, the EEP portfolio included clothes dryers and resulted in realization rates of 58% for demand and 458% for energy. Evaluators developed energy savings algorithms for clothes dryers prior to the 2016 evaluation based on the ENERGY STAR appliance calculator. It appears that the program currently references the DOE-mandated test procedures and efficiency for estimating savings for clothes dryers. We recommend that the program revise the savings algorithms to reflect the latest ENERGY STAR appliance calculator.
- Appliance Recycling: The overall realization rates for all recycled appliances were 108% and 110% for demand and energy, respectively, as shown in Table 3-1. Ex ante assumptions are consistent with ENERGY STAR recommendations for recycled room ACs and recycled dehumidifiers and therefore resulted in realization rates near 100% for energy and demand savings. The 2016 tracking data provided the evaluation team with detailed information on recycled refrigerators and freezers, including size, configuration, and vintage. With this information, the evaluation team accurately assessed the average savings per recycled refrigerator and freezer using ENERGY STAR savings calculation methods. This led to a combined realization rate for recycled refrigerators and freezers of 111% for demand and energy savings. We recommend that the program update all assumptions for recycled refrigerators and freezers to reflect the latest savings calculations recommended by ENERGY STAR.
- Room Air Conditioners: After a 1-year absence, the room AC measure was added back to the EEP portfolio in 2016. Realization rates for ENERGY STAR-rated room ACs were 356% for both demand and energy. The evaluation team estimated the energy use of efficient room ACs using the latest CEER requirements set forth by ENERGY STAR. Evaluated baseline calculations used the "Residential Room AC Baseline Recommendation for PSEG-LI" memo provided to PSEG Long Island in July 2016 by the evaluation team. The memo contains recommendations on baseline efficiency values for room ACs based on a "shelf survey" performed by the evaluation team in the summer of 2016 to examine the diversity and saturation of room ACs available at a selection of retailers on Long Island. The evaluation

team chose to use the Long Island-specific data from the study instead of federal standard baseline recommendations from ENERGY STAR to characterize the efficiency options available to PSEG Long Island's customers. The evaluation team recommends that PSEG Long Island leverage this recent Long Island-specific data to close the gap between ex ante and evaluated savings. We also recommend that PSEG Long Island continue to monitor room AC baseline efficiencies via periodic shelf surveys.

- **Refrigerators:** Realization rates for ENERGY STAR-rated refrigerators were 87% for demand and energy savings. For the first time since 2012, evaluators received detailed tracking information on sizes of refrigerators installed through the program in 2016. The program assumptions for energy savings for prescriptive and most-efficient models referenced ENERGY STAR assumptions that went into effect in 2008. The evaluation team used the latest ENERGY STAR calculator and assumptions to estimate the baseline and efficient energy consumption of the refrigerators. We recommend that the program revise the kWh savings algorithms for refrigerators based on the most up-to-date ENERGY STAR calculator.
- **Air Purifiers:** Realization rates for ENERGY STAR air purifiers were 100% for demand savings and 240% for energy savings. The ex ante energy savings reference the evaluation team's 2014 TRM, which referenced assumptions from the latest ENERGY STAR calculator at the time. The EPA updated the ENERGY STAR the calculator with revised baseline and efficient annual energy consumptions. We recommend that the program revise the energy savings algorithms for air purifiers to reflect the latest ENERGY STAR calculator.

Impacts for Cost-Effectiveness

Table 3-2 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 outlining a recommended NTGR of 0.55 for LED lighting. We include this recommended NTGR value in our ex post savings, but continue to use the program-planning NTGR for LEDs of 1.20 for evaluated savings. For 2017, the evaluation team plans to use our recommended value of 0.55 for both evaluated and ex post savings, and we recommend that the program adopts this value for evaluated savings to avoid significant reductions in evaluated net savings.

Table 3-2. NTGRs for EEP Program

	Ex Ante Net Savings			Ex Post Net Savings		
Program Measures	FR	SO	NTGR	FR	SO	NTGR
CFLs – Standard	30%	4%	0.74	30%	4%	0.74
CFLs – Specialty	25%	20%	0.95	25%	20%	0.95
ENERGY STAR solid state lighting	5%	25%	1.20	n/a	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
Super-efficient dryers and most-efficient clothes washers	20%	10%	0.90	20%	10%	0.90
Air purifiers	30%	15%	0.85	30%	15%	0.85

Applying the NTGRs in Table 3-2 to evaluated gross savings provides ex post net savings. Table 3-3 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 3-3. EEP Program Net Impacts for Cost-Effectiveness

	Ex Ante Net Savings[a]			Ex Post Net Savings			Cost-Effectiveness Realization Rate	
Category	N	kW	kWh	N[b]	kW	kWh	kW	kWh
Lighting	3,472,267	20,134	181,669,993	3,472,267	11,622	101,603,851	58%	56%
Pool Pumps	2,782	3,568	3,940,701	2,782	3,636	5,727,478	102%	145%
Refrigerators	2,220	40	335,028	2,221	34	290,767	87%	87%
Appliance Recycling	4,136	302	1,873,168	4,133	275	1,739,942	91%	93%
Clothes Dryers	5,330	309	179,269	5,330	179	821,197	58%	458%
Clothes Washers Most Efficient	4,869	204	1,060,880	4,869	32	154,286	16%	15%
Room ACs	9,330	154	74,761	9,330	548	266,082	356%	356%
Power Strips	140	2	11,816	140	2	11,816	100%	100%
Air Purifiers	356	23	52,696	356	23	126,407	100%	240%
Total	**3,501,430**	**24,736**	**189,198,313**	**3,501,428**	**16,352**	**110,741,825**	**66%**	**59%**

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

4. The 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.

The 2016 program was the second year in which PSEG Long Island also offered an equipment-only 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 equipment-only 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 incentives for ductless mini-split systems in both the equipment-only and QI pathways. Incentive levels for split CACs, ASHPs, and ductless mini-splits did not change between 2015 and 2016 for both the QI and equipment-only options. Incentives for ground source systems changed in 2016 in both the structure and level of the incentive. Rather than provide the incentive on a per-system basis as in 2015, the program offered incentives on a per-ton basis in 2016. In general, this change resulted in higher incentives for this category of equipment than in the past.

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 $125 per installation. Contractors are also eligible to receive 75% reimbursement on eligible tools used for QI and 50% reimbursement on Manual J software after they have completed 20 approved installations.

In 2016, the program also increased its marketing efforts, both in terms of spending and diversifying the tactics used to reach potential participants. Also in 2016, Lockheed Martin moved to a direct hire model for program implementation, rather than working with CLEAResult for program implementation as in previous years.

Program Performance

In 2016, the Cool Homes program set a demand goal of 4.29 MW and achieved evaluated demand savings of 3.2 MW. The program failed to meet its demand goals, representing a departure from the previous three program years. The program rebated 5,391 measures in 2016, of which 81% were split CACs. The remaining rebated measures were ductless mini-split systems (15%), ground source heat pumps (GSHPs) (2%), and ASHPs (2%), as seen in Table 4-1.

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

Measure	Quantity	Percent
Split CAC	4,362	81%
Ductless Mini-Split	814	15%
GSHP	125	2%
ASHP	90	2%
Total	5,391	100%

Source: Cool Homes program-tracking data. 2016.

Compared to the 2015 program, the 2016 Cool Homes program rebated 16% fewer systems (as seen in Table 4-2). Program-rebated units for each category of equipment declined year over year, with the largest decline occurring among ASHPs (−64%), followed by GSHPs (−25%), split CACs (−15%), and ductless mini-splits (−9%). The year-over-year declines across all product categories partly linked to the 2015 program being able to close out a large volume of early retirement opportunities that were pending from earlier program years. In 2016, these carryover opportunities were not available to the program.

Table 4-2. Difference in Number of Cool Home Program Measures Installed, 2014–2016

Measure	2014	2015	2016	Percent Difference 2015 to 2016
Split CAC	3,881	5,114	4,362	−15%
Ductless Mini-Split	562	894	814	−9%
GSHP	162	166	125	−25%
ASHP	320	249	90	−64%
Total	**5,319**	**6,423**	**5,391**	**−16%**

Source: Cool Homes program-tracking data, 2014, 2015, 2016.

In 2016, the Cool Homes program once again included an equipment-only option, which grew from 477 installations in 2015 to 594 units in 2016. Table 4-3 compares installations in the two program pathways by month for each category of equipment in the 2016 program. Systems incented through the traditional QI pathway continued to represent the largest share of projects.

Table 4-3. Equipment-Only and Quality-Installation Units by Month in 2016

Month	Equipment-Only Installations			Installations by Cool Homes Contractors			
	CAC Systems	Ductless Systems	ASHP Systems	CAC Systems (QI Required)	ASHP Systems (QI Required)	Ductless Systems	GSHP Systems
January	10	11	0	193	6	35	13
February	4	7	0	90	5	18	7
March	9	11	0	131	5	8	8
April	7	2	0	140	3	22	9
May	8	29	0	276	4	22	2
June	79	26	0	324	4	41	2
July	27	29	0	476	8	59	16
August	33	35	0	568	13	64	18
September	31	50	0	579	10	55	13
October	30	55	0	638	6	81	12
November	7	10	0	393	16	57	23
December	34	49	1	275	9	38	2
Total	**279**	**314**	**1**	**4,083**	**89**	**500**	**125**

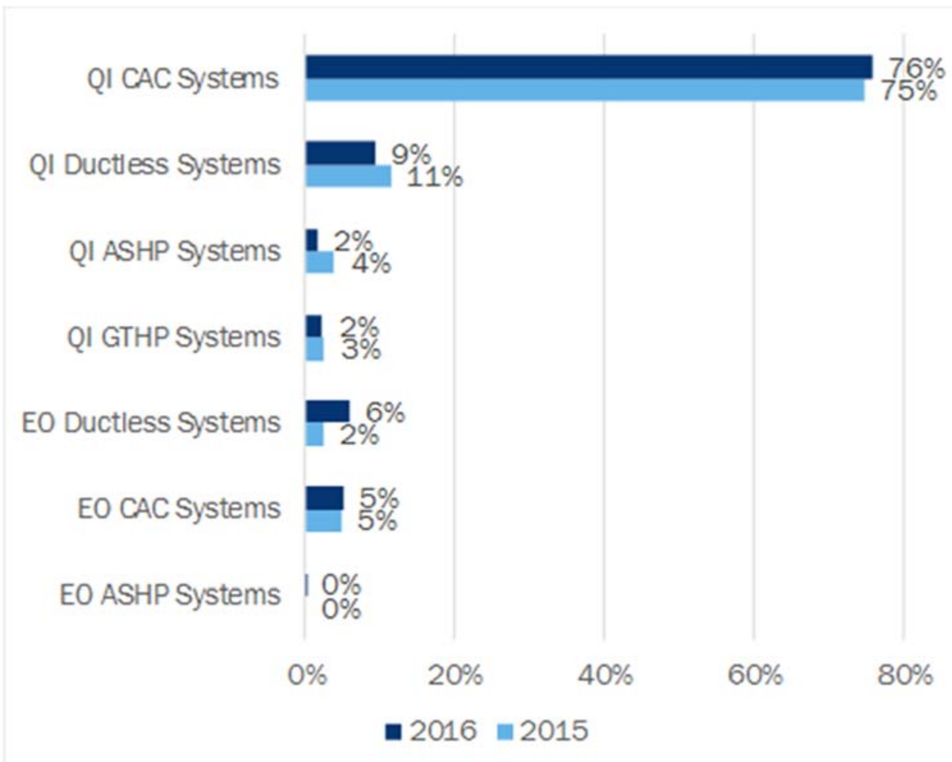
Source: Cool Homes program-tracking data, 2016.

Within the equipment-only category of installations in 2016, 279 were CAC installations, 314 were ductless systems, and 1 was an ASHP, representing 11% of the total program installations. In 2015, the program rebated 316 CACs and 160 ductless systems through the equipment-only offering, for 7% of the total program installs. While the program saw an increase in the overall count of equipment-only installs in 2016, it should be noted that the 2015 program began accepting applications in May and therefore was not offered for the full calendar year.

In 2016, customer rebates for ductless mini-split systems were the same for both equipment-only and QI options. In comparison, the rebate levels for QI ASHPs and split CACs are $500–$650 higher than comparable equipment-only options, depending on equipment tier. This difference in rebate levels may explain why the installations of ductless systems have increased through the equipment-only pathway in comparison to other measures.

Figure 4-1 compares the installations of each measure offered by the program in 2016 and 2015 on a percentage basis, including the equipment-only and QI offerings. With the exception of an increase in equipment-only (EO) ductless systems (which increased from 2% to 6%), the mix of program offerings in 2016 is very similar to that of 2015.

Figure 4-1. Comparison of Installations by Program Offering in 2015 and 2016



Transition from Siebel to LM Captures

In 2016, the program transitioned its application management and processing system from Siebel to LM Captures. During the transition, Cool Homes program staff used a spreadsheet to track applications opened in Siebel so that they could be closed out in the new LM Captures system to effectively and smoothly transition between the two systems. Program staff reported that the transition between the systems was smooth and occurred without disruptions to program operations and administration. Customers and trade allies were unaffected by the change in systems.

Program Marketing

In 2016, the Cool Homes program worked with PSEG Long Island's new marketing partner, MarketSmith, to increase marketing efforts for the program. The overall marketing budget for the Cool Homes program was 50% higher in 2016 than in 2015 and utilized a more diverse mix of channels to market the program than in the past, including print advertisements in local newspapers, radio and television spots, Google AdWords, and social media marketing. The main program marketing effort took place between May and August of 2016, when the program is typically operating at its peak. The program saw increases in participation year over year during the months of May through July. Program staff reported that the collaboration with the new marketing partner on the 2016 marketing campaign was a positive experience.

Impacts for Goal Comparison

Table 4-4 provides a program-level comparison of evaluated net 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. (See the definitions in Section 1.1 for a discussion of the difference between the ex ante and evaluated values.)

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

		Ex Ante Net Savings		Evaluated Net Savings		Realization Rate	
Category	Installs	kW	kWh	kW	kWh	kW	kWh
Split CAC	4,362	2,569	1,709,043	2,752	1,845,487	107%	108%
GSHP	125	210	451,321	212	424,089	101%	94%
Ductless Mini-Split	814	179	234,636	158	245,630	88%	105%
ASHP	90	43	62,631	46	95,937	107%	153%
Total	5,391	3,001	2,457,631	3,167	2,611,143	106%	106%

Note: Totals may not sum due to rounding.

Reasons for Differences in Impacts

To estimate energy and demand savings, the evaluation team used algorithms incorporating average installed size and efficiency for each measure, as determined through examination of the program's 2016 tracking data. We multiplied normalized savings-per-ton values by the total installed capacity to calculate total evaluated savings by measure. Most measure-specific discrepancies between ex ante and evaluated savings are due to differences in assumptions of efficiencies and other efficient equipment characteristics used to calculate savings. The program design includes making predictions about future installations during the planning process, which could lead to discrepancies in ex ante and evaluated savings. For end-of-life replacement and new construction measures, the evaluation team relied on the 2016 tracking data for installed efficiency and the NYTRM for baseline efficiencies. The program and the evaluation team used the same coincidence factors and effective full load cooling hours (EFLCH).

To ensure valid comparisons of the evaluated savings to the ex ante savings, the evaluation team first "backs out" the NTGR used by program implementers to calculate ex ante savings for each measure for comparison to the known planning assumptions. Ex ante gross savings do not contain coincidence factors, line losses, or NTGRs, but do contain QI factors. The evaluation team reviewed the planning assumptions (which appear to be correct), but found slight differences (likely due to rounding) between the NTGRs used by program implementers and the program's established planning NTGRs. As the evaluation team does not recommend deviating from the planning NTGRs at this point, we applied the actual planning NTGRs for all measures rather than the “backed-out” NTGRs when determining evaluated net savings.

