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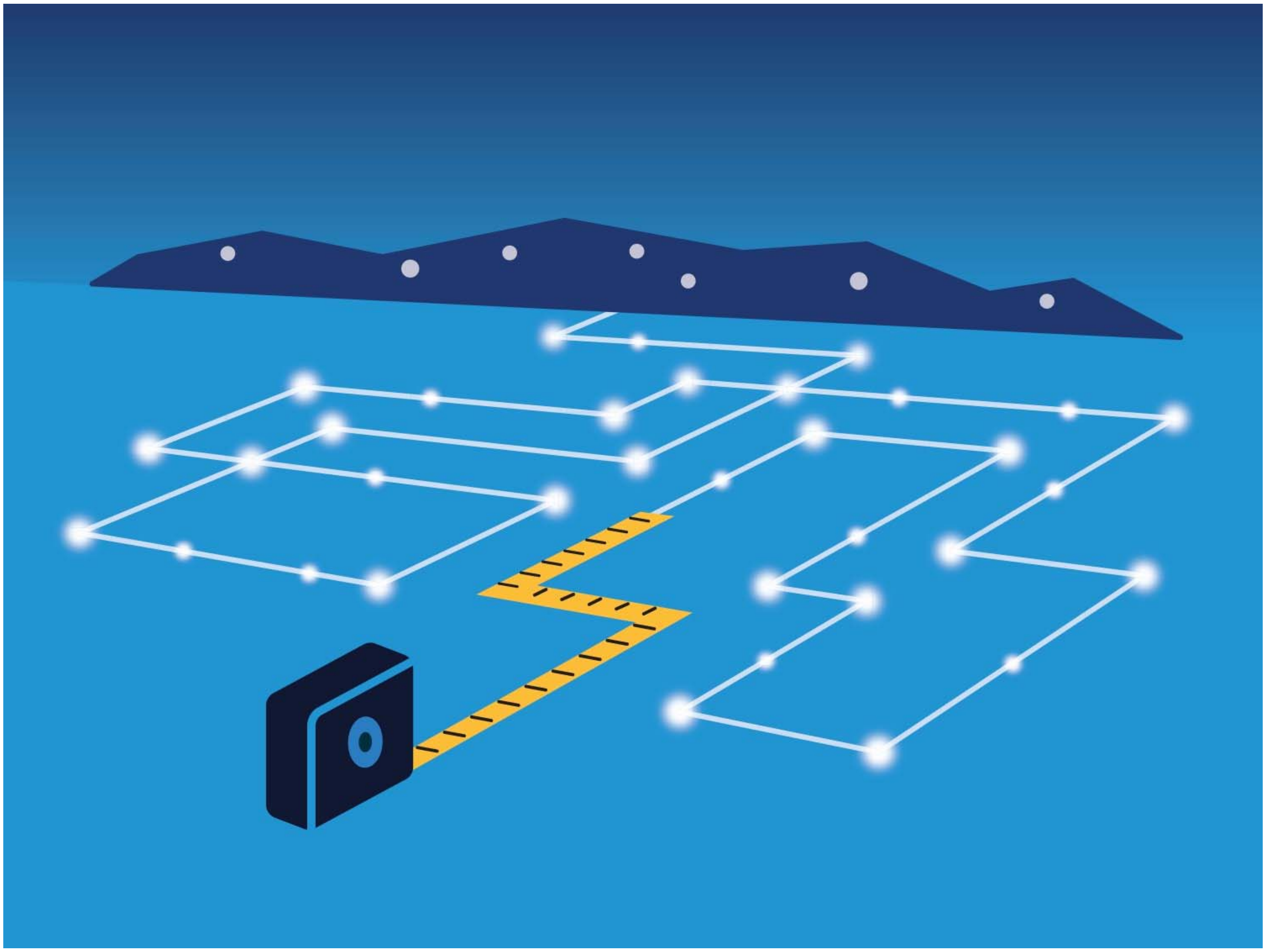

Energy Efficiency and Renewable Energy Portfolios

2018 Annual Evaluation Report
(Volume II – Program Guidance Document)

June 3, 2019

Prepared for:

PSEG LONG ISLAND
We make things work for you.

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1. Introduction

Volume II of the *2018 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 the Opinion Dynamics team employed to analyze the impacts. The Long Island Power Authority (LIPA) administered the Energy Efficiency and Renewable Energy Portfolios through 2013. Effective January 1, 2014, PSEG Long Island began a 12-year contract with LIPA. PSEG Long Island assumed day-to-day management and operations of the electric system, including administration, design, budget, and implementation of the Energy Efficiency and Renewable Energy Portfolios. In March 2015, PSEG Long Island transitioned the implementation of the Energy Efficiency Portfolio to its subcontractor, Lockheed Martin. In 2017, PSEG Long Island added the Home Energy Management program to the Energy Efficiency Portfolio, implemented by its subcontractor Tendril. PSEG Long Island continues to implement the Renewable Energy Portfolio. This evaluation covers the period from January 1, 2018, to December 31, 2018.

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. This evaluation calculates three levels of energy and demand savings: verified ex ante, evaluated, and ex post. We compare these savings types to the expected impacts used for program tracking (ex ante impacts). We define each of these savings calculations and their purpose in Section 1.1.

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, we present the evaluated energy and demand savings realized during the 2018 implementation year. We also provide any measure-specific recommendations for program administrators to update the energy and demand savings calculations moving forward.
- Section 9 provides detailed descriptions of the evaluation team's research methods, including information on the primary and secondary data collection, as well as the analytical methods used to derive savings estimates.
- Appendix A presents the ex ante and ex post net-to-gross values by program and measure.
- Appendix B presents the verified ex ante results delivered to PSEG Long Island as a separate memorandum.

1.1 Key Definitions

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

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

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

would not have occurred absent the program. The difference between the gross and net impacts is the application of the net-to-gross ratio (NTGR).

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

$$NTGR = 1 - FR + SO$$

- **Ex Ante Net Impacts:** The energy and demand savings expected by the program as found in the program tracking database. The ex ante net impacts include program planning NTGRs.
- **Verified Ex Ante Savings:** The energy and demand savings calculated by the evaluation team using methods and assumptions consistent with those used by PSEG Long Island to develop annual savings goals. These savings estimates are used to determine if PSEG Long Island achieves its annual scorecard goals.
- **Evaluated Net Savings:** The net savings attributed to the program. 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 determines gross impacts and applies ex post NTGRs developed 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:** The evaluation team applies line losses of 6.4% on energy consumption (resulting in a multiplier of $1.0684 = [1 \div (1 - 0.064)]$) and of 9.1% on peak demand (resulting in a multiplier of $1.1001 = [1 \div (1 - 0.091)]$) to estimate energy and demand savings at the power plant.
- **kW (Demand or Capacity):** The average level of power used over the course of an hour. Peak demand is the average power used across a 4-hour period when there is high use. For Long Island, peak demand may take place anytime from 2pm to 6pm, Monday through Friday (non-holiday), from June to August. System coincident demand is the level of demand at the hour of the day when there is the maximum demand on the system grid. Demand savings values in this report are based on system coincident demand impacts between 4pm and 5pm on non-holiday weekdays from June to August.
- **kWh (Energy Consumption):** The total power consumed over the course of an hour. Energy impacts are based on annual consumption.
- **Societal Cost Test (SCT):** A test that measures the net costs of an energy efficiency program as a resource option based on the total costs of the program, including both the participants' and the program administrator's costs. Rebate costs are not included in this test because they are assumed to be a societal transfer. To maintain consistency with the most current version of the New York Benefit-Cost Analysis Handbook, we applied the SCT as a primary method of determining cost-effectiveness using the same assumptions as those used by PSEG Long Island's resource planning team.

- **Utility Cost Test (UCT):** A test that measures the net costs of an energy efficiency program as a resource option based on the costs that the program administrator incurs (including incentive costs) and excluding any net costs incurred by the participant. To allow for direct comparison with PSEG Long Island's assessment of all supply-side options, and consistent with previous evaluation reports, we continue to show the UCT as a secondary method of determining cost-effectiveness.
- **Discount Rate:** The interest rate used to calculate the present value of future payments (i.e., the avoided costs from energy and demand savings). PSEG Long Island uses a weighted average cost of capital supplied by LIPA that represents the cost of borrowing to build additional capacity to meet the future supply needs of the service territory. Based on these factors, we used a nominal discount rate of 6.11% in the 2018 evaluation.
- **Levelized Cost of Capacity:** The equivalent cost of capacity (kW) to be incurred each year over the life of the equipment that would yield the same present value of total costs, using a nominal discount rate of 6.11% to be consistent with base load generation supply-side resources in the Long Island service territory. The levelized cost of capacity is a measure of the program administrator's program costs in a form that can be compared to the cost of supply additions.
- **Levelized Cost of Energy:** The equivalent cost of energy (kWh) over the life of the equipment that would yield the same present value of costs, using a nominal discount rate of 6.11%. The levelized cost of energy is a measure of the program administrator's program costs in a form that can be compared to the cost of supply additions.

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 the evaluation methods.

1.2.1 Gross Impact Methods

The Opinion Dynamics team 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 analyses using algorithms and inputs derived from the program tracking databases. We also performed consumption analyses[2] for the Residential Energy Affordability Partnership (REAP) program, Home Performance programs, and the Home Energy Management (HEM) 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 2018 custom projects.