The evaluation team has the following comments on the measure-specific savings calculations summarized in the tables above:

- **Split CAC:** Evaluated savings for CACs were higher than ex ante savings for both demand (107%) and energy (108%) savings. The evaluation team attempted to replicate all ex ante savings at the equipment level using the Cool Homes Planning spreadsheet provided by PSEG Long Island. Through this process, we successfully replicated ex ante savings for LM Captures projects, but not for Siebel projects. The discrepancies in Siebel were not consistently “off” by the same factor, leading us to believe there may be some rounding of individual factors (e.g., line losses, free ridership percentages, coincidence factors) or another unknown discrepancy within Siebel. With the complete transition of Cool Homes to LM Captures in 2017, we do not anticipate this discrepancy will continue.
- **Ground Source Heat Pumps:** GSHPs achieved realization rates of 101% (demand) and 94% (energy). The evaluated energy savings are less than ex ante savings because the evaluators used a baseline heating seasonal performance factor (HSPF) of 8.1, per NYTRM recommendations, while the program's assumption for baseline HSPF was 7.7.
- **Ductless Mini-Split Systems:** Ductless mini-split systems achieved lower evaluated savings for demand (88%) and higher evaluated savings for energy (105%). The evaluation team attempted to replicate all ex ante savings calculations for each measure using the Cool Homes Planning spreadsheet provided by PSEG Long Island. Our team successfully replicated ex ante savings calculations for all ductless mini-split projects in LM Captures, but were not able to do the same for all 2016 projects in the Siebel database. The discrepancies that the evaluation team identified in that sub-set of projects were not off by a consistent factor and, as such, we believe there may have been some rounding errors with individual factors (e.g., line losses, free ridership percentages, coincidence factors) or another unknown discrepancies within Siebel. With the complete transition of Cool Homes to LM Captures in 2017, we do not anticipate these discrepancies to continue in future program years.

  Air-Source Heat Pumps: ASHPs achieved realization rates of 107% (for demand) and 153% (energy). The evaluation team applied baseline efficiencies of 13 SEER and 7.7 HSPF, per NYTRM recommendations, whereas the program planning baselines were 14 SEER and 8.2 HSPF, from the 2015 International Energy Conservation Code (IECC). The 2015 IECC did not go into effect until October 1, 2016 in NY State, therefore the evaluation team referenced the NYTRM as the appropriate baseline for the ASHP in 2016. As with ductless mini-split systems, the evaluation team attempted to replicate all ex ante savings calculations using the Cool Homes Planning spreadsheet provided by PSEG Long Island; however, were unable to replicate ex ante savings for a sub-set of projects tracked in the Siebel database. Similar to issues identified with ductless mini-split projects, the evaluation team assumes discrepancies are due to some rounding errors with individual factors (e.g., line losses, free ridership percentages, coincidence factors), and, with the transition to LM Captures in 2017, do not anticipate these discrepancies to persist in future years.

Impacts for Cost-Effectiveness Calculations

The cost-effectiveness calculations are based on ex post net savings estimates. As discussed previously, 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 non-participating 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

Category	Installs	Ex Ante Net Savings		Ex Post Net Savings		Cost-Effectiveness Realization Rate	
		kW	kWh	kW	kWh	kW	kWh
Split CAC	4,362	2,569	1,709,043	2,634	1,418,429	103%	83%
GSHP	125	210	451,321	212	424,089	101%	94%
Ductless Mini-Split	814	179	234,636	158	245,630	88%	105%
ASHP	90	43	62,631	46	95,937	107%	153%
Total	5,391	3,001	2,457,631	3,049	2,184,084	102%	89%

Note: Totals may not sum due to rounding.

The program applies planning, or ex ante, NTGR values of 0.90 for all measures except ground source heat pumps for which the program applies 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

Summary of Findings and Next Steps

Based on interviews with program staff, program data, and an assessment of PSEG Long Island's long-term goals, the evaluation team makes the following recommendations.

- Overall program installations declined from 2015 to 2016 while marketing efforts increased for the 2016 program year. Program staff should continue to investigate the effectiveness of each marketing channel utilized in 2016 and tailor future marketing efforts to prioritize the most effective channels and drive increased participation and installations of efficient cooling equipment. The program may also look to tailor marketing efforts to promote specific categories of products to increase energy savings in addition to demand savings.
- For ductless mini-spilt systems and GSHPs, program staff should consider applying a new construction/normal replacement baseline based on IECC 2015 and the NYTRM. The evaluation team's updated TRM will reflect these recent code changes.

5. The 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, with the reduction in utility bills through energy efficiency, and lowers PSEG Long Island's financial risk associated with bill collection. To participate in the REAP program, household income must be no more than 70% of the median income, adjusted for household size.

The REAP program includes a free home energy audit, in addition to free energy-saving measures. In 2016, the program included CFL light bulbs, pipe insulation, low-flow shower heads, room ACs, and dehumidifiers. As part of its redesign in 2015, the REAP program added room ACs and dehumidifiers and discontinued its refrigerator offerings in favor of the new measures.

In June 2016, the program completed its transition from entering direct installation information into the Siebel data-tracking system to Lockheed Martin's LM Captures database. Prior to June, program staff tracked REAP program details as they had in prior years, that is, REAP program direct installations, made during the initial visit, continued to be tracked in the Siebel data-tracking system, whereas follow-up visits to install room ACs and dehumidifiers were performed under the HPD program and tracked via Real Home Analyzer (RHA). REAP program staff reconciled project data monthly, both using reports received from RHA and resolving any discrepancies between Seibel and LM Captures, to ensure a smooth transition between data-tracking systems.

Impacts for Comparison to Goals and Cost-Effectiveness

As in previous evaluations, the evaluation team used two approaches to estimate savings for the REAP program in 2016: an engineering analysis and a billing analysis. Because the billing 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 billing analysis. Our billing analysis uses 2015 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 energy savings realization rate of 99% for all measures. The overall program realization rate for demand savings is 102%.

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

Measure Category	N[a]	Ex Ante Net Savings		Evaluated/Ex Post Net Savings		Realization Rate	
		kW	kWh	kW	kWh	kW	kWh
Room AC	741	279.7	136,457	278.0	134,982	99%	99%
CFL Bulbs	1,725	124.3	1,126,828	127.8	1,114,646	103%	99%
Duct Sealing	177	120.1	73,954	118.8	73,155	99%	99%
Dehumidifier	284	43.2	73,397	45.8	72,604	106%	99%
Air Sealing	181	4.6	14,157	4.5	14,004	99%	99%
Domestic Hot Water (DHW)	123	2.3	81,840	9.5	80,955	415%	99%
Duct Insulation	75	1.2	690	1.1	683	99%	99%
Refrigerator	2	0.3	2,207	0.3	2,183	77%	99%
Total	1,849	575.6	1,509,531	585.8	1,493,211	102%	99%

[a] Number of REAP program projects with measures in 2016.
Note: Totals may not sum due to rounding.

Reasons for Differences in Impacts

The billing 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 billing 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 billing analysis.

The combined billing and engineering analysis found that the REAP program generated approximately 1,493 MWh in energy savings in 2016, or about 99% 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 586 kW in demand savings, or 102% of the expected peak demand savings. The sections that follow describe the billing and engineering analyses in more detail.

Billing Analysis

The evaluation team conducted the billing analysis with the goal of determining the overall evaluated net energy savings for the REAP program. Our billing analysis uses 2015 participants as the treatment group, because the method requires post-installation electricity usage data for approximately 1 year after participation.[32] We also included a comparison group consisting of households that participated in 2016. The comparison group acts as the counterfactual or point of comparison for the treatment group (2015 participants) in the post-participation period.

Using future participants as a comparison group gives us some assurance that the effect of self-selection into the program is relatively equivalent between early and later participants. However, it is important to do whatever analyses are possible to determine whether the future participants are similar in other ways so that we feel comfortable 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 saw that the groups were similar in consumption and in weather experienced during the same calendar period. There were some differences in pre-participation usage, and this alerted us to the fact that we should control for those differences during the billing analysis. However, the differences were not so large that we would reject the 2016 participants as a reasonable comparison group

In Table 5-2, 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 see that there are some differences (e.g., refrigerators being installed in 14% of 2015 participants, but almost none in the comparison group), but we believe those differences were more due to changes in program policy than to the nature of the participants.

[32] Note that participants who initiated participation in 2015 and continued participating in 2016 (i.e., through the REAP program) are considered 2015 participants for the purpose of the billing analysis.

Table 5-2. REAP Program Installations by Program Year for Billing Analysis Groups

Measure Installed	Billing Analysis Treatment Group (2015 Participants) (n=1,155)		Billing Analysis Comparison Group (2016 Participants) (n=1,505)	
	Participants	Percentage of Gross kWh	Participants	Percentage of Gross kWh
CFL Bulbs	90%	62%	96%	79%
Room AC	32%	4.0%	43%	9.8%
Refrigerator	14%	18%	0.13%	0.18%
Dehumidifier	13%	3.5%	17%	5.4%
DHW	11%	6.4%	8.2%	5.6%
Air Sealing	11%	0.97%	0.066%	0.0020%
Duct Sealing	10%	4.7%	0.066%	0.36%
Duct Insulation	2.1%	0.047%	0%	0%

The billing analysis model is a linear fixed effects regression (LFER) conditional demand analysis (CDA) model, which utilizes individual "dummy" variables to indicate the presence of any major measure installation. The model also 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, and many other factors. To improve our estimate of the counterfactual (what 2015 participants would have done during the post-participation period absent the program), we added dummy variables for each month of the evaluation period. The monthly dummy variables provide information on time trends external to the program. 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 billing analysis to determine the overall program realization rate. We did not attempt to calculate measure-level realization rates 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, we report the results only for the overall program effect.

Table 5-3 presents the overall net program savings for 2015 REAP program participants. As shown below, the 2015 REAP program realized 93% of its expected net savings at the participant level. These results reflect savings attributable to the program and the types of measures installed during 2015.

Table 5-3. Savings from the REAP Program Billing Analysis Compared to Ex Ante Savings Estimates

End-Use	N (Participants in Billing Analysis)	Observed Savings		Program-Planning Savings		Realization Rate
		Household Daily Savings	Household Annual Savings	Household Daily Savings	Household Annual Savings	
Program	1,155	2.06	752	2.22	812	93%

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 billing 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 5-4 provides a review of impacts for the program in 2016 by category based on an engineering estimate of savings.

Table 5-4. 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
Room AC	741	279.7	136,457	98.0	47,564	35%	35%
CFL Bulbs	1,725	124.3	1,126,828	143.4	1,250,312	115%	111%
Duct Sealing	177	120.1	73,954	120.1	73,953	100%	100%
Dehumidifier	284	43.2	73,397	28.4	45,011	66%	61%
Air Sealing	181	4.6	14,157	4.6	14,157	100%	100%
DHW	123	2.3	81,840	7.7	65,783	337%	80%
Duct Insulation	75	1.2	690	1.2	690	100%	100%
Refrigerator	2	0.3	2,207	0.1	1,023	36%	46%
Total	1,849	575.6	1,509,531	403.4	1,498,492	70%	99%

[a] Number of REAP program projects with measures in 2016.
Note: Totals may not sum due to rounding.

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

- Room AC: For room AC measures, the evaluation team requested equipment capacities, baseline, and installed EERs for a representative sample of projects from the Siebel database. The LM Captures database features extensive information on equipment capacities, baseline, and installed EER. However, installed EERs from the LM Captures database appear unrealistically high compared to ENERGY STAR's approved list of room AC units and EERs observed for the sample of Siebel projects. Therefore, the evaluation team used the baseline and installed EERs from the Siebel representative sample, as they appeared more in line with ENERGY STAR qualifications. We believe this discrepancy causes the lower realization rate for room AC measures.
- Lighting: In 2016, removed lighting wattages were not included in the REAP program direct install data collection spreadsheets. The evaluation team requested the removed and installed bulb wattages for a sample of projects and developed a correlation between them to estimate baseline bulb wattages for all 2016 lighting installs. We believe that discrepancies between ex ante and ex post may be caused by differences in assumed baseline and actual baseline wattages. Additionally, the evaluation team included HVAC interactivity factors in the savings calculations based on the Residential Lighting Study conducted in 2016, which resulted in a slight increase in lighting savings.
- Dehumidifier: For dehumidifiers, the evaluation team used savings referenced from ENERGY STAR algorithms and unit consumptions for federal minimum efficiency standard and ENERGY STAR-qualified units. The program used a similar algorithm, but applied a multiplier of 0.9 to the baseline dehumidifier energy factor, resulting in a discrepancy between ex ante and evaluated savings.

- **Domestic Hot Water:** Shower heads, faucet aerators, pipe insulation, tank wraps, and temperature turndown account for the DHW savings attributable to the REAP program. The program-tracking data lacked several key assumptions to determine and/or validate impacts. These assumptions and the savings calculation methodology are described below:
  - The evaluation team used a comparison between the removed and installed shower head and aerator flow rates (gpm) for a sample of projects to estimate energy savings for these measures. Additionally, we relied on hot water temperatures and inlet water temperatures based on standard engineering assumptions to estimate the energy and demand savings.
  - The evaluated savings for pipe insulation were calculated using DOE 3E Plus software. The LM Captures database shows gross savings of 15.20 kWh per unit and a combination of 0.001 and 0.002 kW per unit to calculate energy and demand savings, respectively. The evaluated savings apply 17.19 kWh per unit and 0.0019 kW per unit to calculate energy and demand savings, respectively. This discrepancy is resulting in an increase in evaluated savings when compared to ex ante savings for pipe insulation.
  - The temperature turndown measure reflects reduced surface losses from maintaining the hot water at a lower temperature (120°F assumed) during standby mode.
  - When estimating peak demand savings, the evaluation team used a coincidence factor of 0.23, adopted from a study of electric hot water heaters.[33]
- **Refrigerator:** The program removed this measure from its portfolio in 2016, resulting in only two installations. The evaluated net savings reflect the weighted average ENERGY STAR-recommended savings based on 2016 installed refrigerator sizes and configurations. The baseline refrigerator energy consumption represents a weighted average energy consumption based on pre-existing refrigerators' ages, per ENERGY STAR, as obtained from the 2014 program-tracking database. Pre-existing unit information was not available in the 2015 or 2016 program-tracking database.

[33] Minnesota Municipal Utilities Association. "Water Heating Load Control." http://www.mmua.org/html/CIP/CIPdocs/pt_loadcontrol95.doc.

6. The Home Performance Direct Program

The HPD and HPwES programs work in concert to provide homeowners with free and low-cost measures and information to encourage greater energy savings. Together, the programs consist of a full-home audit; a Home Energy Score; and possible incentives for new, efficient equipment.

The HPD program conducts free, full-home energy audits by a certified Building Performance Institute (BPI) contractor for 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.[34] The BPI-certified contractor also provides participants with free air- and duct-sealing measures, up to 20 free CFLs or LEDs, and, for customers with electric hot water, efficient faucet aerators and efficient shower heads. Upon completion of the audit, participants are provided with an assessment report that includes an energy efficiency score for the home and suggested improvements, along with estimated energy savings (in dollars).

The HPD program implementation remained mostly consistent between the 2015 and 2016 evaluations, with the exception of the introduction of LEDs in July 2016. Participants whose initial HPD visit occurred prior to July 1, 2016, received CFLs, similar to past program years, while those participating after June 30, 2016, received LEDs. Additionally, prior changes in program eligibility (and targeting) in 2013 shifted the composition of the participant base to a lower proportion of electric space-heated (ESH) homes since that time.

Impacts for Comparison to Goals and Cost-Effectiveness

As in the 2015 evaluation, the evaluation team used two approaches to estimate ex post savings for the HPD program in 2016: an engineering analysis and a billing analysis. Because the billing analysis used actual customer electric usage to estimate savings, and is therefore more realistic and comprehensive than engineering estimates, we based the savings from the program on the results of the billing analysis. Table 6-1 provides a review of impacts for the program in 2016 by measure category. We applied the results of the billing analysis for the purposes of goal comparison and cost-effectiveness analysis for all measure categories. The engineering analysis provides a comparison to the billing analysis and a way to estimate demand savings, an output that is unavailable from a billing analysis that relies upon monthly billing data.

Table 6-1. HPD Program Net Impacts for Goal Comparison and Cost-Effectiveness

Measure Category	N[a]	Ex Ante Net Savings		Evaluated/Ex Post Net Savings		Realization Rate	
		kW	kWh	kW	kWh	kW	kWh
Duct Sealing	2,367	1,794	1,004,512	1,224	685,359	68%	68%
LED Bulbs	1,069	712	712,912	56	486,405	8%	68%
CFL Bulbs	1,596	150	1,736,773	136	1,184,965	91%	68%
Air Sealing	2,422	60	87,114	41	59,436	68%	68%
Heating and Hot Water	1,305	50	63,032	23	43,006	47%	68%
Seal Existing Attic Hatch	1	0	17	0	12	68%	68%
Total	**2,613**	**2,766**	**3,604,360**	**1,480**	**2,459,182**	**54%**	**68%**

[a] Number of HPD program projects with measures in 2016.
Note: Totals may not sum due to rounding.

[34] The type and extent of HPD 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 HPD program visit.

Reasons for Differences in Impacts

The billing analysis found that the HPD and HPwES programs realized 68% of their expected net energy savings. To estimate demand savings, we calculated a ratio between energy and demand using the engineering analysis for the HPD program, and applied this ratio to the billing analysis energy savings. Applying the ratio resulted in the HPD program achieving 54% of its expected peak demand savings. We describe the billing and engineering analyses in more detail below.

Billing Analysis

The evaluation team conducted a billing analysis with the goal of determining the overall ex post net program savings for the HPD and HPwES programs. Given the overlap between the two programs and the relatively small number of participants in each program, we estimated program savings by combining the two programs. This approach allowed us to maximize the number of data points used for the analysis and thus increased both the precision and robustness of our results. Estimating separate models for the HPD and HPwES programs significantly reduces the number of observations used for modeling, which typically results in poorer model fit and estimates that are unstable and susceptible to outliers. Since the HPD and HPwES programs follow a similar program design and exhibit overlap in participants, a combined model approach yields the most accurate estimates of program savings.

Our billing analysis used 2015 participants as the treatment group because the method requires post-participation installation electricity usage data for approximately 1 year after participation.[35] We also included a comparison group consisting of households that participated in 2016. The comparison group helps us assess the counterfactual or baseline for the treatment group (2015 participants) in the post-participation period. As such, results from the billing analysis are net results and application of a NTGR is inappropriate.

Program participation was quite similar across program years, with mostly small differences in the share of measures in the 2015 and 2016 program years (as shown in Table 6-2) and no substantive change in program design across the two years. In both years, lighting accounted for the vast majority of savings (76% in 2015 and 69% in 2016), with duct sealing also contributing a significant share (21% in 2015 and 27% in 2016). Overall, the analysis of the measure composition shows that the two program years are comparable and that it was appropriate to use 2016 as a comparison group.

Table 6-2. Comparison of HPD Program Installed Measures for Participants in Billing Analysis

	Billing Analysis Treatment Group (2015 Participants) n=1,486		Billing Analysis Comparison Group (2016 Participants) n=2,059	
Measures Installed	Percentage of Participants	Percentage of Gross kWh	Percentage of Participants	Percentage of Gross kWh
Air Sealing	92.0%	2.1%	92.9%	2.3%
DHW	3.1%	0.8%	2.7%	1.0%
Duct Insulation	0.3%	0.0%	0.7%	0.0%
Duct Sealing	91.0%	20.6%	90.7%	27.0%
Duct Wrap	38.8%	0.6%	46.7%	0.5%
Insulation	0.0%	0.0%	0.2%	0.0%
Lighting	96.7%	75.8%	97.6%	69.2%

[35] Note that participants who initiated participation in 2015 and continued participating in 2016 (i.e., through the HPwES program) are considered 2015 participants for the purpose of the billing analysis.

The billing analysis model is a LFER CDA model, which utilizes individual indicator variables to represent the presence of any major measure installation. The model also makes individual adjustments for the energy consumption effects of household factors that do not vary over time using customer-specific intercept terms in the equation. This includes such things as square footage, appliance stock, habitual behaviors, household size, and any other factor that stays constant, with constant energy consumption over the period in the models.

To improve our estimate of the counterfactual (or baseline—what 2015 participants would have done during the post-participation period absent the program), we included indicator variables for each month-year of the evaluation period. The monthly indicator variables provide information on time trends that affect both the participant and comparison groups. The monthly indicator variables help adjust for changes in usage that are the same across all participating and comparison group customers, such as economic factors. We also included 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 billing analysis to determine the overall program realization rate for the HPD and HPwES programs combined. We chose not to include measure realization rates due to the considerable number of participants who installed *both* lighting and weatherization measures. Such overlap makes it impossible to accurately estimate individual measure effects, since important measures are highly collinear, and other measures are very low-frequency. The collinearity produces high variances, and therefore too much uncertainty around the estimates. As a result, the low-frequency measures do not produce sufficient numbers to allow stable estimates. As such, we report the results only for the overall program effect.

Table 6-3 presents the overall net program savings for 2015 HPD and HPwES programs' participants. The 2015 HPD and HPwES programs realized 64% of their expected net savings.

Table 6-3. Savings from HPD and HPwES Programs Billing Analysis Compared to Ex Ante Savings Estimates

		Observed Savings		Program-Planning Savings		
End-Use	N[a]	Household Daily kWh Savings	Household Annual kWh Savings	Household Daily kWh Savings	Household Annual kWh Savings	Realization Rate
Overall Savings	1,752	2.16	788	3.38	1,235	64%

[a] Participants in the billing analysis treatment group.

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 billing analysis energy savings to estimate billing demand savings.

The program applies 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 2016, we developed a net realization rate using the billing analysis and therefore did not apply the NTGRs.

Table 6-4 provides a review of impacts for the program in 2016 by category based on an engineering estimate of savings.

Table 6-4. HPD Program Measure-Specific Net Impacts: Engineering Approach

Measure Category	N[a]	Net ExAnte Net Savings		Net Evaluated Net Savings		Realization Rate	
		kW	kWh	kW	kWh	kW	kWh
Duct Sealing	2,367	1,794	1,004,512	1,794	1,004,490	100%	100%
LED Bulbs	1,069	712	712,912	88	765,956	12%	107%
CFL Bulbs	1,596	150	1,736,773	143	1,243,928	95%	72%
Air Sealing	2,422	60	87,114	60	87,112	100%	100%
Heating and Hot Water	1,305	50	63,032	33	60,954	66%	97%
Seal Existing Attic Hatch	1	0	17	0	17	100%	100%
Total	**2,613**	**2,766**	**3,604,360**	**2,118**	**3,162,457**	**77%**	**88%**

[a] Number of HPD projects with measures in 2016.
Note: Totals may not sum due to rounding.

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

- **Duct Sealing and Air Sealing:** For duct sealing and air sealing measures, no information was available regarding input values for the ex ante savings algorithms. We examined the program savings algorithms in prior years and determined that it was reasonable based on engineering judgment. To remain consistent with last year, we assigned a 100% realization rate for these measures.
- **Lighting:** For lighting measures, we estimated savings for LED and CFL bulbs as follows:
  - For LED bulbs, the evaluation team estimated an average installed wattage based on program-tracking data and leveraged ENERGY STAR's latest equivalent baseline wattage table to estimate the baseline wattage. For common LED installations, the program's planning assumptions for gross and net demand savings were 0.036771 kW/unit and 0.005339 kW/unit, respectively. From tracking data, the evaluation team verified that the gross demand savings assumption was applied appropriately, but the assumption for net demand savings was 0.04045 kW/unit. For specialty LED installs, the program's planning assumptions for gross and net demand savings were 0.052128 kW/unit and 0.00757 kW/unit, respectively. From tracking data, the evaluation team verified that the gross demand savings assumption was applied appropriately, but the assumption for net demand savings was 0.05735 kW/unit.
  - For CFL bulbs, the evaluation team estimated an average installed wattage based on program-tracking data and applied an assumed multiplier to estimate baseline wattage. The multiplier was based on the correlation between installed and removed bulbs found in 2016 REAP program tracking data. The evaluation team hypothesizes that discrepancies between ex ante and ex post savings may be caused by differences in the assumed baseline and installed wattages and/or with coincidence factors and assumed hours of use.
- **Heating and Hot Water:** Shower heads, faucet aerators, pipe insulation, tank wrap, and temperature turndown measures account for the DHW savings attributable to the HPD program. The program's tracking data lacked sufficient detail to identify all differences between ex ante and evaluated savings. While these measures are a relatively small component of program savings, PSEG Long Island may want to consider making additions to the program's tracking database to capture additional per-installation details, such as R-value and area (sf) of installed tank wrap. Several key assumptions and savings calculation methods are summarized below.
  - The pre-existing faucet aerator flow rates in gpm were used to estimate gpm and energy savings.

- The pre-existing shower head flow rate information for HPD was not available, so evaluators used 2014 REAP program data for baseline shower head gpm to estimate energy savings.
- The evaluation team calculated the evaluated savings for pipe insulation using DOE 3E Plus software, while the savings for tank wrap measures were calculated using engineering assumptions on boiler surface losses.
- When estimating peak demand savings, we used a coincidence factor of 0.23 adopted from a study of electric hot water heaters.[36] Due to the low peak demand realization rates, we believe that the program used a higher value for the coincidence factor when calculating ex ante savings.

[36] Minnesota Municipal Utilities Association. “Water Heating Load Control.” http://www.mmua.org/html/CIP/CIPdocs/pt_loadcontrol95.doc.

7. The Home Performance with ENERGY STAR Program

The HPD and HPwES programs work in concert to provide homeowners with free and low-cost measures and information to encourage greater energy savings. Together, the programs consist of a full-home audit; a Home Energy Score; and possible incentives for new, efficient equipment.

The HPwES program includes a home audit by a BPI-accredited contractor to evaluate heating and cooling equipment and to assess insulation levels and air leakage. The HPwES program encourages the installation of weatherization, insulation, and other building shell measures through incentives. Homeowners are eligible to receive an incentive from PSEG Long Island for 15% (up to $1,000) of eligible measures installed under the HPwES program. Customers may be eligible for additional incentives and low-interest on-bill financing from NYSERDA for energy efficiency home improvements made as part of the HPwES program. Program implementation was not changed for the 2016 program year.

Impacts for Comparison to Goals and Cost-Effectiveness

As in prior evaluations, the evaluation team used two approaches to estimate ex post savings for the HPwES program in 2016: an engineering analysis and a billing analysis. Because the billing analysis uses actual customer usage to estimate savings, and is therefore more robust than engineering estimates, we based the savings from the program on the results of the billing analysis. Table 7-1 provides a review of impacts for the program in 2016 by category. As described below, we use the billing analysis results for all evaluated savings.

Table 7-1. HPwES Program Net Impacts for Goal Comparison and Cost-Effectiveness

Measure Category	N[a]	Ex Ante Net Savings		Evaluated/Ex Post Net Savings		Realization Rate	
		kW	kWh	kW	kWh	kW	kWh
HVAC	371	324.3	110,213	120.0	75,196	37%	68%
Building Envelope	598	142.7	145,691	97.3	99,402	68%	68%
Air Sealing	576	32.4	37,652	22.1	25,689	68%	68%
Hot Water	95	12.5	25,035	8.2	17,081	66%	68%
Refrigerator	12	8.8	17,593	1.4	12,004	16%	68%
Lighting	53	7.5	55,262	4.3	37,704	58%	68%
Total	612	528.1	391,446	253.4	267,076	48%	68%

[a] Number of HPwES projects with measures in 2016.
Note: Totals may not sum due to rounding.

Reasons for Differences in Impacts

The billing analysis found that the HPD and HPwES programs realized 68% of their expected net energy savings. To estimate demand savings, we calculated a ratio between energy and demand using the engineering analysis, and then applied this ratio to the billing analysis energy savings. Applying the ratio resulted in the HPwES program achieving 48% of its expected peak demand savings. We describe the billing and engineering analyses in more detail below.

Billing Analysis

The evaluation team conducted a billing analysis with the goal of determining the overall ex post net program savings for the HPD and HPwES programs. Given the overlap between the two programs and the relatively small number of participants in each program, we estimated program savings by combining the two programs. This approach allowed us to maximize the number of data points used for the analysis and thus increased both the precision and robustness of our results. Estimating separate models for the HPD and HPwES programs significantly reduces the number of observations used for modeling, which typically results in poorer model fit and estimates that are unstable and susceptible to outliers. Since the HPD and HPwES programs follow a similar program design and exhibit overlap in participants, a combined model approach yields the most-accurate estimates of program savings.

Our billing analysis used 2015 participants as the treatment group because the method requires post-participation installation electricity usage data for approximately 1 year after participation.[37] We also included a comparison group consisting of households that participated in 2016. The comparison group helps us assess the counterfactual or baseline for the treatment group (2015 participants) in the post-participation period. As such, results from the billing analysis are net results and application of a NTGR is inappropriate.

Program participation was quite similar across program years, with small differences in the share of those measures accounting for the majority of differences between savings in 2015 and 2016 (Table 7-2). In both years, insulation, duct sealing, and duct wrap contributed more than half of ex ante program savings. Differences between 2015 and 2016 for other measures are also small and account for less than half the ex ante savings. Overall, the analysis of the measure composition shows that the two program years are comparable.

Table 7-2. Comparison of HPwES Program Installed Measures for Participants in Billing Analysis

	Billing Analysis Treatment Group (2015 Participants) n=428		Billing Analysis Comparison Group (2016 Participants) n=465	
Measures Installed	Percentage of Participants	Percentage of Gross kWh	Percentage of Participants	Percentage of Gross kWh
Air Sealing	96.7%	7.4%	94.0%	10.0%
Attic Work	70.6%	1.3%	61.7%	2.0%
DHW Work	20.8%	5.0%	14.0%	6.9%
Duct Insulation	32.5%	6.2%	16.6%	3.5%
Duct Sealing	35.3%	21.4%	39.8%	19.9%
Duct Wrap	15.7%	16.3%	20.4%	12.9%
HVAC	20.6%	4.0%	15.1%	-7.2%
Insulation	97.7%	21.5%	97.0%	31.5%
Lighting	7.7%	11.6%	9.0%	15.5%
Pipe Insulation	2.6%	0.0%	2.4%	0.0%
Refrigerator	1.6%	3.8%	1.7%	4.4%
Thermostat	6.5%	1.0%	3.9%	0.2%
Windows and Doors	5.8%	0.5%	5.4%	0.5%

[37] Note that participants who initiated participation in 2015 and continued participating in 2016 (i.e., through the HPwES program) are considered 2015 participants for the purpose of the billing analysis.

We used the billing analysis to determine the overall program realization rate for the HPD and HPwES programs combined. As such, the methods for the billing analysis outlined in Section 6 are also applicable here.

As shown in Section 6, the 2016 HPD and HPwES programs realized 64% of their expected net savings. Not shown are the measure-level realization rates for lighting and weatherization due to the high degree of uncertainty around the parameter estimates.[38]

Table 7-3. Savings from HPD and HPwES Programs Billing Analysis Compared to Ex Ante Savings Estimates

End-Use	N[a]	Observed Savings		Program-Planning Savings		Realization Rate
		Household Daily kWh Savings	Household Annual kWh Savings	Household Daily kWh Savings	Household Annual kWh Savings	
Overall Savings	1,752	2.16	788	3.38	1,235	64%

[a] Participants in billing analysis treatment group.

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 billing analysis energy savings to estimate billing demand savings.

The program applies a planning NTGR of 1.0 for each program measure category to develop the ex ante savings estimates. For 2016, we developed a net realization rate using the billing analysis and therefore did not apply the NTGRs.

Table 7-4 provides a review of impacts for the program in 2016 by category based on an engineering estimate of savings.

Table 7-4. HPwES 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
HVAC	371	324.3	110,213	335.3	210,210	103%	191%
Building Envelope	598	142.7	145,691	142.7	145,688	100%	100%
Air Sealing	576	32.4	37,652	32.4	37,651	100%	100%
DHW	95	12.5	25,035	12.6	26,198	101%	105%
Refrigerator	12	8.8	17,593	1.2	9,744	13%	55%
Lighting	53	7.5	55,262	4.7	40,859	63%	74%
Total	**612**	**528.1**	**391,446**	**528.8**	**470,350**	**100%**	**120%**

[a] Number of HPwES projects with measures in 2016.

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

- **HVAC:** For HVAC measures, the evaluated demand savings were 3% higher than ex ante, while evaluated energy savings were 91% higher. For 2016, the evaluation team was provided with detailed

[38] See detailed methodology section for more.

installation data for HVAC equipment, including size, age, and efficiency of removed equipment, which led to more-accurate evaluated savings calculations. No reference information on program algorithms or assumptions was available for the evaluation team to identify specific reasons for the discrepancy in savings. The evaluation team followed the same per-install calculation methods used for similar measures within the Cool Homes program. For ASHP installations, the evaluation team determined that the program estimated negative ex ante savings for both kW and kWh, and this contributed to the higher realization rate.