When conducting the 2018 impact evaluation, the evaluation team relied primarily upon the *2018 PSEG Long Island Technical Reference Manual* (TRM),[3] as well as any relevant primary research that was available to both the implementation and evaluation teams before the start of the 2018 program year (e.g., 2016 PSEG

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

[3] The team also consulted the 2019 Prospective TRM. As of 2017, the "Prospective TRM" is a TRM developed annually by the evaluation team for PSEG Long Island that documents recommended assumptions and algorithms for future program years. The latest version, the 2019 Prospective TRM delivered in June 2018, is intended for use in 2019 program planning and ex ante savings calculations. Therefore, while we leveraged some assumptions from this document in the 2018 evaluation, we did not incorporate code or other changes in the 2018 evaluation that are specific to the future planning efforts.

Long Island Residential In-Home Study). Additionally, to bolster evaluated savings estimates when primary data were unavailable, the evaluation team referenced several secondary sources, such as the New York State TRM version 5 (NY TRMv5), and other regional TRMs and relevant studies, where applicable. Finally, the evaluation team leveraged 2018 program tracking data on installed measures to facilitate inputs to energy savings algorithms. These data included wattages, capacities, efficiencies, and heating and cooling characteristics of homes of participants in the 2018 program.

Information made available to the evaluation team after the start of the 2018 program year will be used in future evaluations. This includes the *2018 PSEG Long Island Commercial and Residential Potential Study 2019–2038* and the *Solar Output Study* completed in 2018. While some initial results from the potential study baseline research were incorporated into the 2019 PSEG Long Island TRM, most of this research will be applied to the 2020 PSEG Long Island TRM for use in the 2020 program planning. In this report, the evaluation team highlights instances where the program implementation team used different planning (ex ante) savings assumptions from those documented in the 2018 PSEG Long Island TRM.

1.2.2 Net Impact Methods

The evaluation team used net impact estimates as inputs to three separate analyses required by PSEG Long Island: the determination of annual demand and energy savings toward annual goal attainment, adjustment of program planning and ex ante assumptions, and the benefit/cost assessment. Based on the specific requirements of each analysis, we developed the three separate net savings estimates described below.

Verified Ex Ante Net Savings

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

Evaluated Net Savings

The evaluation team calculates evaluated savings using detailed measure-level tracking information and applying the best information and methods available at the time of the evaluation to determine evaluated gross savings. We calculate evaluated net savings by applying PSEG Long Island’s planning assumptions for NTGR to the gross demand and energy savings estimated through our evaluation. PSEG Long Island also uses the evaluated net savings to refine its savings estimates going forward and help inform its program planning and goal setting process for the next program year. The evaluated net savings and the realization rate of evaluated savings compared to ex ante savings are the primary focus of this report. An important catalyst in LIPA’s initial decision to invest in the Energy Efficiency and Renewable Energy Portfolios was the need to offset approximately 520 MW of generating capacity over 10 years required to satisfy energy demand forecasted at that time. As such, in addition to its annual energy and demand savings goals, performance relative to the long-range capacity savings goal was a critical performance metric for PSEG Long Island’s programs. Beginning in 2018, PSEG Long Island’s savings goals are primarily focused on energy rather than capacity savings, and the 10-year 520 MW goal is no longer a relevant metric.

Ex Post Net Savings

Among other inputs, the benefit/cost and economic impact assessments require an estimate of net program savings. The best practice approach for both assessments dictates that the net savings used to develop the benefit/cost ratio, or to quantify economic benefits, reflect current levels of FR and SO to provide an accurate estimate of the benefits associated with the current year's investment in the programs. As such, the evaluation team used ex post net savings in both assessments. Ex post net savings are calculated by applying researched NTGRs in place of program planning NTGRs when available. For 2018, we had no new primary data collection or activities with which to update previous NTGRs. While PSEG Long Island typically used NTGRs researched by the evaluation team in the program planning process, there are some notable exceptions. For programs where these exceptions exist, evaluated net savings and ex post net savings may be different. 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

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

Table 1-1. Portfolio Evaluated Impacts

Program	Ex Ante Net Savings		Verified Ex Ante Net Savings		Evaluated Net Savings		Realization Rate[a]	
	MWh	MW	MWh	MW	MWh	MW	MWh	MW
Energy Efficiency Portfolio								
Commercial Efficiency Program	99,521	21.0	99,108	20.9	95,633	20.7	96%	98%
Residential Efficiency Programs								
Energy Efficient Products	135,527	29.7	136,036	27.9	135,795	28.4	100%	96%
Cool Homes	3,425	2.3	3,528	2.4	3,697	2.2	108%	96%
Residential Energy Affordability Partnership	2,001	0.49	1,907	0.48	972	0.20	49%	40%
Home Performance	3,473	2.2	3,458	2.2	1,402	0.27	40%	12%
Home Energy Management	47,810	N/A	47,845	N/A	55,662	N/A	116%	N/A
Subtotal Residential	192,237	34.7	192,774	33.0	197,527	31.1	103%	90%
Total Energy Efficiency Portfolio (Commercial and Residential)	291,758	55.7	291,882	53.8	293,161	51.8	100%	93%
Renewable Energy Portfolio	14,663	6.0	14,663	6.0	13,595	5.7	93%	96%
Total Energy Efficiency and Renewable Energy Portfolios	**306,421**	**61.7**	**306,545**	**59.8**	**306,756**	**57.5**	**100%**	**93%**

Note: Totals may not sum due to rounding.

[a] Realization rate compares evaluated net savings to ex ante net savings

1.4 Summary of Cost-Effectiveness Results

Based on an analysis of program- and portfolio-level impacts and costs, the savings generated by the Energy Efficiency and Renewable Energy Portfolios are cost-effective. The evaluation team used two separate tests to establish a benefit/cost ratio for each program: the Utility Cost Test[4] (UCT) and the Societal Cost Test (SCT). The tests are similar in most respects but consider slightly different benefits and costs in determining a benefit/cost ratio. The UCT measures the net costs of an energy efficiency program as a resource option based on the costs incurred by the program administrator, including all program costs and any rebate and incentive costs, but excludes costs incurred by the participant. The SCT considers costs to the participant, but excludes rebate costs, as these are viewed as transfers at the societal level. The SCT also includes the benefits of non-electric (i.e., gas and fuel oil) energy savings where applicable resulting in different benefit totals than the UCT. Consistent with PSEG Long Island's *Benefit-Cost Analysis (BCA) Handbook,* we applied the SCT test as the primary method of determining cost-effectiveness and used assumptions including avoided costs and discount rates matching PSEG Long Island's latest Utility 2.0 filing.

Table 1-2 presents the benefit/cost ratios for both the SCT and UCT for each program and for each portfolio separately. The portfolio-level SCT values are 1.9 and 0.56 for the Energy Efficiency and Renewable Energy Portfolios, respectively. This indicates that from a societal perspective the Energy Efficiency Portfolio is cost-effective, while the Renewable Energy Portfolio is not (a benefit/cost ratio greater than 1 indicates that portfolio benefits outweigh costs). The UCT test benefit/cost ratio is 1.9 for the Energy Efficiency Portfolio and 5.4 for the Renewable Energy Portfolio, indicating that portfolio benefits exceed program administrator costs in both cases.

The SCT ratio was less than 1 for four programs in 2018: Cool Homes, REAP, Home Performance, and Renewables (Solar PV). The cost-effectiveness of the Cool Homes program increased from 0.67 in 2017 to 0.92 in 2018. The REAP program SCT ratio of 0.32 is close to the 2017 result of 0.35. However, cost-ineffectiveness is not unusual for low-income programs, which typically are not required to be cost-effective. The SCT ratio of the Home Performance program decreased from 0.46 in 2017 to 0.17 in 2018 due to lower savings for this program in 2018. The Renewable Energy Portfolio had an SCT ratio less than 1 largely because this test accounts for the relatively high costs that participants bear for installing renewables. In 2017, the HEM program also had an SCT ratio of less than 1 as the program was being rolled out and had not yet realized its full savings potential. In 2018, the HEM program achieved a cost-effectiveness of 1.5 in the SCT ratio following a more complete rollout of the program.

The UCT was also less than 1 for Cool Homes, REAP, HEM, and Home Performance in 2018. The Renewable Energy Portfolio had a UCT ratio significantly greater than 1 in 2018, largely due to the low costs incurred by PSEG Long Island to implement this program.

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

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

Program	Utility Cost Test			Societal Cost Test		
	NPV Benefits	Costs	B/C Ratio	NPV Benefits	Costs	B/C Ratio
Energy Efficiency Portfolio						
Commercial Efficiency Program	$49,405,358	$31,868,666	1.6	$66,094,648	$41,643,828	1.6
Residential Efficiency Programs						
Energy Efficient Products	$77,243,092	$20,734,101	3.7	$104,302,500	$35,695,553	2.9
Cool Homes	$3,698,910	$4,136,648	0.89	$4,553,959	$4,952,779	0.92
Residential Energy Affordability Partnership	$477,919	$1,976,197	0.24	$651,126	$2,039,234	0.32
Home Performance	$674,243	$10,063,831	0.07	$1,400,039	$8,459,906	0.17
Home Energy Management	$2,225,281	$2,283,008	1.0	$3,408,303	$2,317,251	1.5
Subtotal Residential	$84,319,444	$39,193,785	2.2	$114,315,926	$53,464,724	2.1
Total Energy Efficiency Portfolio (Commercial and Residential)	$133,724,802	$71,062,451	1.9	$180,410,574	$95,108,552	1.9
Renewable Energy Portfolio	$15,995,336	$2,959,559	5.4	$19,949,575	$35,477,031	0.56
Total Energy Efficiency and Renewable Energy Portfolios	$149,720,138	$74,022,010	2.0	$200,360,148	$130,585,583	1.5

Legend: NPV = Net Present Value; B/C = Benefit/Cost.