- Building Envelope: For building envelope measures, the program-tracking data did not include information on R-values of pre-existing or installed insulation, windows, or doors. Due to the lack of program-tracking data, the evaluation team assigned a 100% realization rate for energy and peak demand savings for envelope measures. Going forward, we recommend that the program develop and use more-transparent algorithms for determining ex ante savings values for building envelope measures.
- Air Sealing: For air sealing measures, no information was available on the algorithm inputs used to develop ex ante savings estimates. The evaluation team examined the program savings algorithm in prior years and determined that it was reasonable based on engineering judgment. We assigned a 100% realization rate for these measures.
- Domestic Hot Water: For DHW measures, including pipe insulation and water heater replacement, the program's tracking data lacked sufficient detail to identify specific differences between ex ante and evaluated savings. While these measures are a relatively small component of HPwES program savings, PSEG Long Island should consider making additions to the program's tracking database to capture additional per-installation details, such as type of pipe insulation and size of the replaced water heater. The following points summarize several key assumptions and savings calculations methods.
  - The evaluation team applied a realization rate of 100% to the hot water heater replacement measures, similar to previous years, due to a lack of program-tracking data.
  - Our team calculated the evaluated savings for tank wrap measures using engineering assumptions for boiler surface losses.
  - The evaluation team calculated the evaluated savings for pipe insulation using DOE 3E Plus software, resulting in a realization rate of 77% for demand and 356% for energy for these measures. Due to the relatively small contribution to hot water savings, these realization rates did not affect the overall hot water realization rates.
- Refrigerator: Ex ante refrigerator savings are significantly higher than those of other residential programs, such as EEP and REAP. The evaluation team cannot determine specific reasons for this discrepancy, as detailed refrigerator characteristics are not available from HPwES program-tracking data. Evaluated savings for the 15 refrigerators installed in 2016 reflect the weighted average ENERGY STAR-recommended savings based on 2016 installed refrigerator sizes and configurations. The baseline refrigerators represent a weighted average energy consumption based on year of pre-existing refrigerator, per ENERGY STAR. Since the 2016 HPwES program-tracking spreadsheet did not contain information on the age of the pre-existing refrigerators, 2014 REAP program data for 448 installations were used by the evaluation team when performing these weighted savings calculations.
- Lighting: For lighting measures, no information was available on algorithm inputs used to develop ex ante savings estimates. Information on removed lighting wattages was not available in the program-tracking data. The evaluation team estimated an average installed wattage based on program-tracking data from other similar PSEG Long Island programs and applied an assumed multiplier to estimate baseline wattage based on a correlation between installed and removed bulbs found in 2016 REAP

program-tracking data. The evaluation team believes that the REAP program tracking data are representative of residential lighting baseline per our research on lumen equivalence between incandescent and CFL bulbs. The evaluation team hypothesizes those discrepancies between ex ante and ex post savings may be caused by differences in the assumed baseline and installed wattages and/or with coincidence factors and assumed hours of use.

8. The Solar Photovoltaic Program

In 2016, PSEG Long Island continued to offer rebates 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 to residential projects as large as 25 kW for residential projects and up to 200 kW for commercial projects. Within some commercial blocks, the per-watt incentive is slightly higher for the first 50 kW of the project than for any additional kW. Table 8-1 provides the layout of the MW block structure.

Table 8-1. NY-Sun MW Block Structure for Long Island

	Residential		Nonresidential		
	MW	Incentive/Watt	MW	Incentive/Watt, First 50 kW	Incentive/Watt, up to 200 kW
Block 1	37	$0.50	7	$0.50	$0.50
Block 2	15	$0.40	6	$0.45	$0.43
Block 3	20	$0.30	7	$0.40	$0.36
Block 4	77[a]	$0.20	9	$0.35	$0.30
Block 5			22	$0.25	$0.23
Block 6			14	$0.15	$0.15

[a] Revised (initially 50 MW).

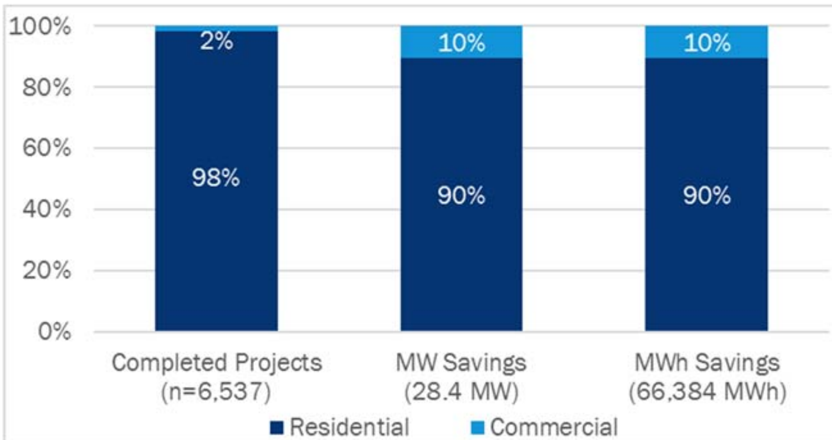
The final block of funding for Long Island region residential rebates was fully allocated in April 2016, meaning no new applications for rebates were accepted after that point. However, the program continued to accept applications for solar for the On-Bill Recovery Finance Program offered by Green Jobs – Green New York through the remainder of the year. On the commercial side, funding for the first four blocks and approximately 25% of the fifth block was claimed by the end of 2016.

The NY-Sun program continued to require that participating contractors possess North American Board of Certified Energy Practitioners (NABCEP), International Brotherhood of Electrical Workers (IBEW)-National Electrical Contractors Association (NECA), or Underwriters Laboratories (UL) certification. The program also maintained a hands-off approach to marketing and outreach, allowing contractors to communicate the program benefits to their customers. In previous years, these companies coordinated advertising and door-to-door campaigns to recruit residential customers. Leasing and power purchase agreements (PPAs) continued to drive residential participation in 2016, accounting for nearly two-thirds (62%) of residential solar PV systems rebated by the program. Leases and PPAs accounted for slightly fewer than half (48%) of commercial PV systems.

In September 2016, program staff transferred their program-tracking system from PowerClerk to Salesforce. All NY-Sun projects were included in the transfer, except for the final six projects funded by PSEG Long Island's Legacy Solar Pioneer program, completed in 2016, remain in the legacy program's Siebel program-tracking system.

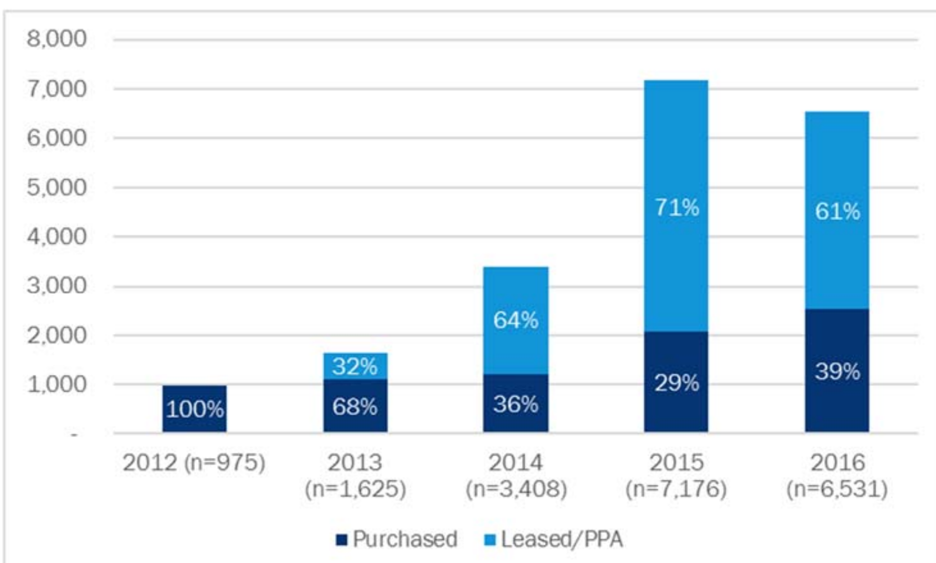
In 2016, PSEG Long Island provided rebates or financing for 6,537 solar PV systems, amounting to fewer projects than the previous year for the first time since 2012. The program attributes this slowdown to the exhaustion of rebates for residential projects in April 2016. For the previous 4 years of the program, the number of projects roughly doubled from the prior year (975 in 2012, 1,625 in 2013, 3,408 in 2014, and 7,176 in 2015). As in 2015, residential systems accounted for the vast majority of installations (98%) and energy and demand savings (90%). Figure 8-1 provides a breakdown of 2016 completed projects and savings by sector.

Figure 8-1. Solar PV Projects and Associated Savings by Sector



Leases continued to account for the majority of residential projects, although for the first time in the program's history, they accounted for a lower portion of projects than in the prior year. Program staff reported that the growth rate for leasing companies seems to have flattened out, but the market remains robust. Figure 8-2 illustrates changes in participation over the past 4 years broken out by payment method.

Figure 8-2. PV Systems Installed per Year by Purchase Type (2012–2016)



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

Residential projects continued to vastly exceed expectations, reaching more than 140% of its goals for both energy and demand savings, while the commercial side of the program fell short of its goals, achieving 66% and 65% of its MW and MWh goals, respectively. Approximately one-third (32%) of projects completed in 2016 were initiated in 2016, while 66% of projects were started in 2015. The remaining 2% of projects began in 2014 or 2013, including the six projects initiated by the legacy Solar Pioneer program.

Program staff expect that commercial participation will continue to increase in 2017, and anticipate the rollout of a new residential financing initiative that would work much like the current Green Jobs – Green New York initiative, but the New York Green Bank is the facilitator.

IMPACTS FOR GOAL COMPARISON

For the 2017 evaluation, the evaluation team completed a desk review of PSEG Long Island's Solar PV tracking data. Recalculation of ex ante savings resulted in slightly lower demand and energy savings (by 2% and 5%, respectively). Table 8-2 shows the evaluated and ex ante savings for the PSEG Long Island solar program (including both NY-Sun and Legacy projects) by program sector.

Table 8-2. Solar PV Residential and Nonresidential Net Impacts for Goal Comparison

Program	N	Ex Ante Net Savings		Evaluated Net Savings		Realization Rate	
		kW	kWh	kW	kWh	kW	kWh
Residential	6,434	25,876	62,380,064	25,469	59,548,258	98%	95%
Commercial	103	2,979	7,558,840	2,924	6,836,226	98%	90%
Total	6,537	28,855	69,938,904	28,393	66,384,484	98%	95%

Note: Totals may not sum due to rounding.

For the first time, the evaluation team independently verified the accuracy of program performance test conditions (PTCs) output estimates. For a selection of 91 projects in the 2016 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 a 0.4% 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 2016 installations to determine verified ex ante saving for the 6,537 installations completed in 2016.

The evaluation team received clarification from PSEG Long Island staff on how they mapped the fields from 2015 in PowerClerk to Salesforce in 2016. We observed that the contents of the "CEC PTC ratings" fields were not transferred from PowerClerk to Salesforce, and the program had to recalculate the CEC PTC ratings for legacy projects. We believe this caused the slight difference between program savings and verified ex ante savings.

The evaluated and ex post demand savings differed from ex ante savings for two reasons. First, we 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. The lower evaluated and ex post energy savings result from the application of 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, which is lower than the modeled value of 1.128 used in program planning and ex ante savings estimates.

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, and the evaluated NTGR was set to 1.0 (equal to the program-planning value).[39] The values in Table 8-3 show the savings by program for the cost-effectiveness calculations. Since the NTGRs for both the evaluated and ex post savings are the same value, this table is identical to Table 8-2 above, as are the reasons for the differences in impacts.

Table 8-3. Solar PV Residential and Nonresidential Net Impacts for Cost-Effectiveness

		Ex Ante Net Savings		Evaluated Net Savings		Realization Rate	
Program	**N**	**kW**	**kWh**	**kW**	**kWh**	**kW**	**kWh**
Residential	6,434	25,876	62,380,064	25,469	59,548,258	98%	95%
Commercial	103	2,979	7,558,840	2,924	6,836,226	98%	90%
Total	6,537	28,855	69,938,904	28,393	66,384,484	98%	95%

Note: Totals may not sum due to rounding.

[39] 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 2016 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 2016 was limited mainly to in-depth interviews with program and implementation staff to provide context for our impact evaluation and to assess program processes. However, as part of the In-Home Study completed for the EEP program, the evaluation team performed primary data collection through customer phone interviews and site visits (see Section 9.4 for details). 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 2016. 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 2016 Evaluation

	Qualitative Analysis of In-Depth Interviews	Secondary Data Review	Survey and In-Home Site Visit Primary Research	Billing Analysis	Engineering Review of Algorithms	Engineering Desk Review of Projects
Program	Process/Impact	Process/Impact	Process/Impact	Impact	Impact	Impact
CEP	X	X			X	X
EEP	X	X	X		X	
Cool Homes	X				X	
REAP	X			X	X	
HPD/HPwES	X			X	X	
Solar PV	X				X	

9.3 Commercial Efficiency Programs

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 2016 CEP evaluation, we conducted in-depth interviews in December 2016 with three program staff members at Lockheed Martin who are responsible for the implementation of the CEP. The interviews were designed to understand programmatic changes made in 2016 and planned in 2017, to gather program staff perspectives on program performance and effectiveness of processes, and to understand any challenges that the program experienced in 2016.

Engineering Analysis

In 2016, the evaluation team performed two types of engineering analysis: a review of program-tracking data (Siebel and LM Captures) 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.

We reviewed program-tracking data and applied engineering algorithms to evaluate savings for all prescriptive measures except for Prescriptive Lighting and Performance Lighting measures. We relied on the engineering desk reviews of a sample of 72 projects to determine ex post savings for the following CEP components: Prescriptive Lighting and Performance Lighting, Existing Retrofit Non-Lighting, and Existing Retrofit Lighting. 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.[40]

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 2016. Instead, we relied on the realization rates determined through on-site M&V work completed as part of the 2012 evaluation. We are working with PSEG Long Island to update our Custom realization rates for 2017.

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.[41] 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. 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 Prescriptive Lighting and Performance Lighting, Existing Retrofit Non-Lighting, and Existing Retrofit Lighting 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

[40] Detailed data that are useful for an engineering analysis are stored in Siebel and LM Captures as attachments. We used project total gross demand savings to pull our sample for each component.

[41] 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).

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[42] 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.[43]

$$n_h = n \frac{N_h s_h}{\sum N_h s_h} \qquad (1)$$

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 since the overall sampling fraction is large and some strata are much more variable than others. If the original allocation gives, for example, a n_1 that is greater than N_1, then equation 1 is revised as follows:

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

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:

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

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.

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[42] Kish, L. (1995). *Survey Sampling.* Wiley Classics Library Edition.

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

ENGINEERING REVIEW SAMPLE DESIGN

In 2016, the CEP transitioned from Siebel to LM Captures. Furthermore, in early 2016, the program saw a short-term backlog of applications. Adjusting to the new data capture and management system, as well as processing a high volume of 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 9-2 shows the sample designs for the three program components. As can be seen in the table, for each program component, we developed three distinct sampling frames—Siebel, Early LM Captures (January–April 2017), and Remaining LM Captures—and drew either a simple random or stratified random sample from each. 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 9-2. CEP Prescriptive Lighting, Existing Retrofit Lighting, and Existing Retrofit Non-Lighting Engineering Review Sample Design

Sampling Component	Sample Design	Total Ex Ante Savings (kW)	Projects in Population[a]	Projects in Sample
Prescriptive Lighting and Performance Lighting				
Siebel	Simple Random	341	43	5
LM Captures – January to November	Stratified Random	1,471	294	8
LM Captures – January to April[b]	Simple Random	500	282	5
LM Captures – May to November[b]	Stratified Random	884	541	7
Total		**3,195**	**1,160**	**25**
Existing Retrofit Lighting Projects				
Siebel	Stratified Random	4,383	530	10
LM Captures – January to April		3,975	822	12
LM Captures – May to November	Simple Random	10,908	1,796	13
Total		**19,266**	**3,148**	**35**
Existing Retrofit Non-Lighting Projects				
Siebel	Simple Random	289	48	5
LM Captures – January to April		91	18	2
LM Captures – May to November	Stratified Random	324	67	5
Total		**18,604**	**2,296**	**12**

[a] At the time of sampling, population included projects completed from January to November, 2016.
[b] The need for this sampling component was a result of the error in project classification that Opinion Dynamics made. All of these projects are Fast Track Lighting, yet we erroneously classified them as Existing Retrofit Lighting. We corrected the error by separating these Fast Track projects as an independent sampling component and drawing a simple random sample of projects for desk reviews.

Table 9-3 provides strata boundaries for program components where we relied on a stratified random sample design.

Table 9-3. Strata Boundaries for Stratified Sample Design

Stratum	Boundaries (kW)	Total Ex Ante Savings (kW)	Projects in Population	Projects in Sample
Prescriptive Lighting and Performance Lighting (LM Captures January – November)				
1	0.0–15.0	519	278	3
2	16.0–160.0	559	14	3
3	161.0–232.0	393	2	2
Subtotal		1,471	294	8
Prescriptive Lighting and Performance Lighting (LM Captures May – November[a])				
1	0–0.6	418	428	2
2	2.1–25.0	466	113	5
Subtotal		884	541	7
Existing Retrofit Lighting (Siebel)				
1	0.0–6.0	1,119	367	3
2	7.0–41.0	1,792	144	4
3	42.0–240.0	1,473	19	3
Subtotal		4,383	530	10
Existing Retrofit Lighting (LM Captures January – April)				
1	0.0–4.0	939	594	3
2	4.1–15.0	1,328	171	3
3	15.1–103.0	1,709	57	6
Subtotal		3,975	822	12
Existing Retrofit Non-Lighting (LM Captures May-November)				
1	0.0–0.5	118	51	2
2	6.0–40.0	206	16	3
Subtotal		324	67	5

[a] The need for this sampling component was a result of the error in project classification that Opinion Dynamics made. All of these projects are Fast Track Lighting, yet we erroneously classified them as Existing Retrofit Lighting. We corrected the error by separating these Fast Track projects as an independent sampling component and drawing a simple random sample of projects for desk reviews.

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[44] to extrapolate results for each site back to the overall 2016 component population. Figure 9-1 shows the algorithm we used to extrapolate the results to the population of projects.

Figure 9-1. Ratio Adjustment Algorithm

$$I_{EP} = \frac{I_{EPS}}{I_{EAS}} * I_{EA}$$

where:

I_{EP} = the ex post population impact
I_{EA} = the ex ante population impact
I_{EPS} = the ex post impact from the sample
I_{EAS} = the ex ante impact from the sample
I_{EPS} / I_{EAS} = realization rate

There are background algorithms that are used as part of the ratio adjustment algorithm that we describe next. To obtain the phase-specific realization rate, we used the following algorithm:

$$Realization\ Rate = \sum_{i=1}^{n} \frac{Ex\ Post\ Savings_i * W_{si}}{Ex\ Ante\ Savings_i * W_{si}}$$

where:

W_{si} = expansion weight for stratum I (shown in tables above)

$Savings_i$ = project values for sampled projects

Once we obtain the realization rate, we calculate the standard error, error bound, and relative precision, as shown next.

$$e_i = Ex\ Post\ Savings_i - (Realization\ Rate * Ex\ Ante\ Savings_i)$$

$$Standard\ Error = \sqrt{\frac{W_{si}(W_{si} - 1) * e_i^2}{\sum_{i=1}^{n} Ex\ Ante\ Savings_i * W_{si}}}$$

$$Error\ Bound = 1.645 * Standard\ Error$$

$$Relative\ Precision = \frac{Error\ Bound}{Realization\ Rate}$$

[44] Judith T. Lessler and William D. Kalsbeek. *Nonsampling Error in Surveys.* 1992. p. 269.

To pull together the multiple samples and arrive at a single precision for the population, we used the following algorithm:

$$Relative\ Precision\ across\ Multiple\ Samples = \frac{\sqrt{Error\ Bound_1\ + Error\ Bound_2\ + Error\ Bound_n}}{\sum_1^n Ex\ Post\ Savings_i}$$

9.4 Energy Efficient Products Program

The evaluation team conducted an in-depth interview with the EEP program manager, reviewed program-tracking data, and conducted primary research for the 2016 EEP program evaluation. In the summer of 2016, Opinion Dynamics conducted an In-Home Study, contacting 788 customers for the eventual completion of 144 in-home site visits. We collected data on the prevalence of lighting technologies, dehumidifiers, and pool pumps. We found that, since our previous in-home study in 2013, energy-efficient lighting penetration has grown by 45 percentage points and that more than two-fifths of all bulbs in PSEG Long Island homes are now energy-efficient bulbs (42% are either CFL or LED). To understand the context around the growth of energy-efficient products on Long Island, we conducted exploratory research and secondary research. We explored trends in program-tracking data for lighting products, pool pumps, room ACs, clothes washers, and clothes dryers. We then provided context to these program data trends through secondary research on regional and national market trends and policy shifts. Section 3 reports on these findings in more detail.

In 2016, the evaluation team also conducted a shelf survey to assess the availability and pricing of ENERGY STAR and non-ENERGY STAR room ACs in major Long Island retail stores. The evaluation team collected detailed information on the various models of room ACs for sale at nine participating appliance retail locations across Long Island during the week of June 27, 2016. Overall, non-ENERGY STAR room ACs were more prominent in participating retailer stores than ENERGY STAR models, accounting for 65% of all room AC models, warranting the addition of rebates for the ENERGY STAR models. The results of this study were presented in a separate report.

9.5 Cool Homes

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 Billing Analyses of REAP, HPD, and HPwES

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 2015 and 2016. PSEG Long Island also provided a billing history going back 50 months from January 2012 to December 2016 for both 2015 and 2016 program participants.[45] Prior to carrying out the statistical modeling, we matched, cleaned, and provided QA for all data.

[45] PSEG Long Island provided some of these data to the evaluation team for the 2015 evaluation and some (2016 participates) for the 2016 evaluation.

We focus primarily on the 2015 participants for analysis purposes, but retained 2016 participants to create a comparison group. We used the same data-cleaning procedures for both 2015 and 2016 participants.

Cleaning Participation 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 2016 included complete 2015 and 2016 participant data.

Our cleaning procedures were consistent with those employed in prior year's evaluations. First, we checked to make sure that all accounts had measure data. In the combined 2015–2016 REAP program-tracking data, we found one record without any measure data and removed it from the analysis. Furthermore, we flagged 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 identified nor removed any for this reason.

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 (2014), Home Performance Direct (2014–2016), Home Performance with ENERGY STAR (2014–2016), and Cool Homes (2014–2016). We identified 125 cross-participation accounts and removed them from the analysis (77 in 2015 and 48 in 2016).

For the final step in the billing data cleaning, we aggregated the remaining records into nine major end-use categories, which we then rolled up to a unique household level (defined as unique account). The nine categories are CFLs, Refrigerator, Air Sealing, Basic Interface Class, Hot Water, Dehumidifier, Duct Insulation, Duct Sealing, and Window A/C.

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 HPD, 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 participation data to match billing histories to program participants.

Cleaning Billing Data

We merged 2015 and 2016 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 zero billing days. Second, we cleaned the data for customer accounts with anomalous or insufficient data for billing 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), periods with a missing date, and those with 0 kWh of energy usage. For participants who participated in 2016 only, we did not include billing periods occurring after their first installation date, as these 2016 participants served as the comparison group.

- **Extremely High or Low Average Daily Consumption:** We removed customers with entire pre- or post-participation periods having very high or very low usage. We dropped households with average daily consumption (ADC) at or below 2 kWh/day on average (across their billing history in both the pre- and post-participation periods). We also dropped customers with extremely high usage (over 300 kWh/day). 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 2015 and 2016 program participants, and 180 days after participation for 2015 participants.
- **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 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 degrees for HDDs and 75 degrees for CDDs.[46] Using different

[46] 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

base temperatures may be more representative of actual heating and cooling behaviors of customers than using the same base point. 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 randomized control trial, but it is especially important in designs not based on random assignment. It could be that different demographics or usage patterns are the focus of program targeting efforts, or that programs provide incentives for measures that trigger different groups to apply to the program. Either scenario 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 the sections that follow.

Model Development

As mentioned previously, all models included a comparison group consisting of households that participated in 2016 to construct the counterfactual baseline (what 2015 participants would have done during their post-participation period absent the program). Billing 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 2015–2016 (up to the point of their participation in 2016) reflect equipment installations and behavioral changes that currently evaluated participants (during 2015 and early 2016) 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 2015 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 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 fulfill 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 R-sq, which gives an estimate of how much the model explains. An R-sq of 1.0 would represent a model that explains 100% of the variance in the depend variable, and an R-sq of 0.5 would explain 50%. In our quasi-

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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)" (quoted from http://www.srh.noaa.gov/ffc/?n=degdays). "If the mean temperature for the day is, say, 5 degrees higher than 75, then there have been 5 CDDs. On the other hand, if the weather has been cool, and the mean temperature is, say, 55 degrees, then there have 10 HDDs (65 minus 55 equals 10)" (paraphrased from http://www.srh.noaa.gov/ffc/?n=degdays).

experiment, R-sq will appear low because of our use of two fixed effects, but a higher R-sq 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 the 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[47] 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 evaluation team also tested measure-specific dummy variables, indicating the installation of each measure category. These variables take on a value of 1 during the period *after* a home received its final measure installation (i.e., excluding the month of the installation). In cases where a participant received multiple installations, we excluded the period between the first and last installation from the analysis. The installation variable(s) were set to 0 for all months before the start of program participation. Modeling measures that program staff installed in almost all sites does not allow the separation of those effects from general participation; and modeling relatively rare measures adds little to the explanation of variation in usage over time. Because some measures were nearly universally installed, and because others were quite rare, we chose to keep our focus on the program overall.

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 only excluded one billing month from the model. 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.

9.7 REAP Program Estimation of Savings Using Billing Analysis

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

Final Analysis Data Set

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 9-4 presents the results of

[47] 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.

cleaning participation data, integrating clean billing data, and checking for sufficient billing data for each customer.

Table 9-4. REAP Program Participation and Billing Data Cleaning Steps

	Total Accounts	Percent of Accounts
Total Unique Accounts	3,957	100.0%
Reason Account Was Dropped		
No Billing Data	157	4.0%
# of accounts remaining	3,800	96.0%
No Participant Tracking Data	0	0%
# of accounts remaining	3,800	96.0%
Cross-Participation	122	3.1%
# of accounts remaining	3,678	92.9%
Low Overall ADC: < 2 kWh	6	0.2%
Low Overall Pre-Participation ADC: < 2 kWh	3	0.1%
Low Overall Post-Participation ADC (Treat): < 2 kWh	1	0.0%
# of accounts remaining	3,668	92.7%
High Overall ADC: > 300 kWh	0	0%
High Overall Post-Participation ADC: >300 kWh	0	0%
# of accounts remaining	3,668	92.7%
Less than 45 Summer Days per Period	387	9.8%
# of accounts remaining	3,281	82.9%
Less than 60 Summer Days Post-Participation Period (Treat)	49	1.2%
# of accounts remaining	3,232	81.7%
Less Than 2 Summer Bills Post-Participation Period	197	5.0%
# of accounts remaining	3,035	76.7%
Less Than 6 Months in Pre-Participation Period Days	254	6.4%
Less Than 6 Post-Participation Billing Periods (Treat)	121	3.1%
# of accounts remaining	2,660	67.2%
Accounts Remaining for Analysis	**2,660**	**67.2%**

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 treated 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 2015 (as well as 2016) since the evaluated treatment group would have begun their post participation period sometime during 2015.

Graphing average energy consumption during the baseline period makes the similarities and differences between the groups visible. Figure 9-2 shows the ADC for December 2012 through December 2014 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, but there are some differences as well. For the most part, the comparison group seemed to use a little more energy than the treatment group, with several exceptions. Our assessment was that the groups were similar enough to warrant use of the comparison group in the analysis.

Figure 9-2. REAP Program Analysis – Baseline kWh by Sample Group in Analysis

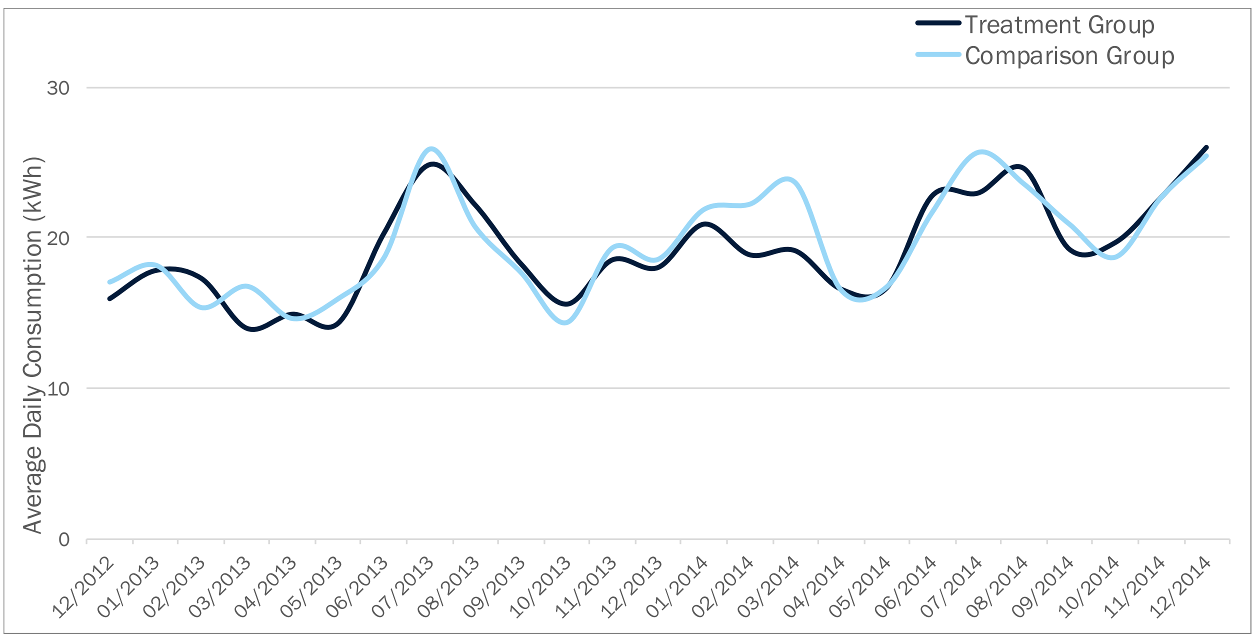


Figure 9-3 and Figure 9-4 demonstrate striking similarities in the weather patterns experienced by both groups over the course of the approximately 2 years of common pre-participation period. Thus, the groups likely occupy similar geographic areas and are affected by similar weather.

Figure 9-3. REAP Program Analysis – HDDs by Sample Group

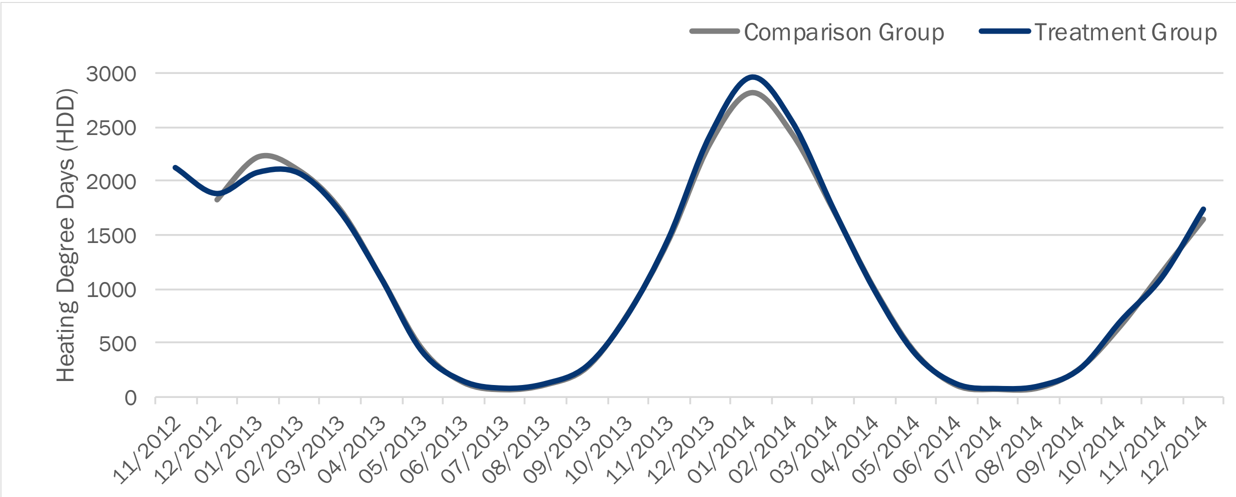
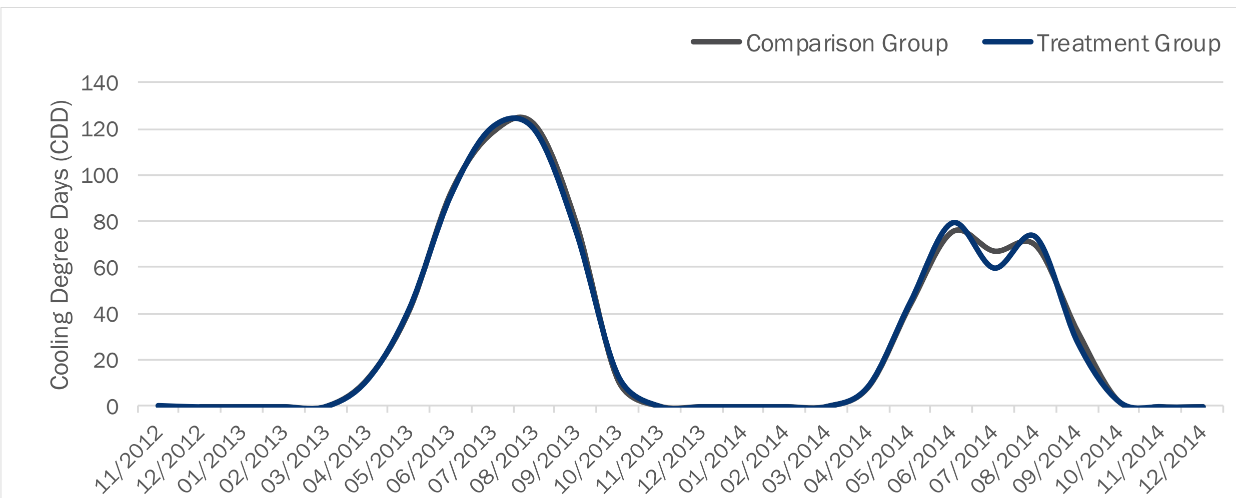


Figure 9-4. REAP Program Analysis – CDDs by Sample Group



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 in this section. Table 9-5 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 may also be associated with weather. The post-participation period included a milder winter and a warmer summer than in the pre-participation period. Because it is unclear from these summary numbers exactly how these factors may have influenced energy consumption, billing analysis is necessary to isolate program-related changes from other factors, such as the separate effects of CDDs and HDDs on consumption

Table 9-5. 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*	23.61	21.60
	SD	22.76	18.67
CDDs	*Mean*	21.95	34.33
	SD	31.95	48.22
HDDs	*Mean*	861.57	585.70
	SD	824.14	576.48

Statistical Method Used

We conducted a billing analysis to determine ex post net program savings using a 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. One measure, CFLs, was installed in most participating homes, 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 not feasible either.