1.5 Summary of Economic Impacts

The evaluation team estimated the expected changes to Long Island's overall economic output and employment resulting from PSEG Long Island's 2018 Energy Efficiency and Renewable Energy portfolios over the next 10 years. Table 1-3 and Table 1-4 present the direct impacts and the combined indirect and induced impacts for 2018 and for the 10-year period of 2018 to 2027. To account for expected inflation and the assumed increasing cost of electricity, the tables show the results as NPV using the discount rate of 6.11% used in PSEG Long Island's supply-side planning and the cost-effectiveness analysis.

Over 10 years, the 2018 investments in the Energy Efficiency Portfolio are expected to return $150.0 million in total economic benefits to the regional economy (in 2018 dollars), with an employment benefit of 1,127 new full-time equivalent employees (FTEs)[5] over that time period.

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

Table 1-3. Economic Impact of 2017 Energy Efficiency Portfolio Investments

2018 Energy Efficiency Portfolio Investments	2018 Economic Impact	2018-2027 Economic Impact (NPV[a])
Economic Impact		
Total Economic Output (millions)	$73.0	$150.0
Direct Effect	$56.1	$56.1
Indirect & Induced Effects	$16.9	$94.0
Employment (FTE)	512	1,127
2018 Program Investment (millions)	$71.7	$71.7
Total Economic Output in M per $1M Investment	$1.02	$2.1
Employment (FTE) per $1M Investment	7.1	15.7

[a] Using nominal discount rate of 6.11%, based on PSEG Long Island Utility 2.0 filing assumptions.

The investments in the Energy Efficiency Portfolio resulted in a slightly lower total economic output in 2018 ($73.0 million) than in 2017 ($73.5 million), reflecting a slight decline in program expenditures between 2017 and 2018, as well as adjustments to the composition of the Energy Efficiency Portfolio between the years.

Over 10 years, the 2018 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 $26.2 million in total economic benefits to the regional economy (in 2018 dollars), with an employment benefit of 159 new FTEs over that time period.

Table 1-4. Economic Impact of 2018 Renewable Energy Portfolio Investments

2018 Renewable Energy Portfolio Investments	2018 Economic Impact	2018-2027 Economic Impact (NPV[a])
Economic Impact		
Total Economic Output (millions)	$22.6	$26.2
Direct Effect	$20.0	$20.0
Indirect & Induced Effects	$2.6	$6.1
Employment (FTE)	131	159
Impact per $1M Investment		
2018 Program Investment (millions)	$3.0	$3.0
Total Economic Output in M per $1M Investment	$7.6	$8.7
Employment (FTE) per $1M Investment	43.7	53.2

[a] Using nominal discount rate of 6.11%, based on PSEG Long Island Utility 2.0 assumptions.
[b] Program investment does not include $1.7 million in solar funding from NYSERDA NY-Sun. Economic impacts, however, do include the benefits of these projects.

Similar to the 2017 results, 2018 spending on PSEG Long Island's Renewable Energy Portfolio resulted in greater benefits to the Long Island economy than in earlier program years, however economic impacts have declined since the peak in 2015, due to reduced funding availability through NYSERDA's NY-Sun program. This reduction in funding resulted in fewer systems installed in 2018 compared to the past three years. The Renewable Energy Portfolio still realized positive economic impacts in 2018 because of the inclusion of $1.7 million in funding from the NY-Sun program, however NY-Sun funding has declined from a peak of $20 million in 2015. The NY-Sun funding had a large impact on the results because it positively contributed to the direct impact of the program but did not incur a corresponding renewables charge to PSEG Long Island ratepayers.

2. Commercial Efficiency Program

2.1 Commercial Efficiency Program Description

PSEG Long Island's CEP caters to a 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. The CEP is delivered through several distinct program components. In 2018, PSEG Long Island continued to optimize the CEP to best address current market conditions and customer and contractor needs. As described below, one new program component (exterior lighting) was added, and several were modified over the course of the year.[6]

- Comprehensive Lighting: Includes predefined new construction, as well as replacement and retrofit measures. Initially, only large customers (i.e., customers with accounts billed under rate code 285) were able to apply for incentives under Comprehensive Lighting. Incentive amounts were fixed for the qualifying measures. All projects continue to require preapproval and pre-inspection (except for new construction) and are subject to post-inspection. Midway through 2018, CEP administrators modified the eligibility requirements and incentive structure of Comprehensive Lighting. These modifications are discussed in Section 2.1.1.

- Fast Track Lighting: Initially aimed at small business customers, this program was formerly limited to the subset of commercial customers with accounts billed under rate codes 280 or 281. The program participation process is streamlined and is designed to address key barriers to participation among small business customers; namely, lack of time and resources. Measure offerings continue to match those of the Comprehensive Lighting program component. Only Prime Efficiency Partners (PEPs), contractors and distributors who have been vetted, trained, and certified by PSEG Long Island, may submit Fast Track Lighting applications. Midway through 2018, CEP administrators modified the eligibility requirements of Fast Track Lighting. These modifications are discussed in Section 2.1.1.

- Exterior Lighting: Launched in May 2018, exterior lighting is a standalone program component that rebates exterior lighting replacement and retrofit measures. This program component was added to the CEP portfolio after the CEP shifted focus from demand savings to energy savings. All projects require preapproval and pre-inspection and are subject to post-inspection.

- Heating, Ventilation, and Air Conditioning (HVAC): Includes both prescriptive and retrofit HVAC projects. In 2018, the HVAC program component covered high efficiency air conditioners (ACs) and heat pumps, including ductless mini-split heat pumps, variable refrigerant flow heat pumps, and geothermal heat pumps.[7]

- Standard: All other prescriptive measures are offered under the Standard program component. This includes building envelope measures, compressed air, refrigeration, and variable frequency drives (VFDs). Standard projects require preapproval and are subject to pre- and post-inspections.

[6] CEP administrators also claimed savings achieved through legacy Prescriptive Lighting, Online Marketplace, and Building Operator Training program components in 2018, although these channels represent a *de minimis* proportion of 2018 CEP energy and demand savings.

[7] CEP administrators launched a standalone geothermal application midway through 2018, but rebates and savings are still included in the broader HVAC program component. The standalone application is applicable to both commercial and residential geothermal installations, which, according to program administrators, better aligns with the contractor market.

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

- **Other Program Components:** In addition to the core components describe above, PSEG Long Island's 2018 CEP portfolio included no-cost energy assessments, building operator trainings, cost-shared technical assistance studies, building commissioning co-funding, Leadership in Energy and Environmental Design (LEED) certification incentives, Online Marketplace, and ENERGY STAR® Benchmarking certification.

2.1.1 Program Design and Implementation

CEP implementation processes and incentives underwent several changes in 2018. Noticeable changes included:

- Offering performance-based lighting rebates through the Comprehensive Lighting program component

- Updating program eligibility requirements for the Comprehensive Lighting and Fast Track program components

- Offering a contractor incentive for part of the program year

Performance Lighting Rebates

In August 2018, Comprehensive Lighting rebates changed from being calculated on a per-fixture basis to being calculated on a per-kWh basis, based on the energy savings that a measure generates. This shift better aligns rebates with the claimable savings a project generates, as rebates are directly related to the level of inefficiency of the replaced equipment and the expected operating hours of the facility.[8] By aligning incentives directly with program goals, program administrators can provide for a more transparent and efficient process, which by design can better align budgets and energy savings goals over the course of a program year. This shift also helps to incentivize lighting optimization, as the marginal benefit of "over lighting" a space is now reduced compared to a dollars-per-fixture rebate design.

Program Eligibility

In conjunction with the rollout of performance-based lighting rebates, the CEP administrator adjusted the eligibility requirements for both Comprehensive Lighting and Fast Track Lighting. By opening up Comprehensive Lighting to all commercial rate classes, CEP administrators allowed all commercial customers access to the new performance-based lighting rebates. Program administrators also removed the rate class eligibility restriction on Fast Track Lighting participation. As of August 2018, all commercial rate classes, instead of only small commercial customers, can apply for Fast Track Lighting rebates, although program administrators also reinstated the $5,000 project cap on Fast Track Lighting projects. In addition, in 2018, preapproval of Fast Track lighting applications was no longer required.

[8] Operating hours for all facilities are deemed by the NY TRM based on the primary space type of a facility.

Contractor Incentives

CEP program administrators offered limited-time contractor incentives from August through November 2018 with the aim of increasing project closures by the end of the program year and to meet 2018 savings goals. All project types were eligible for these contractor incentives. Incentives ranged from $250 to $1,000 per project depending on the size of the project and were available for any CEP project with a rebate over $1,000. According to program administrators, the incentives were successful in increasing the rate of project applications, especially among non-managed account projects, which tend to be smaller and can get overlooked as contractors focus on closing larger projects toward the end of the program year.

2.1.2 Program Participation and Performance

PSEG Long Island's CEP performed well in 2018, with its verified ex ante net savings reaching 101% of the energy savings goal and 84% of the peak demand goal. Table 2-1 presents 2018 CEP program performance compared to goals.