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, including variables for different measures, interaction weather with the treatment and time variables, and interacting pre-participation consumption with weather and with months. 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.

The following equation represents the final model:

Figure 9-5. Final Model Equation

$$ADC_{it} = B_h + B_1 Treat_{it} + B_2 HDD_{it} + B_3 CDD_{it} + B_4 Post \cdot HDD_{it} + B_5 Post \cdot CDD_{it} + B_{t1} MY \cdot PreADC + \varepsilon_{it}$$

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_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 9-6 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, and the household characteristics (reflected in the 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). Since 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 9-6. REAP Program Billing Analysis: Final Model

					90% Confidence Interval	
Predictor	Coefficient	Robust Std. Err.	T	P > |t|	Lower	Upper
Treatment	−1.3055	0.4346	−3	0.003	−2.1577	−0.4534
HDD	−0.0040	0.0005	−8.58	<0.001	−0.0049	−0.0031
CDD	0.0913	0.0069	13.25	<0.001	0.0777	0.1048
Post-Participation Period HDD	−0.0260	0.0055	−4.69	<0.001	−0.0369	−0.0151
Post-Participation Period CDD	0.0002	0.0004	0.62	0.533	−0.0005	0.0010
Constant	36.7632	1.4482	25.39	<0.001	33.9234	39.6029

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 9-7. Adjusted Estimate of Daily Program Savings

ADC	Estimate	Std. Err.	T	P >|t|	90% Confidence Interval	
					Lower	Upper
(1)	−2.06	0.294	−7.01	<0.001	−2.546	−1.578

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 within the interval between 1.58 kWh and 2.55 kWh per day per participant.

BILLING ANALYSIS COMPARED TO EXPECTED SAVINGS

Table 9-8 compares the observed (ex post) savings from the billing 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 752 kWh per year. This compares to 812 expected savings, for a realization rate of 99%.

Table 9-8. Savings from the REAP Program Billing 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	1,155	2.06	752	2.22	812	99%

[a] Number of program participants in billing 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 9-4 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.

9.8 HPD/HPwES Estimation of Savings Using Billing Analysis

In this section, we present the statistical methods and results of a billing analysis to estimate program savings for the HPD and HPwES programs.

FINAL ANALYSIS DATA SET

In total, our Home Performance data set includes 3,965 unique accounts. Approximately 78% of the total participant population was available for analysis after data preparation and cleaning. Table 9-9 presents the results of cleaning participation data, integrating clean billing data, and checking for sufficient billing data for each customer.

Table 9-9. HPD/HPwES Participation and Billing Data Cleaning Steps

	Total Accounts	Percent of Total
Total Unique Accounts	5,107	100%
Reason Account Was Dropped		
High Overall ADC: >300 kWh	1	
High Overall Post-Participation ADC: >300 kWh	3	
High Overall Pre-Participation ADC: >300 kWh	58	
Accounts Remaining	5,045	98.8%
Less Than 6 Months in Post-Participation Period Days (Treat)	1	
Less Than 6 Months in Pre-Participation Period Days	95	
Accounts Remaining	4,949	96.9%
Less Than 60 Summer Days Post-Participation Period (Treat)	87	
Less Than 60 Summer Days Pre-Participation Period	831	
Account Remaining	4,031	78.9%
Low Overall ADC: <2 kWh	2	
Low Overall Post ADC: <2 kWh	1	
Low Overall Pre ADC: <2 kWh	1	
Accounts Remaining	4,027	78.9%
Cross Participants	62	
Accounts Remaining	3,965	77.6%
Final Number of Accounts 2015	**3,965**	**77.6%**

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 treated 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 2015 (as well as 2016) since the evaluated treatment group would have begun their post-participation period sometime during 2015.

Graphing average energy consumption during the baseline period makes the similarities and differences between the groups visible. Figure 9-6 shows the ADC for December 2012 through December 2014 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, but there are some differences as well. For the most part, the comparison group seemed to use a little less energy than the treatment group, except for one period during the fall of 2013 and the spring of 2014. Our assessment was that the groups were similar enough to warrant use of the comparison group in the analysis, but also different enough to call for special attention in the modeling phase.

Figure 9-6. Home Performance Analysis – Baseline kWh by Sample Group

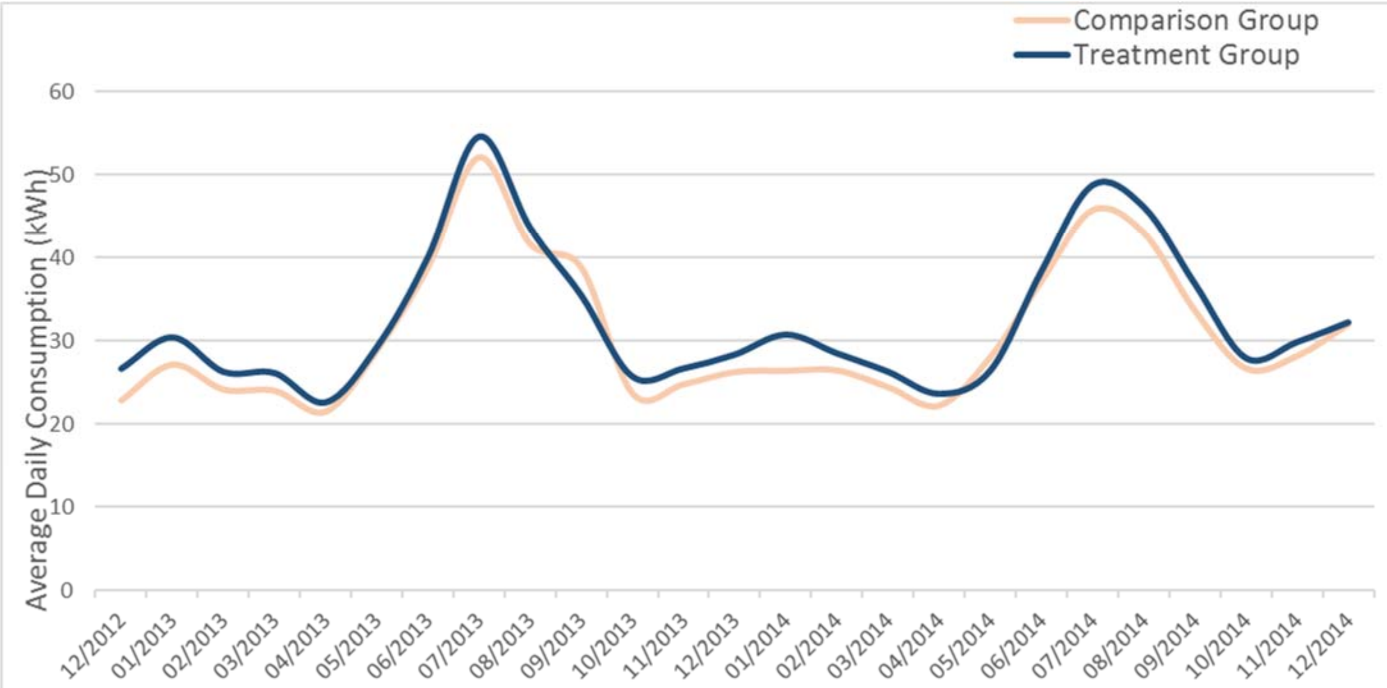


Figure 9-7. Home Performance Analysis – HDDs in the Pre-Participation Period by Sample Group

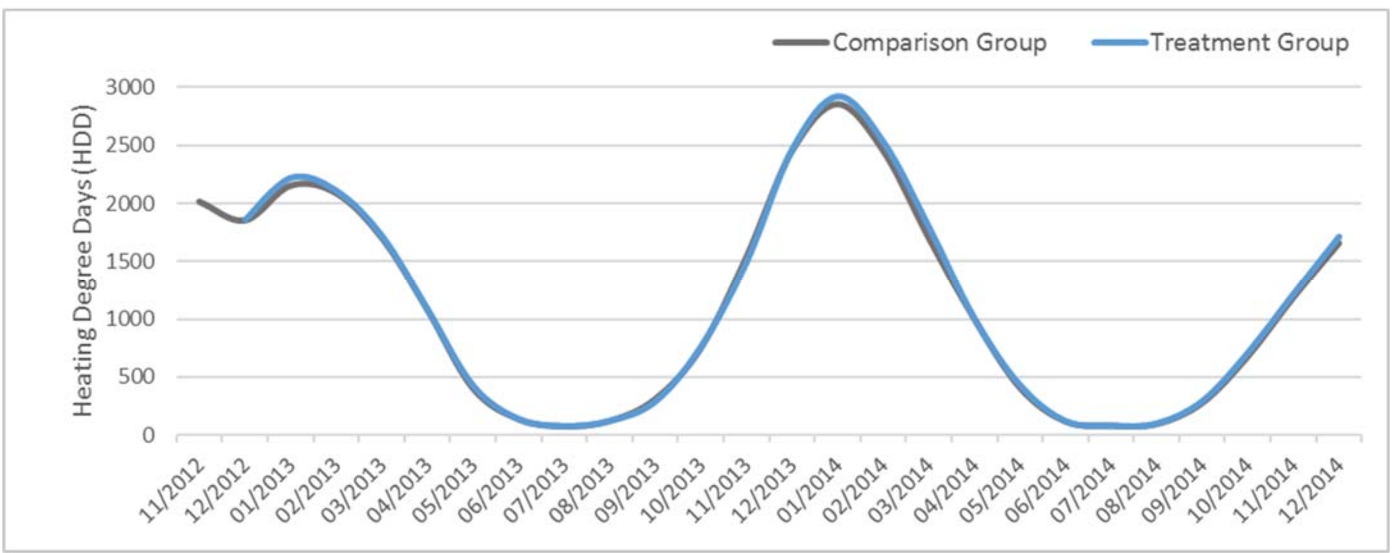
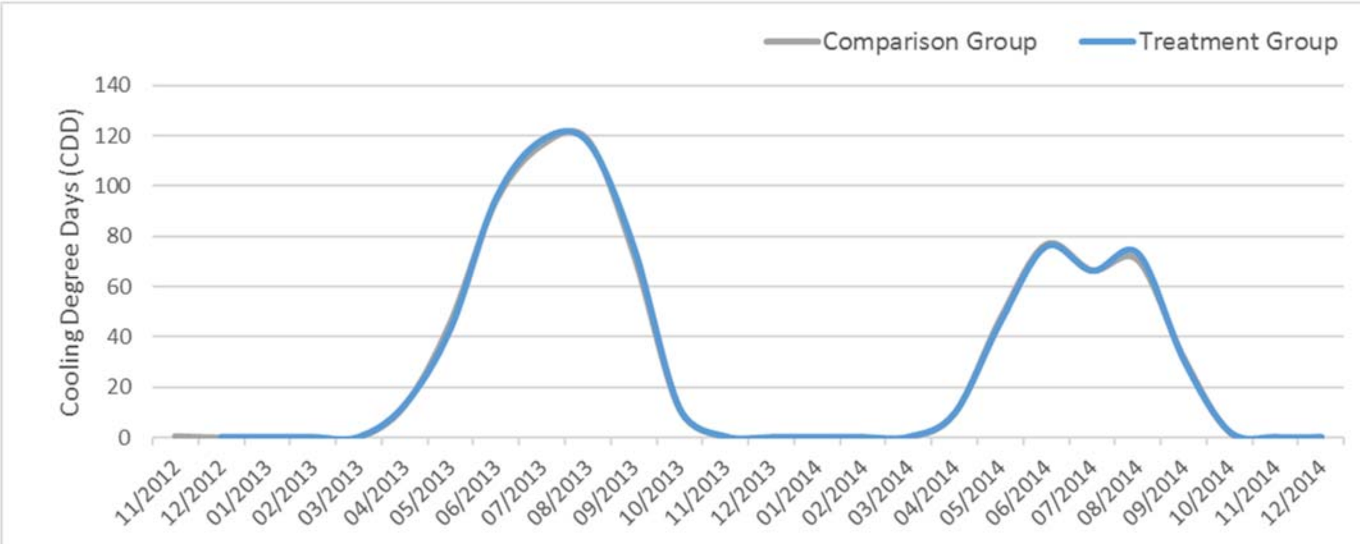


Figure 9-8. Home Performance Analysis – CDDs in the Pre-Participation Period by Sample Group



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, the pre- and post-participation periods are defined as they will be for the consumption analysis, with the dividing points staggered over time, and the dividing point being the same for all variables. 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 in this section. Table 9-10 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 may also be associated with weather. The post-participation period included a milder winter and a warmer summer than in the pre-participation period. Because it is unclear from these summary numbers exactly how these two offsetting factors may have influenced energy consumption, billing analysis is necessary to isolate program-related changes from other factors, such as the separate effects of CDDs and HDDs on consumption.

Table 9-10. HPD/HPwES Program Analysis: Average Values of Key Variables by Time Period for 2015 Treatment Group

Variable	Statistic	Period	
		Pre-	Post-
Daily kWh	*Mean*	34.60	32.90
	SD	28.09	27.80
CDDs	*Mean*	24.35	33.82
	SD	33.63	48.61
HDDs	*Mean*	890.29	604.42
	SD	853.35	586.60

Statistical Method Used

We conducted a billing analysis to determine ex post net program savings using a LFER CDA model. The final model includes terms for treatment, which is an indicator variable indicating participation in the program, time, and weather. Due to a high degree of overlap between program measures, especially in the case of CFLs, we do not separate out any individual measures in the final model.[48]

In deciding on our final model specification, we fit a number of possible models, and selected the one with the best overall fit, based on both measures of statistical model fit (R^2 and AIC). The resulting model is the same as what was used last year, and provides a reliable estimation of program-level savings. The following equation represents the final model:

Figure 9-9. Final Model Equation

$$ADC_{it} = B_h + B_1 Post_{it} + B_2 HDD_{it} + B_3 CDD_{it} + B_4 Post \cdot HDD_{it} + B_5 Post \cdot CDD_{it} + B_t MY + \varepsilon_{it}$$

where:

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

$Post$ = 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 dummies for all time periods in the model

B_h= Average household-specific 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 HDD

B_3= Increment in ADC associated with one-unit increase in CDD

B_4= Increment in ADC associated with each increment increase of HDD 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

ε_{it} = Error term

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48 However, we did test model specifications that included dummy variables for measures and we found no differences in our main results.

ELECTRIC SAVINGS RESULTS

Table 9-11 shows the model results. The model is meant to show changes in electricity use after participation in the Home Performance programs, controlling for weather and the household characteristics (reflected in the constant term). When evaluated using the means of 2014 program participation indicators, the program effects term (Treatment) is negative, indicating that program participants did reduce energy consumption in the post-participation period (after controlling for weather). Since 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 Home Performance programs.

Table 9-11. HPD/HPwES Program Performance Billing Analysis: Final Model

Predictor	Coefficient	Robust Std. Err.	T	P > |t|	90% Confidence Interval	
					Lower	Upper
Treatment	−1.012475	0.573838	−1.76	0.078	−2.13752	0.11257
HDD	−0.0031556	0.0006384	−4.94	0	−0.0044073	−0.0019
CDD	−0.0828569	0.3829899	−0.22	0.829	−0.8337325	0.668019
Post-Participation Period HDD	−0.0007639	0.0004681	−1.63	0.103	−0.0016816	0.000154
Post-Participation Period CDD	−0.0202155	0.0063586	−3.18	0.001	−0.032682	−0.00775
Constant	33.56032	1.785941	18.79	0	30.05887	37.06177

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 9-12. Adjusted Estimate of Daily Program Savings

ADC	Estimate	Std. Err.	T	P >|t|	90% Confidence Interval	
					Lower	Upper
(1)	−2.157957	0.336023	−6.42	0	−2.710796	−1.605119

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 within the interval between 1.61 kWh and 2.71 kWh per day per participant.

The evaluation team also compared these observed savings estimates to expected savings from the program-tracking database to determine the realization rate. The realization rate indicates what percentage of the expected savings was observed in the data. Table 9-13 below shows that the 2016 Home Performance programs realized 64% of their expected net savings.

Table 9-13. Savings from HPD/HPwES Program Billing Analysis Compared to Savings Expected from Program-Planning Estimates

End-Use	N[a]	Observed Savings		Program-Planning Savings[b]		Realization Rate
		Household Daily kWh Savings	Household Annual kWh Savings	Household Daily kWh Savings	Household Annual kWh Savings	
Overall Savings	1,752	2.16	788	3.38	1,235	64%

[a] There were a total of 2,275 unique accounts from 2016. Of that total, 523 program participants were excluded from the billing analysis for reasons outlined in Table 9-9.
[b] Excludes line losses.

9.9 Cost-Effectiveness Method

The Evaluation Team developed an Excel-based tool to assess cost-effectiveness at the program and portfolio levels using information derived from the PSEG Long Island 2016 Year End Expenditure Report and the evaluation results. We used three metrics to assess the cost-effectiveness of PSEG Long Island's Energy Efficiency and Renewable Energy programs: the Utility Cost Test (UCT), the Societal Cost Test (SCT), and the levelized cost of capacity and energy. PSEG Long Island considers the Energy Efficiency and Renewable Energy portfolios as alternative supply-side resources. In both the UCT and SCT we used assumptions similar to those used by PSEG Long Island's resource planning team. Each of the three methods is described below.

Calculation of Utility Costs

The UCT measures the net costs of an energy efficiency program as a resource option based on the costs incurred by the PA. These costs include all program costs and any rebate and incentive costs, but exclude any measurement and evaluation costs unless those costs are necessary to administering the program. The UCT excludes any net costs incurred by the participant, such as the actual measure cost, and includes the benefits accrued over the life of the measure, including electric energy and capacity savings for an electric utility.

The UCT calculates a benefit/cost ratio by taking the NPV of benefits and dividing them by the first-year program costs, as shown in Equation 1. NPV discounts for the time value of money using a discount rate. In other words, savings that accrue in the future are less valuable than immediate savings. Taking a NPV normalizes for the present value of future savings. This evaluation used a nominal discount rate of 4.17%.[49]

$$Utility\ Cost = \frac{NPV\ of\ Benefits\ [MCE*NRG*EUL+mAD*DR]}{2016\ Costs\ [PA]} \quad \text{(Eq. 1)}$$

A benefit/cost ratio greater than 1 indicates a cost-effective investment of funds from a UCT perspective.

Table 9-14 presents the sources for inputs used to calculate cost-effectiveness using the UCT.

[49] All cost-effectiveness analyses used a nominal discount rate of 4.17% to be consistent with supply-side alternatives.

Table 9-14. UCT Algorithm Inputs

Name	Variable	Units	Source	Input Type	Notes
MCE	Annual Marginal Utility Avoided Cost of Energy (includes costs for RGGI, NOx, and SO_2 compliance)	$/kWh	PSEG Long Island	Benefit	
NRG	Energy Reductions by Measure	kWh	Net Ex Post kWh, includes transmission losses	Benefit	First-year annual value
EUL	Effective Useful Life by Measure	Year	PSEG Long Island (from AEG)	Benefit	
mAD	Marginal Utility Avoided Cost of Demand	$/kW	PSEG Long Island	Benefit	
DR	Demand Reductions by Measure	kW	Net Ex Post kWh, includes transmission losses	Benefit	First-year value – coincident peak estimate
PA	Program Administrator Cost	$ or % of incentives	PSEG Long Island (2016 Actual Expenditure report)	Cost	
DR	Discount Rate	%	PSEG Long Island (Nominal discount rate of 4.17% used in calculations of supply-side alternatives)	Discount Rate	Interest Rate

Calculation of Societal Costs

The SCT measures the total costs of a program based on both the participants' and the utility's costs. The SCT considers the same program costs as the PA Test, with the addition of the incremental cost to the participant of purchasing the program measure. Further, the SCT does not consider the costs of rebates, as these are viewed as transfers at the societal level. Specifically, the program administrator costs no longer include the incentive costs when used within the calculation of the SCT. A benefit/cost ratio greater than 1 indicates a cost-effective investment of funds from the perspective of society as a whole.

Calculation of Levelized Costs

A levelized cost analysis is a way to quickly compare the cost of energy efficiency programs relative to the demand and energy saved from the programs. 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. If the cost of the efficiency investment is less than the cost of capacity additions or generated electricity, efficiency is considered a wise investment.

The Evaluation Team determined levelized cost estimates at the program and portfolio levels. The sources for this analysis are the same as the UCT calculations. To determine the levelized costs of the program, we determined the demand and energy savings over the life of the measure installed in a single year, discounted back to the same year of investment. The PSEG Long Island's investment (incentives and overhead) was divided by the present value of the savings to yield the lifetime levelized cost. Equation 2 shows the methodology used to calculate the levelized cost values. For a description of these costs, see Table 9-14.

$$Levelized\ Costs = \frac{2016\ Total\ Utility\ Expenditures}{NPV\ (Lifecycle\ kW\ or\ kWh\ Savings\ from\ 2016\ Installs)} \quad \text{(Eq. 2)}$$

9.10 Economic Impact Method

As part of the 2016 evaluation of the Energy Efficiency and Renewable Energy portfolios, the Evaluation Team conducted an economic impact analysis to quantify the benefits of PSEG Long Island's 2016 program spending on economic output and employment on Long Island. The economic impact analysis quantifies the 10-year impact of PSEG Long Island's 2016 Energy Efficiency Portfolio and 2016 Renewable Energy Portfolio on the economies of Nassau and Suffolk counties. In particular, it quantifies each portfolio's economic impact in terms of the following impact metrics:

- Overall economic output (value-added portion of sales)
- Employment or jobs created
- Labor income/wages from these jobs

These impacts can be broken into three dimensions—direct, indirect, and induced impact—summarized as:

- Direct Impacts: Direct impacts are equal to the localized portion of direct spending of the PSEG Long Island programs. For example, direct impacts would include money (and associated increases in employment) supplied to contractors to install energy efficiency measures in homes and businesses, such as the HVAC contractor installing energy-efficient CAC systems on a project incented by the Cool Homes program.
- Indirect Impacts: Indirect impacts are determined by the amount of the direct impacts spent within Long Island on supplies, services, labor, and taxes. For example, indirect impacts would include money (and associated employment) transferred to local businesses by contractors for supplies needed to install energy efficiency measures, such as if a local wholesaler of HVAC equipment increased sales and added additional workers to help meet the growing demand for the company's products.
- Induced Impacts: Induced impacts are associated with the effects of the direct and indirect impacts on household and business proprietors' income, for example, money expended on Long Island by households or business proprietors benefiting from energy efficiency savings and direct and indirect program spending, such as if the employee of an HVAC contractor used his or her income (increased by work through the Cool Homes program) to purchase a car, which stimulates business at the local car dealership.

Along each dimension, we quantify economic impact in terms of economic output and employment outcomes.

Next, we describe the methodology and key assumptions used in this economic impact analysis.

Evaluated Program Effects

Program actions create effects that are the mechanisms through which PSEG Long Island programs may benefit participants and the regional economy—essentially via changes in cash flow. Based on a review of publicly available economic impact analyses of efficiency and renewable energy programs, and discussions with PSEG Long Island, we identified two main program effects (and associated costs) to quantify in the 2016 analysis. These high-priority program effects are participant bill savings and program and measure spending (on administration and management and equipment and installation), shown in the "Societal Benefits" column in Table 9-15. To determine the overall impact of net participant bill savings and program spending on the regional economy, we also quantify the monetary costs associated with these efforts, namely, incremental participant costs and the efficiency and renewable charge (that funds programs). These costs are also shown in the "Societal Costs" column of Table 9-15.

Table 9-15. Evaluated Program Effects

Category	Societal Benefits *(Realized Benefit or Avoided Cost)*	Societal Costs *(Realized Cost or Opportunity Cost)*
Participant Savings	**Program Participant Bill Savings** Increased household and business savings over 10 years, with potential increase in regional spending	**Incremental Participant Spending**[a] Participant co-payments that are incrementally higher than what they may have been in the absence of PSEG Long Island programs, due to purchase of higher-efficiency equipment
Program and Measure Spending	**Program Spending** Increased sales of goods and services and increased employment, due to PSEG Long Island's spending on equipment, contractors, customer services, administration, and management **Incremental Participant Spending**[a] Increased spending on goods and services due to purchase of higher-efficiency equipment and contractor services	**Efficiency and Renewables Charge** Decreased disposable income for ratepayers in 2014 due to small efficiency and renewable charge(s) and riders leveraged to fund PSEG Long Island programs

[a] Incremental participant spending is measured as both a benefit and a cost to reflect the flow of funds in the local economy; while program participants experience this spending as a negative cash flow, contractors, retailers, manufacturers, and other service providers experience an equivalent positive cash flow.

Our analysis of high-priority program impacts estimates economic gains associated with portfolio-level spending and net participant savings. The impacts we estimate will be "net" in the sense that they account for the complete flow of funds associated with the benefits we are estimating: Program spending enters the model as inflows and outflows, as does incremental participant spending. Because only avoided costs are used to estimate bill savings, the total monetary value of bill savings in each year is equal to the net societal benefit of installation of high-efficiency measures in 2016. Though participant savings will be "net" and the flow of funds will be "net" in the sense that we account for both societal benefits and costs, the economic impact will be gross, as it will not "net out" what economic output, employment, and wages would have been *without* any program spending.

MODEL-BASED APPROACH

The economic impact analysis is based on an input-output (I-O) model. We used IMPLAN (Impact Analysis for Planning) software to analyze the economic impact of PSEG Long Island's programs. With information on program spending and costs, and the IMPLAN software, the Evaluation Team built a static model for the effects of program spending based on a matrix of underlying relationships among various sectors, including households, industries, and government. Assumptions about these relationships are an underlying component of the IMPLAN software, based on localized economic and employment data from such sources as the Bureau of Economic Analysis Regional Economic Accounts and the Bureau of Labor Statistics Census of Employment and Wages. These assumptions are also specific to the local economy (i.e., Nassau and Suffolk Counties), containing information on how spending is "multiplied" to multiple local sectors, as well as what portion of spending may extend beyond the local economy.[50]

[50] It is worth noting that IMPLAN makes a number of simplifying assumptions, such as fixed prices, no substitution effects, no supply constraints, and no changes in competitiveness or other demographic factors. However, such assumptions are not worrisome in assessing short-term impacts, in which the focus is on attaining a snapshot of a regional economy. In

To prepare the model, the Evaluation Team aggregated spending and cost data at a sector level for each year and entered this information into the software. There are 536 IMPLAN sectors, which generally correspond to NAICS codes, plus a household sector to represent residential customers. The model accounts for spending going to a specific sector (e.g., contractors), as well as expenditures from a specific sector (e.g., household spending on incremental measure costs). For example, the stream of residential *household* benefits accounts for *participant* bill savings, *participant* incremental measure cost, the efficiency and renewable charge (proportional to energy sales), and rebate payments from the program to participants, where participant bill savings persist for as long as the expected measure life of installed measures. Similarly, the stream of *commercial* benefits accounts for *participant* bill savings, *participant* incremental measure cost, and the efficiency and renewable charge (proportional to energy sales), as well as any program spending related to that sector.

Data Inputs and Assumptions

In this section, we briefly describe the data that we used as inputs in our model. The data inputs are broken into the four different spending and savings components outlined in Table 9-15.

We performed all steps for the Efficiency Long Island Portfolio and Renewable Energy Portfolio separately, though the steps were identical. Therefore, we provide a single methodology that reflects analysis steps taken for both portfolios.

Program Participant Bill Savings

To calculate the monetary value of participant bill savings over a 10-year period due to measure installation in 2016, we incorporated the following data inputs:

- **Evaluated net ex post annual kW and kWh savings for each program:** At a measure, measure-category, or program level, depending on the level used in the cost-effectiveness screening tool.
- **Effective useful measure life for each program:** To estimate savings by sector for each of the next 10 years, we applied program-level effective useful measure life value (EUL) to net savings for each program, utilizing the same assumptions as the PSEG Long Island's cost-effectiveness tests.
- **Load shapes:** We used measure-level load shapes to distribute net ex post kWh savings to load periods (e.g., summer on-peak) so that we could apply avoided energy cost per kWh values appropriately, in each year.
- **Avoided costs:** To calculate the monetary value of bill savings for the next 10 years, we used the same avoided capacity and energy cost forecast that is used for the benefit/cost screening tool. Multiplying net ex post savings (kW and kWh) by avoided costs (capacity and energy, respectively) gives the total monetary savings that will be realized among PSEG Long Island customers.
- Using net ex post savings, load shapes, avoided costs, and measure life assumptions, we calculated the nominal monetary value of bill savings for each program, at the program or measure-category level. We distributed all annual bill savings achieved by residential programs to the residential sector. We distributed bill savings achieved by commercial and industrial (C&I) programs to C&I participant sectors in two steps.

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fact, this methodology is deemed to be an effective tool for the evaluation of impacts that do not shift economic equilibrium conditions and has been used successfully in economic impact evaluations of a number of different energy efficiency and renewable energy programs.

First, we assigned participants to IMPLAN sectors based on the SIC codes of C&I participants.[51] For Efficiency Long Island programs, we then calculated the proportion of gross kWh savings by sector and by program and applied these proportions to the annual monetary bill savings values. For Renewable Energy programs, we calculated the proportion of gross kW savings by sector and by program and applied these proportions to the annual monetary bill savings values.

PROGRAM SPENDING

Program spending on measures and installation: PSEG Long Island provided program-level actual 2016 expenditures for three spending categories: rebates, incentives, and customer services. To assign expenditures to an IMPLAN sector, we took a slightly different approach for each category:

- **Rebates:** Spending on rebates is assigned to participating customer sectors—either the household sector or the C&I sector. For C&I, we linked participant accounts to SIC codes (available in CAS data). We then matched SIC codes to IMPLAN sectors.
- **Incentives and Customer Services:** For most programs, incentives are defined as spending that goes directly to the specialty trade contractors, and customer service expenditures are defined as spending on installation services in participant homes or businesses, which may include spending on "direct transfers" to participants (e.g., direct install). Because spending in each of these categories could be distributed to multiple sectors for a given program, we leveraged additional information, such as program budgets and discussions with program staff, to determine what comprised incentives and customer services for each program and how to distribute these expenditures (e.g., by identifying sectors in the budget and distributing actual expenditures proportional to the budget).

Program administration and management expenditures: PSEG Long Island provided actual expenditures on program delivery and administration spending, broken out by the following categories:

- **Contractors, Marketing, Advertising, and Evaluation:** These expenditures were available at a program level. We identified appropriate sectors based on detailed information in the budget and, where applicable, applied the budgetary proportions (of sector spending) to each program-level spending category. For a few expenditures, we developed sector assumptions (both sector assignment and proportion) based on discussions with PSEG Long Island program staff.
- **Professional Services, General and Administrative, Salaries:** These expenditures were available at the portfolio level. We first developed assumptions about the sectors of each expenditure line item (e.g., IT consulting) based on a breakdown of subcategories provided by PSEG Long Island, which we assigned to an IMPLAN sector. We then assigned expenditures to a portfolio (i.e., Efficiency Long Island or Renewable Energy). Though some line items were specific to one or the other portfolio, in most cases we assigned expenditures to either the Efficiency Long Island Portfolio or the Renewable Energy Portfolio in proportion to each portfolio's staffing levels for each program, provided to us by PSEG Long Island in the form of FTEs.

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[51] For this analysis, we used 2015 CAS data obtained as part of the 2015 Small Business Profiling Study, which contains 2- and 4-digit SIC codes that can be mapped to IMPLAN sectors. We also supplemented this data with data purchased from Dun & Bradstreet. For participants without a SIC code or whose account number was not present in 2015 or earlier data, we assigned IMPLAN sectors in proportion to gross kWh achieved by all participants with known SIC codes.

Incremental Participant Spending

The Evaluation Team modeled the additional measure spending that occurs due to programs (i.e., total participant spending on measures and installation that is attributable to programs) using three sources of information:

- **Incremental measure cost assumptions:** We use the same per-unit incremental cost assumptions as developed by AEG for program planning and used for the 2016 benefit/cost screening tool. In some cases, we updated these costs with new assumptions based on more recent research. Incremental costs are available at a measure level (per unit) for the majority of programs.
- **Ex post measure counts:** Final measure counts from the 2016 evaluation, which are needed if incremental costs are per unit.
- **Free-ridership and spillover rates:** After estimating the total incremental measure expenditures associated with each measure (or program, if incremental costs are at the program level), we estimated the incremental spending that occurred due to PSEG Long Island's programs by using FR and SO rates using evaluated NTGRs.