Table 2-1. 2018 CEP Verified Ex Ante Net Program Performance Against Goals

Metric	MWh	MW
Goal	97,802	25
Verified Ex Ante Net Savings	99,108	21
% of Goal	101%	84%

Comprehensive Lighting projects account for the largest share of CEP net energy and demand savings. As shown in Table 2-2, Comprehensive Lighting projects accounted for 57% of ex ante net energy savings and 67% of ex ante net demand savings in 2018. Fast Track Lighting accounted for 16% of ex ante net energy savings and 19% of CEP ex ante net demand savings in 2018.

Table 2-2. 2018 CEP Ex Ante Net Savings by Program Component

Program Component	Ex Ante Net Savings	
	MWh%	MW%
Comprehensive Lighting	57%	67%
Fast Track Lighting	16%	19%
Custom (non-lighting)	7%	2%
Standard	6%	2%
Exterior Lighting	4%	0%
Custom (CHP)	4%	3%
HVAC	2%	5%
Custom (lighting)	2%	2%
Other Program Components[a]	1%	<1%

[a] Includes savings from Building Operator Trainings, Online Marketplace, and legacy Prescriptive Lighting installations

While the CEP continues to rely primarily on lighting measures for savings, the overall importance of lighting measures to the CEP declined over time as the program administrators have made concerted efforts to diversify program offerings by expanding non-lighting program offerings. Reflecting these efforts, the proportion of savings derived from lighting has decreased from 94% in 2016 to 91% in 2017, and then fell again to 80% in 2018, as shown in Table 2-3.

Table 2-3. Historical Ex Ante Net Energy Savings by End Use

End Use	Energy Savings (MWh)			Energy Savings (%)		
	2016	2017	2018	2016	2017	2018
Lighting	101,800	93,850	79,412	94%	91%	80%
Non-Lighting	6,603	9,791	20,109	6%	9%	20%

2.1.3 Program Marketing

Program marketing and outreach efforts in 2018 remained largely consistent with 2017 and leveraged a range of marketing strategies and tactics to broaden customer and trade ally awareness of the CEP and its benefits. Marketing strategies employed in 2018 included continued reliance on trade allies and Lockheed Martin energy consultants to reach and educate customers about program offerings, energy efficiency conferences, testimonials, webinars, and web and radio advertising. In addition, the program hosted community partner events in 2018, managing booths at various community events to promote energy efficiency programs and distribute literature and brochures to customers. The program continued to host open houses once a week to answer trade ally questions, review application forms, provide project preapproval, and address other contractor issues. The annual Energy Efficiency Conference on Long Island continued to be another source of customer and trade ally engagement.

2.1.4 Anticipated Changes in 2019

The Comprehensive Lighting program component will continue to offer performance-based rebates in the beginning of 2019 while CEP administrators assess the impact of this new approach on program enrollment, savings, and budgets. The Comprehensive Lighting application that incorporates performance-based lighting rebates expires on March 31, 2019, giving CEP administrators time to assess the impact of this approach over the first part of 2019. While program administrators fully intend to offer performance-based rebates after March 31, 2019, based on program performance of the first few months of 2019, program administrators may deem it necessary to limit participation in Fast Track Lighting to small business customers again or make other adjustments to Comprehensive Lighting.

A landlord incentive will be offered to commercial landlords in 2019 based on the rebate value of completed projects at non-owner-occupied commercial buildings. This initiative is focused on addressing the "split-incentive" issue that arises in such commercial (and residential) buildings where one party invests in the energy-efficient equipment (the landlord) and another party benefits from the energy savings (the tenant or building operator). These added incentives aim to improve the business case for commercial landlords to invest in efficient upgrades.

Other anticipated changes to the CEP program in 2019 include:

- Offering new incentives for fuel cells and combing these incentives with existing CHP incentives onto a standalone Distributed Generation application
- Launching a standalone Refrigeration application
- Potentially expanding the PEP program launched last year for Fast Track Lighting to geothermal and HVAC projects

2.2 Commercial Efficiency Program Impacts

The following sections provide the results of the engineering analysis for the CEP. Section 2.2.1 presents evaluated net savings, and Section 2.2.2 presents ex post net savings. 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 NTGRs. Program-planning NTGRs differed from evaluated values by program component. For a detailed list of NTGRs see Appendix A.

2.2.1 Evaluated Impacts

Table 2-4 compares evaluated net savings to ex ante net savings for the CEP by program component and shows the associated realization rates. The evaluation team calculated evaluated realization rates by dividing evaluated net savings values by ex ante net savings values. Overall, the CEP achieved 96% of its ex ante net energy and 98% of its ex ante net demand savings. Evaluated realization rates for energy savings ranged from 86% for the CHP program component to 110% for the HVAC program component. Evaluated realization rates for demand savings ranged from 76% for the CHP program component to 131% for the Standard program component. The Comprehensive Lighting, Fast Track Lighting, Custom (non-lighting), and Standard program components make up more than 85% of the overall CEP energy savings; therefore, these components highly influence the overall CEP realization rates. A further discussion of discrepancies seen among all program components is provided in the following section. We rank program components in Table 2-4 from largest to smallest evaluated net energy savings.

Table 2-4. 2018 CEP Evaluated Net Impacts

Program Component	Ex Ante Net Savings		Evaluated Net Savings		Realization Rate	
	kWh	kW	kWh	kW	kWh	kW
Comprehensive Lighting	57,069,849	14,165	56,264,285	13,939	99%	98%
Fast Track Lighting	15,732,563	3,931	14,284,980	3,927	91%	100%
Custom (non-lighting)	6,895,948	361	6,551,150	289	95%	80%
Standard	5,759,287	468	5,105,580	613	89%	131%
Exterior Lighting	4,466,877	0	4,466,877	0	100%	N/A
Custom (CHP)	4,375,197	639	3,751,588	488	86%	76%
HVAC	2,105,078	1,020	2,320,073	1,082	110%	106%
Custom (lighting)	1,670,898	342	1,587,353	273	95%	80%
Other Program Components	1,445,405	90	1,301,222	77	90%	85%
CEP Total	**99,521,101**	**21,014**	**95,633,109**	**20,687**	**96%**	**98%**

Note: Totals may not sum due to rounding.

The 2018 program year included four CHP projects for the first time. Overall CHP ex ante net savings, evaluated net savings, and realization rate are illustrated in Table 2-4 above, under "Custom (CHP)." The four projects consist of electricity generation through natural gas engines and waste heat recovery. Table 2-5 summarizes the electricity savings, additional gas consumption to produce the electricity, and gas savings through waste heat recovery.

Table 2-5. 2018 Combined Heat and Power Project Summary

Project ID	Ex Ante Net Savings		Evaluated Net Savings				
	kWh	kW	kWh	kW	Additional Gas Consumption (therms)	Heat Recovery Savings (therms)	Total Facility Net Gas Impact (therms)
2016-1711722	577,276	72	419,014	59	(57,601)	25,316	(32,285)
2016-1711709	577,276	72	434,461	48	(61,267)	27,653	(33,614)
2017-1723394	2,363,495	345	1,676,606	235	(225,548)	127,871	(97,677)
2017-1726815	857,151	151	1,221,508	146	(136,085)	47,793	(88,292)
CHP Total	4,375,197	639	3,751,588	488	(480,502)	228,634	(251,868)

Note: Totals may not sum due to rounding.

Reasons for Differences in Impacts

Below we describe the evaluation team's measure-specific savings calculations and reasons for discrepancies in savings.

- For **Comprehensive Lighting** measures, the desk reviews revealed one main discrepancy between ex ante and evaluated savings. For projects that included occupancy sensors, the evaluation team applied a 30% energy savings factor (ESF) per the New York Technical Reference Manual (NY TRM). The ex ante ESF assumption ranged from 13% to 50%, depending on the sensor type. The evaluation team's updates to occupancy sensor savings factors, on average, decreased evaluated net savings compared to ex ante savings and are the key driver of the 99% and 98% realization rates for energy and demand savings, respectively, shown in Table 2-4. The evaluation team recommends that PSEG Long Island align its ESF assumptions with those presented in the NY TRM.[9] We also recommend tracking the lamps controlled by the occupancy sensor to allow for population-level evaluations of the Comprehensive Lighting program component.[10]

- For **Fast Track Lighting** measures, the population-level analysis revealed one discrepancy between ex ante and evaluated savings related to operating hours assumptions. The implementers applied operating hours from the 2010 LIPA Technical Manual, whereas the evaluation team adhered to the operating hours assumptions provided in the NY TRM. The 2010 LIPA Technical Manual references studies from 1994 to 1996. We believe the NY TRM is the more accurate source and aligns operating hours across other PSEG Long Island commercial programs. Overall, this resulted in lower evaluated savings, as reflected in the 91% kWh realization rate reported in Table 2-4 above. The evaluation team recommends adopting the NY TRM operating hours assumptions for future program years.

- For both the **Custom (non-lighting)** and **Custom (lighting)** measures, the evaluation team based evaluated and ex post energy and demand savings on the evaluation of 67 sites via engineering M&V during the 2012 impact evaluation. We applied the same realization rates (95% for energy savings and 80% for demand savings) from this past analysis to the 2018 custom projects. The research that informed these realization rates is now several years old, and non-CHP custom projects make up just

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[9] The NY TRMv5 (effective for the 2018 program year) assumes a 30% ESF. Updates to PSEG Long Island inputs should reference v6 of the NY TRM.

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

over 8% of total ex ante energy savings. The evaluation team recommends further research be completed during the next evaluation period to inform new realization rates for Custom measures.

- Within the **Standard** program component, there are four measure types: Refrigeration, Compressed Air, Motors and VFDs, and Building Envelope. The evaluation team describes measure-specific analysis results below:
  - For **Refrigeration** measures, the evaluated savings realization rates are 80% and 102% for energy and demand savings, respectively. In 2018, refrigeration measures made up 68% of the standard component ex ante energy savings and 4% of overall CEP ex ante energy savings. This is larger than in previous program years,[11]; therefore, the evaluation team developed evaluated savings through a desk review approach.[12] We followed the PSEG Long Island TRM using project-specific required inputs from the specification sheets collected for each project within the sample of projects reviewed. We then developed measure-specific realization rates to apply to all refrigeration measures. Evaluated savings are based on desk reviews because PSEG Long Island does not track all inputs needed to follow the NY TRM within LM Captures.[13] In contrast to evaluated savings, PSEG Long Island calculated deemed per-installation ex ante savings using historic program data from the Siebel database as inputs to the algorithms presented in the 2010 LIPA Technical Manual. The evaluation team requested but did not receive the historical data or the specific input assumptions associated with the historical data. Therefore, the team is unable to pinpoint specific input discrepancies, but rather an overall methodological difference. The evaluation team recommends tracking the necessary parameters within LM Captures and following the PSEG Long Island TRM for ex ante calculations to allow for a population-level review of these measures in future evaluations.
  - For **Compressed Air** measures (22% of ex ante total energy savings within the Standard component), the evaluation team made the following updates that resulted in 92% and 250% realization rates for energy and demand savings, respectively:
    - Ex ante assumptions and algorithms are sourced from the 2010 LIPA Technical Manual. Alternatively, the evaluation team followed the algorithms and input assumptions from the PSEG Long Island TRM, which is also in alignment with the NY TRM. This led to differing input assumptions for demand savings factors for high efficiency air compressors and cycling dryers and ultimately higher evaluated demand savings. Additionally, the evaluation team developed demand savings for cycling dryers following the PSEG Long Island TRM, whereas the ex ante calculations did not claim these savings. These savings are a key driver for the 250% realization rate for demand.
    - The evaluation team also updated the NTGR from 0.93 to 0.91 to align with appropriate planning assumptions for Compressed Air measures. This led to a slight decrease in evaluated savings compared to ex ante savings.
  - For **Motor and VFD** measures (7% of ex ante total energy savings within the Standard Component), the engineering analysis resulted in the evaluated net realization rate of 124% for energy savings and 65% for demand savings. Program tracking data contained detailed and extensive information for each installation that enabled the evaluation team to conduct engineering analyses by facility

[11] In 2017, refrigeration measures made up 23% of the standard component ex ante energy savings and 1.2% of overall CEP ex ante energy savings.

[12] During previous evaluation years, refrigeration measures were assigned evaluated realization rates of 1.00 for energy and demand savings by the evaluation team.

[13] Project application documents (specification sheets) contain the needed information (i.e., Voltage and Amperage of refrigeration components) to follow the PSEG Long Island TRM.

and motor type. We used normalized savings values (i.e., kW/hp or kWh/hp) that the NY TRM recommends based on different building types and VFD application. The evaluation team believes that PSEG Long Island is using the 2010 LIPA Technical Manual planning document for VFD savings factors, resulting in savings differences when compared with the NY TRM. We recommend that the program adopt the savings algorithms and assumptions outlined in the TRM provided by the evaluation team.

- For Building Envelope measures (3% of ex ante total energy savings within the Standard Component), the evaluation team found the following discrepancies that ultimately resulted in 173% and 114% realization rates for energy and demand savings, respectively, for building envelope measures:
  - The evaluation team used installation-specific building types, installed areas, and normalized savings values (kW/sf or kWh/sf) by building type recommended by the NY TRM. Alternatively, ex ante savings rely on the New York State Energy Efficiency Portfolio Standard for normalized savings values. The evaluation team recommends aligning ex ante savings algorithms and inputs with the PSEG Long Island Prospective TRM, which is in alignment with the NY TRM.
  - The evaluation team also updated the NTGR from 0.93 to 1.00 to align with appropriate planning assumptions for Building Envelope measures. This led to an increase in evaluated savings compared to ex ante savings.

- For Exterior Lighting measures, the evaluation team did not find any issues that led to realization rate discrepancies.
- For Combined Heat and Power projects, the evaluated net realization rates are 86% and 76% for energy and demand savings, respectively, based on four projects completed in 2018. For three out of four projects, the evaluation team received monthly reports that provided the CHP systems' cumulative runtime, electricity generation, and waste heat output over eight months in 2018. For the remaining project, the evaluation team received a combination of 15-minute and 1-minute interval data for natural gas input, electricity generation, and thermal energy recovered by the CHP system. To estimate the electric energy impacts for all four projects, the evaluation team first calculated typical power production (in kW), which was found to vary seasonally for some projects, as the team verified through interviews with project vendors. The average produced power (kW) was then multiplied by an estimated 8,300 annual operating hours (similar to ex ante assumptions) to account for system downtime and maintenance, as the monthly and trended data were not sufficiently indicative of these inactive periods.
  - The evaluated energy and demand savings are lower than ex ante primarily due to differences in electrical production. For three out of four projects in 2018, the evaluation team determined that the reciprocating engines were operating at power set points lower than proposed by the applicant. The ex ante energy savings were calculated using an assumed power set point considerably higher than the actual operating power set point, resulting in lower electricity production and lower evaluated savings. These differences were more pronounced in the summer months, leading to a lower demand realization rate.
  - Using manufacturer data and CHP modeling software, the evaluation team also separately quantified the required natural gas input as well as the estimated recovered thermal energy for each of the four projects, totaling 25,187 MMBtu per year overall.

- For HVAC measures, the evaluation team identified several factors that led to discrepancies between ex ante and evaluated savings, resulting in realization rates of 110% for energy and 106% for demand savings:
  - The evaluation team updated the assumed CF from 0.72 to 0.80 to align with the NY TRM. As a result, evaluated net demand savings are greater than ex ante net demand savings.
  - The evaluation team included heating energy savings for heat pump measures larger than 5.4 tons, whereas ex ante savings include cooling savings only. This is the primary driver for the elevated evaluated energy savings for HVAC measures.
  - For HVAC measure installations, the evaluation team referenced American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1 2016 to define measure baselines for HVAC installations in 2018. It appears that the program referenced ASHRAE 90.1 2010 to define baseline efficiencies for legacy project applications (pre-2017). This difference in baseline led to lower evaluated demand and energy savings, particularly for the smaller (<5.4 ton) HVAC units, for which the cooling efficiency baseline changes from a seasonal energy efficiency ratio (SEER) of 13 in ASHRAE 90.1 2010 to a SEER of 14 in ASHRAE 90.1 2016. This issue appears to be addressed in newer applications and was limited to legacy applications (older than 2017).
- For the Other Program Components, which are the Building Operator Trainings, legacy Prescriptive Lighting Measures, and the newly offered Online Marketplace, the evaluation team found the following discrepancies as described below:
  - For the legacy Prescriptive Lighting measures, the evaluation team's desk reviews found two main sources of savings discrepancies responsible for the realization rates seen in the Other Program Components category as discussed below. However, we note that based on previous discussions with the implementer, we understand that Prescriptive Lighting measures are being phased out and projects completed in 2018 honored pre-2017 applications and assumptions. The evaluation team does not anticipate them being part of the CEP in 2019.
  - The evaluation team found that all ex ante savings estimates incorrectly applied waste heat factors (WHF) twice. The deemed per-measure savings assumptions used in ex ante calculations included WHF, as did ex ante savings algorithms. The evaluated savings include WHF only once, which lowered both energy and demand realization rates.
    - The evaluation team also adjusted the operating hours to adhere to the NY TRM, which is consistent with evaluated calculations for the Fast Track and Comprehensive Lighting measures. Ex ante operating hours rely on the 2010 LIPA Technical Manual. Because operating hour estimates affect only energy savings, the realization rate for energy savings is significantly lower than that of demand savings.
  - For the Online Marketplace measures, the evaluation team made the following updates to evaluated savings:
    - The evaluation team found that savings tracked in LM Captures did not account for cooling bonuses for either energy or demand savings for lighting measures. We include cooling bonuses in evaluated savings, resulting in larger energy and demand impacts compared to ex ante savings.
    - The evaluation team also found that ex ante savings tracked in LM Captures did not include NTGRs. The evaluation team accounts for NTGRs in evaluated net savings, resulting in smaller energy and demand impacts compared to ex ante. A comprehensive list of NTGRs can be found in Appendix A.

2.2.2 Ex Post Net Impacts for Cost-Effectiveness

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 energy savings and 77% for demand savings. Ex post realization rates for energy savings ranged from 69% for the Standard program component to 88% for the HVAC program component. Ex post realization rates for demand savings ranged from 64% for the Custom (lighting and non-lighting) program component to 100% for the Standard program component.