To model positive cash flows of participant spending to the local economy, we assigned an IMPLAN sector to each measure in the cost-effectiveness screening tool.

To model negative cash flows of participant spending to appropriate sectors, we assigned all residential program incremental spending to the household sector. In addition, program-induced, non-labor-related cash flows to the household sector were modeled as household income change. Here, we assumed that the distribution of cash flows is proportional to the distribution of households into different income brackets.[52] For Commercial programs, we distributed spending across commercial sectors by first assigning a sector to participants based on their SIC code (using the same assignments as for participant bill savings) and then calculating the percentage of total rebate dollars each sector accounts for (with the assumption that incremental measure costs will be roughly proportional to available rebates). Program-induced non-sale-related cash flows—specifically rebates, savings, incremental cost, and Efficiency Long Island charges—were modeled as change in proprietor income.

Efficiency and Renewables Charges

To adequately represent local cash flows resulting from offering Efficiency Long Island and Renewable Energy programs, the model includes efficiency and renewable charge revenues that were used to fund the 2016 programs. We assumed that this revenue was equivalent to total program spending. To distribute revenue across portfolios, we used the sum of program spending by portfolio, described above. To distribute revenue across sectors, PSEG Long Island provided a breakdown of 2016 sales (in MWh) for residential and C&I customers. The Evaluation Team applied these proportions to the total efficiency and renewable charge revenue estimate. The estimated proportion of charges from residential customers was applied to the household sector. We then broke down the C&I portion by IMPLAN sector based on the distribution of annual kWh by IMPLAN sector (again, based on SIC code) reflected in CAS data.

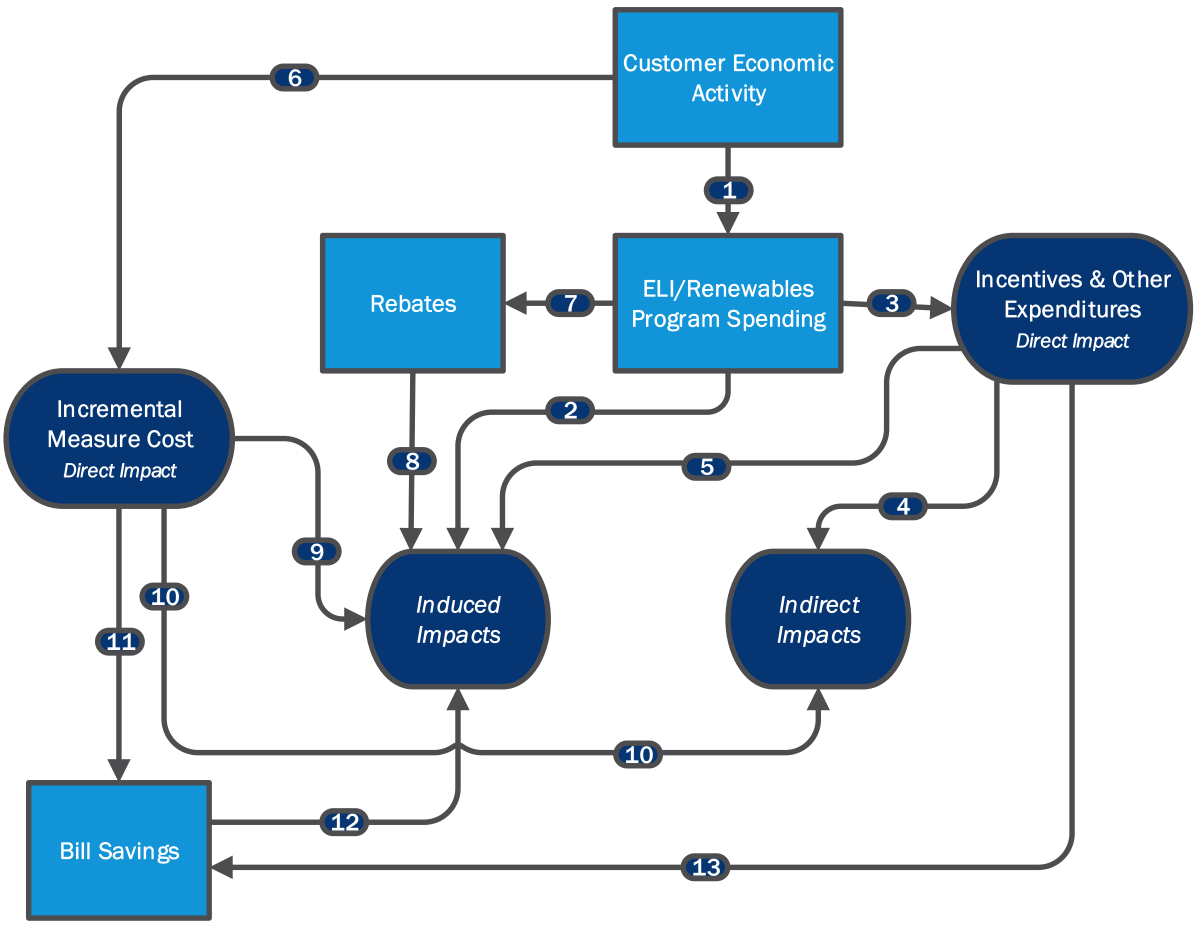
Visual Model

A simplified visual model illustrates how the economic impact is calculated. Figure 9-10 presents the economic impacts model for PSEG Long Island's Efficiency Long Island and Renewable Energy portfolios. Note that the

[52] Source: U.S. Census Bureau's American Community Survey. 2015.

figure represents the portfolios as a whole, and individual programs may not contain all parts of the model due to variations in the program designs.

Figure 9-10. Visual Model of Economic Impacts of the PSEG Long Island Portfolio



Description of Model Elements

Each box in Figure 9-10 represents a dollar amount either defined as an input into the model or produced by the model as a result. Boxes with rounded corners represent impacts, while boxes with unrounded corners represent intermediate amounts. Each arrow in Figure 9-10 represents a flow of money or an effect resulting from an expenditure. It is important to note that flow numbers do not necessarily represent a sequential order of effects.

Dollar Amounts

The named boxes in Figure 9-10 represent:

- **Customer Economic Activity:** This box represents the base level of customer spending before program intervention.

- **Efficiency Long Island/Renewables Program Spending:** This box represents the total amount of program spending in 2016. The model assumes that program spending in each program year is equal to the Efficiency Long Island and Renewables Energy Charge collected in that year (see Flow #1).
- **Rebates:** This box represents the total amount of program spending in 2016 on rebates moving directly from the program to program participants.
- **Incentives & Other Expenditures:** This box represents the balance of the program spending after rebate expenditures (represented in Flow #7) and program staff salaries (represented in Flow #2). This box includes the cost of measures purchased by the program as part of direct installation program spending, as well as installation costs (Customer Services), program spending on marketing and advertising, and incentives paid directly to contractors. The portion of this spending amount (Flow #3) that occurs within Long Island is treated by the model as a *direct impact* on the Long Island economy.
- **Incremental Measure Cost:** This box represents the incremental measure cost expenditures paid by program participants toward program measures (Flow #6). The portion of this spending amount that occurs within Long Island is treated by the model as a *direct impact* on the Long Island economy. It is important to note that this dollar amount represents total incremental cost expenditures multiplied by the ex post NTGRs to account only for spending attributable to the program.
- **Bill Savings:** This box represents the bill savings resulting from installation of efficient equipment incentivized through the program.
- **Indirect Impacts:** This box represents the *indirect impacts* resulting from program activities.
- **Induced Impacts:** This box represents the *induced impacts* resulting from program activities.

Flows

The numbered flows in Figure 9-10 represent:

1. **Description:** Customers pay the Efficiency and Renewables Charge. This charge funds PSEG's Efficiency Long Island and Renewable Energy portfolios.

   Inputs: The Evaluation Team assigned the Efficiency and Renewables Charge to IMPLAN sectors for household income bracket and business sector. We distributed the charge by total usage in each sector.

2. **Description:** Customer spending levels drop due to additional spending on utility bills from the Efficiency and Renewables Charge. At the same time, PSEG Long Island pays the salaries of its program staff, increasing customer spending levels. This produces *induced impacts*.

   Inputs: We assigned PSEG Long Island's payroll figures to individual income bracket IMPLAN sectors. These sector values were entered as inputs into the IMPLAN individual spending matrices. The assigned amounts of the Efficiency and Renewables Charge (from Flow #1) were entered as inputs into IMPLAN individual spending matrices. Induced impacts are outputted from the negative effect of the charge and the positive effect of program staff salaries.

3. **Description:** PSEG Long Island spends money on the implementers, advertisers, evaluators, and other outside businesses necessary to run the programs. PSEG Long Island also spends money on measure costs for direct installation programs and on incentives going directly to contractors. The portion of this spending that occurs within Long Island is a *direct impact*.

Inputs: PSEG Long Island program spending data by area (advertising, evaluation, incentives, etc.) is assigned to IMPLAN sectors by the Evaluation Team.

4. Description: The implementers, evaluators, contractors, and other outside businesses paid by PSEG Long Island spend money within Long Island on goods and services from other businesses, producing *indirect impacts*.

   Inputs: IMPLAN matrices automatically assign cascading expenditures by the initial sector to which we assigned PSEG Long Island spending (see Flow #3).

5. Description: The implementers, evaluators, contractors, and other outside businesses paid by PSEG Long Island pay their own internal employees. This leads to *induced impacts* when employees spend this money inside the Long Island economy.

   Inputs: IMPLAN matrices automatically assigned cascading expenditures by the initial sector to which the Evaluation Team assigned PSEG Long Island spending (see Flow #3).

6. Description: Participants purchase a new measure, incented by program activities and rebates. This is a *direct impact:* Participants spend their money inside the Long Island economy at a retailer/contractor, etc.

   Inputs: Based on secondary research, the Evaluation Team assigned participant incremental spending to business sectors corresponding to where spending takes place (e.g., retailers, contractors). Wherever this spending occurred inside Long Island, it is considered a *direct impact*.

7. Description: Participants are rebated by the program for their measure purchase.

   Inputs: PSEG Long Island program spending data were used to assign total rebate spending to participant IMPLAN sectors by income bracket or commercial segment.

8. Description: Flow #7 leads to *induced impacts*, as participants' spending levels elsewhere increase due to the effect of the rebate. It is important to note that, from the participant's perspective, the rebate effectively decreases the cost of the measure purchased. However, this is modeled in two separate flows in this model: first, the outflow of dollars in Flow #6 from the participant to purchase the measure and second, the flow of the rebate dollars from the program to the participant (Flow #7), which leads to *induced impacts* as mentioned above.

   Inputs: Sector values representing rebate spending assigned to income brackets and commercial segments were entered as inputs into IMPLAN individual spending matrices to output *induced impacts* from the positive effect of rebates on participant spending levels (Flow #7).

9. Description: Flow #6 leads to negative *induced impacts*, as participants' spending levels elsewhere decrease due to the expenditure on the measure. Flow #6 also leads to positive *induced impacts* as retailers, contractors, and others hire more staff/pay their staff more in order to respond to increased demand for their goods and services.

   Inputs: Expenditures by sector produced in Flow #6 were entered as inputs into IMPLAN matrices to produce impacts. Expenditures in Flow #6 were also inputted into IMPLAN individual spending matrices as a negative effect on participant spending levels. As mentioned above in the description for Flow #8, this is the pre-rebated expenditure made by the participant.

10. **Description:** Flow #6 also leads to *indirect impacts*, as retailers and distributors from whom energy-efficient equipment is purchased order more equipment from manufacturers and distributors. The retailers and distributors from whom these items are purchased also purchase transportation services for these items, additional equipment for stores, and more items and services related to doing additional business.

    Inputs: IMPLAN matrices automatically assigned cascading expenditures by the initial sector to which we assigned PSEG Long Island spending (see Flow #6).

11. **Description:** Flow #6 also leads to bill savings as efficiency levels of energy-using appliances increases.

    Inputs: The Evaluation Team estimated bill savings as a result of program measures based on net ex post energy and demand savings multiplied by PSEG Long Island's estimates of the avoided costs of generation. These bill savings were then distributed across various income brackets and business sectors.

12. **Description:** Bill savings produce *induced impacts*, as participants' spending levels change due to their decreased expenditure on their utility bills.

    Inputs: Bill savings values from Flows #11 and #13 were inputted into IMPLAN individual spending matrices to produce impacts.

13. **Description:** Program spending on measures installed directly by programs (e.g., CFL bulbs installed through the REAP program) lead to bill savings, as increased efficiency resulting from these measures decreases energy usage and demand.

    Inputs: We estimated bill savings as a result of program measures as described in Flow #11.

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%
HPD	All Measures (kW)	-34%	*	*	54%**	0%	0%	100%
HPD	All Measures (kWh)	-38%	*	*	68%**	0%	0%	100%
HPwES	All Measures (kW)	-26%	*	*	48%**	0%	0%	100%
HPwES	All Measures (kWh)	-25%	*	*	68%**	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%	30%	4%	74%

Program	Measure	Ex Post – Ex Ante	Ex Post Values			Ex Ante – Calculated Program Values (all values calculated from gross and net values provided by the program)		
		NTGR Differences	FR	SO	NTGR	FR	SO	NTGR
EEP	ENERGY STAR Specialty CFLs	0%	25%	20%	95%	25%	20%	95 %
EEP	Solid State Lighting	0%	*	*	55%	5%	25%	120%
EEP	ENERGY STAR Fixtures	0%	1.7%	3.2%	101.5%	1.7%	3.2%	101.5%
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%
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%	15%	85%
CEP Prescriptive	Lighting (kW)	-20.13%	30%	1.87%	71.87%	*	*	92%
CEP Prescriptive	Lighting (kWh)	-20.45%	30%	1.55%	71.55%	*	*	92%
CEP Prescriptive	HVAC (kW)	-18.13%	30%	1.87%	71.87%	*	*	90%
CEP Prescriptive	HVAC (kWh)	-18.45%	30%	1.55%	71.55%	*	*	90%
CEP Prescriptive	Kitchen Equipment (kW)	-3%	30%	1.87%	71.87%	*	*	75%
CEP Prescriptive	Kitchen Equipment (kWh)	-3%	30%	1.87%	71.87%	*	*	75%
CEP Prescriptive	Compressed Air (kW)	-19%	30%	1.87%	71.87%	*	*	91%
CEP Prescriptive	Compressed Air (kWh)	-19%	30%	1.87%	71.87%	*	*	91%
CEP Prescriptive	Refrigeration (kW)	-28%	30%	1.87%	71.87%	*	*	100%
CEP Prescriptive	Refrigeration (kWh)	-28%	30%	1.87%	71.87%	*	*	100%
CEP Prescriptive	Refrigeration (vending) (kW)	-27%	30%	1.87%	71.87%	*	*	99%
CEP Prescriptive	Refrigeration (vending) (kWh)	-27%	30%	1.87%	71.87%	*	*	99%
CEP Prescriptive	Motors and VFDs (kW)	8%	30%	1.87%	71.87%	*	*	64%
CEP Prescriptive	Motors and VFDs (kWh)	8%	30%	1.87%	71.87%	*	*	64%

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
CEP Prescriptive	Building Envelope (kW)	-28%	30%	1.87%	71.87%	*	*	100%
CEP Prescriptive	Building Envelope (kWh)	-28%	30%	1.87%	71.87%	*	*	100%
CEP Existing Retrofit	Lighting (kW)	-20.13%	30%	1.87%	71.87%	*	*	92%
CEP Existing Retrofit	Lighting (kWh)	-20.45%	30%	1.55%	71.55%	*	*	92%
CEP Existing Retrofit	Non-Lighting (kW)	-18.13%	30%	1.87%	71.87%	*	*	90%
CEP Existing Retrofit	Non-Lighting (kWh)	-18.45%	30%	1.55%	71.55%	*	*	90%
REAP	All Measures (kW)	0%	*	*	102%**	0%	0%	100%
REAP	All Measures (kWh)	0%	*	*	99%**	0%	0%	100%
Solar Pioneer	All	0%	0%	0%	100%	0%	0%	100%
Solar Entrepreneur	All	0%	0%	0%	100%	0%	0%	100%
CEP Custom	(kW)	-18.13%	30%	1.87%	71.87%	*	*	90%
CEP Custom	(kWh)	-18.45%	30%	1.55%	71.55%	*	*	90%

* 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.

For more information, please contact:

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