Table 2-6. 2018 CEP Ex Post Net Impacts for Cost-Effectiveness

Program Component	Ex Ante Net Savings		Ex Post Net Savings		Realization Rate	
	kWh	kW	kWh	kW	kWh	kW
Comprehensive Lighting	57,069,849	14,165	43,757,713	10,889	77%	77%
Fast Track Lighting	15,732,563	3,931	11,101,303	3,069	71%	78%
Custom (non-lighting)	6,895,948	361	5,208,165	231	76%	64%
Standard	5,759,287	468	3,946,037	467	69%	100%
Exterior Lighting	4,466,877	0	3,473,968	0	78%	N/A
Custom (CHP)	4,375,197	639	3,751,588	488	86%	76%
HVAC	2,105,078	1,020	1,844,458	864	88%	85%
Custom (lighting)	1,670,898	342	1,261,946	218	76%	64%
Other Program Components	1,445,405	90	1,228,263	60	85%	67%
CEP Total	99,521,101	21,014	75,573,440	16,285	76%	77%

Note: Totals may not sum due to rounding.

[a] Includes savings from Building Operator Trainings, Online Marketplace, and legacy Prescriptive Lighting installations

2.3 Conclusions and Recommendations

Based on the results of this evaluation, the evaluation team offers the following key findings and recommendations for the CEP moving forward:

- Key Finding #1: While the CEP has made significant progress in expanding its non-lighting program offerings (e.g., CHP), program savings continue to come largely from lighting measures (80% of ex ante energy savings and 88% of ex ante demand savings).
    - Recommendation: The LED market is experiencing dramatic changes in pricing, product availability, and prominence. PSEG Long Island should continue to monitor product pricing and availability as the commercial lighting market transforms and should adjust incentives accordingly.
    - Recommendation: To ensure stable performance and savings sources moving forward, PSEG Long Island should continue to look for ways to diversify program offerings by researching the potential energy and demand savings from other end-uses. The evaluation team recommends exploring the addition of high efficiency commercial kitchen equipment as well as continued development of the Custom, HVAC, and Refrigeration standalone program components. Incorporating more non-lighting end-uses will help to ensure lasting success for the CEP.

- Key Finding #2: For select measures, critical project-level details, while tracked in individual project files and often used in ex ante calculations, are excluded from LM Captures tracking data. As a result, the evaluation team is prevented from conducting engineering analysis of the population of projects for all program components, but rather relies on desk reviews for comprehensive lighting and refrigeration measures.
  - Recommendation: The program should begin consistently tracking the following data in LM Captures:
    - Occupancy sensor watts controlled (Comprehensive Lighting program component)
    - Building type (Comprehensive Lighting program component)
    - Voltage and amperage ratings for refrigeration equipment (Standard program component)
- Key Finding #3: Program savings algorithms and input assumptions continue to reference the 2010 LIPA Technical Manual for some CEP program components.
  - Recommendation: The evaluation team developed a memorandum (*PSEG Long Island TRM Measure Alignment Memo_2019_01_31*) and shared it with the implementation team. This memorandum documents the discrepancies observed and recommendations for aligning with the 2019 PSEG Long Island TRM and NY TRM moving forward. We recommend continuing to align with these TRMs as much as possible, and we will work to develop agreed-upon algorithms and inputs with the implementation team in conjunction with the annual evaluation.
- Key Finding #4: The evaluation of CHP projects found discrepancies between planned set points and the actual operation of the CHP systems once installed.
  - Recommendation: To ensure that CHP savings are accurately quantified moving forward, the evaluation team recommends that the program revise eligibility requirements to require all applicants to provide 15-minute interval data on the following CHP performance parameters:
    - Net power output from CHP unit, in kW
    - Gas input to the CHP unit, in ft^3/hr
    - Parasitic loads, in kW
    - Hot water flow rates, in GPM
    - Hot water loop temperatures, in °F
    - Heat recovery rates (useful and rejected), in Btu/hr

    To appropriately account for seasonal variation and equipment persistence, we recommend that these data be trended for a period of three years. For context, a similar CHP program in New York requires five years of such trending. To implement this recommendation, all applicants must install monitoring equipment and provide a communication route (phone line or Internet connection) so that the performance data can be provided to PSEG Long Island on a continual basis.

3. Energy Efficient Products Program

3.1 Energy Efficiency Products Program Description

The objective of the Energy Efficient Products (EEP) program is to increase the purchase and use of energy-efficient appliances and lighting among PSEG Long Island residential customers. In 2018, the program provided rebates on a range of ENERGY STAR products, including solid state lighting (LED) bulbs and fixtures, pool pumps, appliances, and smart thermostats. The program also offered advanced power strips (APSs).

Overall, 2018 was a successful year for the EEP program. The program exceeded its internal goals (achieving savings within budget) even though the lighting program did not kick off in earnest until June given delays in finalizing retailer agreements, as well as lighting retailer inventory resets that made most lighting products ineligible for rebates early in the year. The program credits the success of the lighting program in the second half of the year, as well as several new marketing initiatives and internal process improvements discussed later in this section, for playing an important role in the program's ability to effectively reach customers and meet its goals.

During 2018, the program once again updated the list of qualifying products to reflect ENERGY STAR's standards and market trends. Notably, program staff made adjustments in part to start proactively building up the non-lighting components of the EEP program in anticipation of Energy Independence and Security Act of 2007 (EISA) Tier 2 lighting standards coming into effect in 2020. Specifically, the program added ENERGY STAR most efficient dishwashers and discontinued rebates for room air conditioners mid-year, while it continued offering efficient clothes washers and dryers, refrigerators, dehumidifiers, air purifiers, pool pumps, heat pump water heaters, and APSs.

Additionally, PSEG Long Island made the following changes to product incentives during 2018:

- Increased lighting incentives for both standard and specialty LED lights from 2017 levels. Initially, incentives were $1 for standard LEDs and $2 for specialty LEDs; they were increased to $2 for standard and $3 for specialty approximately midway through the year.
- Reduced the incentive from $75 (up to 50% of the retail price) to $50 (up to 50% of the retail price) for ENERGY STAR "most efficient" refrigerators.
- Reduced the incentive from $125 (up to 50% of the retail price) to $40 (up to 50% of the retail price) for efficient clothes dryers.
- Reduced the incentive from $65 (up to 50% of the retail price) to $40 (up to 50% of the retail price) for ENERGY STAR "most efficient" clothes washers.
- Introduced ENERGY STAR "most efficient" dishwashers with a $50 incentive.

The following sections provide a detailed examination of notable trends in program participation and savings for several EEP measure categories, as well as process analysis of changes to program implementation and design.

3.1.1 Program Participation and Performance

PSEG Long Island's EEP program performed very well in 2018, with its verified ex ante savings reaching 121% of the energy savings goal and 113% of the peak demand goal. Table 3-1 presents 2018 EEP program performance compared to goals.

Table 3-1. 2018 EEP Program Verified Ex Ante Net Program Performance Against Goals

Metric	MWh	MW
Goal	112,363	25
Verified Ex Ante Net Savings	136,036	28
% of Goal	121%	113%

Note: Totals may not sum due to rounding.

Lighting continues to account for the largest share of EEP net energy and demand savings. As shown in Table 3-2, lighting projects accounted for 92% of ex ante net energy savings and 81% of ex ante net demand savings in 2018. Pool pumps and appliance recycling contributed the next highest shares of savings, as in 2017. Program staff added two measures in 2018 (smart thermostats and dishwashers). Table 3-2 shows the distribution of ex ante net energy and demand savings by EEP program measure. Below the table, we provide additional detail on program performance by key measure category.

Table 3-2. 2018 EEP Program Ex Ante Net Savings by Program Component

Program Component	Ex Ante Net Savings	
	MWh%	MW%
Lighting	92%	81%
Pool Pumps	5%	14%
Appliance Recycling	1%	1%
ENERGY STAR (ES) Dehumidifiers	1%	4%
Smart Thermostats	<1%	0%
Heat Pump Water Heaters	<1%	<1%
Air Purifiers	<1%	<1%
Power Strips	<1%	<1%
Clothes Washers - Most Efficient	<1%	<1%
Clothes Dryers	<1%	<1%
Refrigerators	<1%	<1%
Dishwashers	<1%	<1%
Room ACs	<1%	<1%

Lighting

In 2018, lighting remained the foundation of the Energy Efficient Products program, providing approximately 92% of the EEP program's ex ante net energy savings and 81% of its ex ante net demand savings. The lighting program component also exceeded its savings goals, achieving 24.2 MW in ex ante net demand savings and 124,919 MWh in ex ante net energy savings. The program achieved this success by overcoming three early challenges:

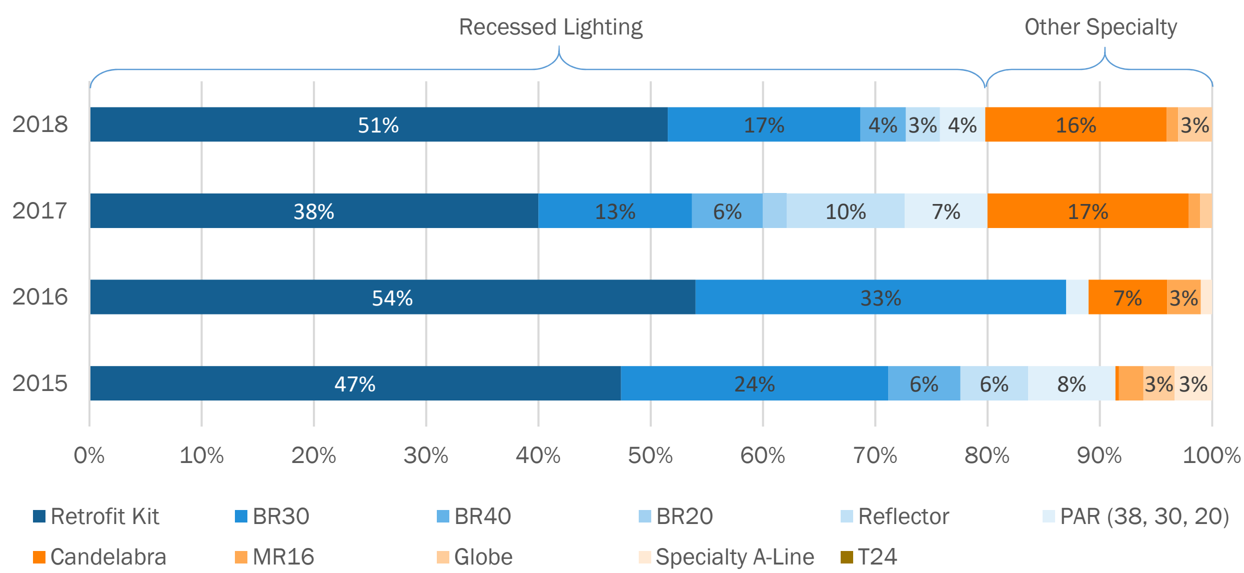
- Delays in finalizing agreements with program partners, which pushed back product rollout.
- Lighting retailer inventory resets, which restricted the number of products available for rebate. Retailers sold much of their lighting on clearance in 2018 to make room for new manufacturers' products, but lighting on clearance is typically ineligible for incentives. Notably, Lowe's offered only three lighting products eligible for incentives during the first six months of the year.

- Program staff believed that the initial incentives on lighting products were not high enough to be compelling to customers.

The program overcame these challenges through a combination of increasing the incentives on lighting products and pursuing more savings through other EEP product offerings. The program also launched targeted initiatives such as limited-time offers, corporate events, and free lighting distribution via local food banks to reach traditionally underserved customer segments.

As in past years, the EEP program marked down a mix of specialty and standard lighting (53% and 47% of markdowns, respectively). Figure 3-1 contains a comparison of specialty lighting markdowns in 2018 and in recent years. Recessed lighting, such as retrofit kits and BR30 bulbs, continued to dominate the specialty lighting offering (79% of markdowns). Candelabras, MR16 bulbs, and globe lights again made up the remaining one-fifth (20%) of the program's specialty markdowns.

Figure 3-1. Share of EEP Program Specialty LED Markdowns by Lighting Type, 2015-2018



Source: EEP upstream rebate program tracking data, 2015–2018.

After increasing for several years, the percentage of LEDs sold in packages of multiple bulbs (multi-packs) remained constant from 2017 to 2018 at 84% (Figure 3-2). Moreover, sales of the largest multi-packs of standard bulbs (8 and 10 bulbs) declined dramatically this year, from 43% of standard bulbs in 2017 to 14% in 2018. The shift toward mid-size packages is a positive trend for the program, as the largest multi-packs get more bulbs into homes, but also correlate with reduced first-year installation rates.

Figure 3-2. Distribution of EEP Lighting Measures by Package Size, 2017-2018

	1-Pack	2-Pack	3-Pack	4-Pack	6-Pack	8-Pack	10-Pack
Standard							
2018	4%	8%	1%	53%	20%	9%	5%
2017	4%	5%	<1%	36%	11%	17%	26%
Specialty							
2018	26%	12%	23%	15%	19%	0%	5%
2017	26%	16%	22%	14%	18%	4%	

In recent years, PSEG Long Island has anticipated that its current level of lighting savings will diminish after EISA Tier 2 standards come into effect. PSEG Long Island's 2019-2038 potential study, for example, indicated that after full compliance with EISA 2020 and an assumed two-year sell-through period, lighting would be practically eliminated as a source of residential savings after 2021.[14] However, in February 2019, the Department of Energy issued a plan to rescind the expansion of one part of the Tier 2 standards (the definition of general service lamps). This plan creates uncertainties regarding which products will be eligible for rebate in the future. Nonetheless, LEDs are popular with customers and so are displacing compact fluorescent lamps (CFLs). CFLs are increasingly displacing less efficient halogens as well. Given these marketplace trends, it remains prudent for the EEP program to bring in additional high-savings appliances and test out targeted marketing approaches.

Pool Pumps

Pool pumps provide the EEP program's greatest total source of non-lighting savings and offer the second-highest savings on a per-measure basis (following heat pump water heaters). Moreover, PSEG Long Island's recent potential study identified an ongoing opportunity to continue achieving pool pump savings for the next three years before expected updates federal minimum efficiency standards in 2021. In 2018, PSEG Long Island lifted its prior limit of two pool pump rebates per customer. As a result, the program rebated 3,015 pool pumps in 2018, a 7% increase from 2017 (2,815 rebates) and 126% of its 2018 unit goal. Ninety percent of rebated pool pumps were variable speed, and the remaining 10% were two-speed pumps. Pool pumps contributed 5% of the EEP program's overall ex ante net energy savings and 14% of overall ex ante net demand savings.

Midway through the 2018 program year, Lockheed Martin transitioned pool pump fulfillment to an in-house tool, moving away from its historical process of having implementation subcontractors process rebates. This move allowed program staff to monitor the offering's real-time impact on the portfolio, rather than waiting for the bimonthly data pull from a subcontractor. Further, the move allowed program staff to more efficiently and

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[14] Opinion Dynamics (December 2018). *PSEG Long Island Commercial and Residential Potential Study 2019–2038. Volume 1: Methodology and Results (FINAL DRAFT).*

effectively address customer issues related to rebate qualifications. Moving forward, Lockheed Martin will use a similar method to process all appliance rebate data in-house.

Heat Pump Water Heaters

In 2017, PSEG Long Island introduced ENERGY STAR heat pump water heaters as a pilot offering. In its second year, the program expanded to rebate 147 heat pump water heaters (147% of its unit goal). Eighty-four percent of heat pump water heaters rebated in 2018 were small, less than 55-gallon units, while the remaining 16% were larger units of more than 55 gallons. This split between small and large unit sizes is similar to 2017 (80% and 20%, respectively).

Moving forward, continuing to incentivize efficient heat pump water heaters enables PSEG Long Island to tap into savings opportunities for the customer base using electric water heaters (15% of customers) and moreover capitalize on a market in which very few customers (<1%) are adopting this emerging technology on their own.[15] PSEG Long Island's 2019–2038 potential study suggests that, in the short term, uptake is going to be most cost-effective for larger households that use a relatively large amount of hot water. Over the long term, however, this measure is poised to offer broader savings opportunities across PSEG Long Island's service territory.

Dishwashers

PSEG Long Island introduced an incentive program for ENERGY STAR "most efficient" dishwashers in 2018. Efficient dishwashers offer another opportunity for PSEG Long Island to diversify the EEP program portfolio with large appliance savings. In its first year, the ENERGY STAR "most efficient" dishwasher offering rebated 216 units, 17% of its unit goal.

Program staff discussed the challenges of introducing large appliance measures to the program due to a lack of floor space in retail stores and the time it takes for customers to become aware of a new offer. Retailers typically do not devote a large amount of floor space to "most efficient" models, as they tend to be more expensive. As a result, customers are less likely to see these models while shopping in-store. Additionally, program staff point to a lack of efficient dishwasher models that meet program criteria as another explanation for the program's slow start. PSEG Long Island plans to continue offering ENERGY STAR "most efficient" dishwashers in 2019.

Clothes Washers and Dryers

Clothes washers and dryers have been a staple and relatively popular EEP offering for several years, but as higher-cost appliances, they are also relatively expensive to incentivize. To balance EEP program cost-effectiveness, the program reduced incentives for ENERGY STAR "most efficient" clothes washers and clothes dryers in 2018 from $65 and $125 (respectively) to $40 each. Accordingly, participation in these offerings dipped this year, totaling 2,248 clothes dryers compared to 4,315 in 2017 (a 47% reduction), and 2,938 clothes washers compared to 4,721 in 2017 (a 37% reduction). Moving forward, program staff acknowledge that a rebate less than $50 for relatively expensive appliances is not compelling for customers, and they are assessing the viability of new incentive formats (e.g., instant gift cards) that could help to regain participation while continuing to maintain program cost-effectiveness at a lower incentive point.

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[15] Opinion Dynamics (August 2018). *PSEG Long Island Commercial and Residential Potential Study 2019–2038. Volume 2: Market Baseline Data Collection Details.*

Smart Thermostats

In 2018, the EEP program supported a PSEG Long Island push to market smart thermostats to customers through the Online Marketplace. PSEG Long Island sent a marketing e-blast to its approximately 470,000 residential customers with an email on file, offering them a rebate of $80 to $120 per thermostat when purchased through the Online Marketplace. This offer ran concurrent with manufacturers' Black Friday sales, which garnered additional price savings and was very popular with customers. In certain locations, this offer also overlapped with the Super Saver program, giving customers the opportunity to save an additional $50 on smart thermostats. The program rebated 7,542 smart thermostats.

Program Implementation Enhancements to Confirm ENERGY STAR Qualification

In 2018, the EEP program rolled out an across-the-board automated quality control tool that checks equipment in program tracking data against the ENERGY STAR Certified Product list. This tool flags any measure in the data that may not be qualified for a rebate. Program staff can then research the measure and quickly respond to applicants, improving customer satisfaction and streamlining data processing. For 2019, program staff added a similar ENERGY STAR lookup to the program's online appliance rebate application form, enabling customers to instantly determine whether their appliance is program eligible.

Future Planning

Looking forward to the 2019 program year, the EEP program plans to maintain all current offerings while also adding freezers, connected lighting, ENERGY STAR ventilation fans, and ENERGY STAR "most efficient" 2018 ventilation fans. Additionally, the program will move all appliance rebate applications to an online platform, allowing the program to use newly developed quality control tools.

3.1.2 Program Marketing

In addition to increasing signage and adding more prominent logos, the program offered calendars to all residential customers through customer service offices and trade shows. The calendars feature general information on all available energy efficiency programs. Notably, the program also implemented several new marketing initiatives in 2018, partly to make up for the lighting program's slow start, but also to reach previously underserved customer segments.

Food Bank Partnerships

PSEG Long Island partnered with Long Island's largest food banks (Long Island Cares and Long Island Harvest) to offer a free 2-pack of standard LEDs to a typically underserved segment of the market. According to program staff, the food pantry programs were well received by customers and successful overall; program staff report that they distributed 296,064 standard LEDs and 5,130 desk lamps through these partnerships.

Corporate Events

PSEG Long Island held four corporate marketing events to offer rebated lighting products to employees at RXR Properties, a property management company that owns office parks in the service area. All employees received a flyer advertising the date and time of the events, as well as pricing for lighting kits and other products. Events were held on site at the RXR offices and, according to program staff, were very well received by the employees. Due to the timing of these events, lighting products sold at events were not invoiced for the 2018 program year, and associated savings will count toward 2019 program savings.

Limited-Time Offers

The EEP program ran two limited-time offers during 2018 to promote lighting sales through a third party vendor, Techniart. One offer occurred in the summer and one in the fall. In each offer, program staff sent a marketing e-blast to the residential customer base, reaching approximately 470,000 customers. The program rebated 116,000 standard LEDs and 91,100 specialty LEDs during the summer offer, and 92,110 standard LEDs and 83,890 specialty LEDs during the fall offer.

3.2 Energy Efficient Products Program Impacts

The following sections provide the results of the engineering analysis for the EEP program. Section 3.2.1 presents the evaluated net savings, and Section 3.2.2 presents ex post net savings. Ex post net savings differ from evaluated net savings in that ex post net savings are developed using ex post NTGRs, while evaluated net savings are based on program planning NTGRs. Program-planning NTGRs differed from evaluated values for appliance recycling and dehumidifiers. For a list of NTGRs used in this evaluation, see Appendix B.

3.2.1 Evaluated Impacts

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

Table 3-3. 2018 EEP Program Evaluated Net Impacts

Category	N	Ex Ante Net Savings		Evaluated Net Savings		Realization Rate	
		kWh	kW	kWh	kW	kWh	kW
Lighting	4,738,328	124,918,541	24,166	124,451,587	23,312	100%	96%
Pool Pumps	3,015	6,549,573	4,050	7,173,481	4,554	110%	112%
Appliance Recycling	4,006	1,289,832	243	1,139,356	194	88%	80%
Dehumidifiers	5,559	1,096,235	1,084	1,057,657	195	96%	18%
Smart Thermostats	7,545	645,852	0	610,292	0	94%	N/A
Heat Pump Water Heaters	147	457,743	50	601,484	27	131%	55%
Air Purifiers	616	218,742	40	421,249	50	193%	124%
Power Strips	781	98,229	9.3	40,800	4.2	42%	45%
Clothes Washers - Most Efficient	2,983	94,561	21	117,861	12	125%	57%
Clothes Dryers	2,248	70,751	16	81,143	12	115%	79%
Refrigerators	1,369	70,367	8.2	82,832	10	118%	119%
Dishwashers	216	17,021	3.2	10,446	1.1	61%	34%
Room ACs	248	6,991	15	6,817	15	98%	98%
Totals	4,767,061	135,534,437	29,705	135,795,004	28,386	100%	96%

Notes: Totals may not sum due to rounding. N = Number of measures rebated.

Reasons for Differences in Impacts

The following discussion focuses on discrepancies between ex ante and evaluated results. Notably, many of the reasons for differences between ex ante and evaluated impact results relate to the program's use of historical measure mix and baseline data from prior years' program tracking data as a basis of ex ante savings assumptions, while the evaluation team was able to use the actual 2018 tracking data for its calculations.

Below we describe the evaluation team's measure-specific savings calculations and reasons for discrepancies in savings.

- Lighting: Lighting accounted for approximately 92% of the evaluated net energy savings and 82% of evaluated net demand savings across the EEP program in 2018. The evaluation team calculated lighting realization rates of 100% for net energy savings and 96% for net demand savings. The differences between ex ante and evaluated savings are due to the following:
    - LED In-Storage: In 2017, the program assumed an in-service rate (ISR) of 100% for LEDs, while the evaluation team assumed an 89% ISR based on the 2017 Residential In-Home Study.[16] As a result, the program administrators assumed zero in-storage savings in 2018, also referred to as carryover savings, from 2017 incentivized LEDs. Conversely, the evaluation team applied a second-year ISR of 9% to 2017 incentivized LEDs, assumed to be installed in 2018. In-storage LEDs increased evaluated savings approximately 2% for both energy and demand savings. In 2018, both the program and evaluation team applied a first-year ISR of 89% and will apply a second-year carryover ISR of 9% in 2019, so this discrepancy is limited to the 2018 evaluation.
    - Hours: The program administrators calculated a weighted average of 1,172 annual operating hours using an assumed mix of 86% interior and 14% exterior sockets. The evaluation team applied the 2018 PSEG Long Island TRM-specified mix of 89% interior and 11% exterior sockets, based on the Residential In-Home Study, for a weighted average of 1,159 annual hours. The difference in interior-to-exterior measure mix led to slightly lower demand and energy evaluated savings.
    - Delta Watts (the difference between the replaced and installed lamp wattage): Ex ante assumptions reflected the measure mix from 2016 program tracking data to estimate the difference in lighting wattage after installation of the energy-efficient unit. The evaluation team calculated a realized difference in lighting wattage from 2018 tracked data and calculated baseline wattage for standard LED bulbs using EISA minimum requirements. For specialty LED bulbs not addressed by EISA, the evaluation team used baseline incandescent wattages mapped from 2018 installed wattage data. This approach resulted in higher baseline watts for standard lamps and lower baseline watts for specialty lamps for 2018 in comparison to 2016 data, and subsequently an increase in the overall lighting realization rate for both demand and energy.
    - Rounding: The 96% realization rate for demand savings is due in large part to rounding in LM Captures identified during the verified ex ante analysis. LM Captures rounds values to three decimals, and because unitary demand savings are small values on the order of 1/100th of a kW, rounding errors accumulate more quickly and present more prominently than for energy savings.
- Pool Pumps: Ex ante assumptions for pool pumps were based on 2016 tracking data, as recommended in the 2018 PSEG Long Island TRM. In 2018, program administrators began tracking motor size data. The evaluation team incorporated motor size values into evaluated calculations, rather than assuming motor sizes as in past evaluation cycles. Evaluators analyzed the 2018 tracking data and determined that the weighted average horsepower for a two-speed pool pump was 33% larger than the value assumed in ex ante calculations, resulting in a larger baseline energy consumption. Similarly, the 2018 weighted average horsepower for variable-speed pool pumps was 36% larger than the value assumed by the program. Combined with increases in the weighted average

[16] Opinion Dynamics. (October 2017). *PSEG Long Island Residential In-Home Study.*

pool volume, evaluated savings surpassed ex ante with realization rates of 110% for energy and 112% for demand.

- Appliance Recycling: The overall realization rates for appliance recycling are 88% and 80% for energy and demand, respectively. Increased granularity of program tracking data in 2018 led to improved evaluated savings accuracy. The improved accuracy impacted realization rates because ex ante assumptions relied on 2016 data, as recommended by the 2018 PSEG Long Island TRM. Below is a discussion of individual appliance recycling measures for which discrepancies between ex ante and evaluated results were observed.
  - Room Air Conditioner Recycling: The evaluation team implemented a change in the evaluated savings calculation method for room air conditioners. The updated method, adopted from NY TRMv5, utilizes the known energy efficiency ratio (EER) value of the removed unit in coordination with federal standard EER values and estimated annual operating hours to calculate savings. As recommended by the 2018 PSEG Long Island TRM, program administrators continued to use the ENERGY STAR guidelines[17] for estimating electricity savings from recycled room air conditioners; the guidelines assume a deemed savings of 132 kWh annually. The evaluation team implemented the NY TRMv5 algorithm in coordination with recently improved program tracking data, which offers increased accuracy of savings. This method, which will be recommended in the next iteration of the 2018 PSEG Long Island TRM, resulted in realization rates for energy and demand of 83% and 86%, respectively.
  - Dehumidifier Recycling: In 2018, program tracking data for recycled dehumidifiers include removed unit capacities, which the evaluation team used to determine the distribution among the size categories listed in the 2018 PSEG Long Island TRM. As the vintages of the removed units were not available in the tracking data, the evaluation team applied 2005 and current federal standard efficiencies to determine the savings of a retired dehumidifier approaching the end of its effective useful life. Historically, the program administrators used the deemed savings assumptions of 0.28 kW and 471 kWh in ex ante calculations. The increased granularity in 2018 tracking data led to increased accuracy of evaluated savings, resulting in unit savings of 0.035 kW and 198 kWh annually. Additionally, the program applied a coincidence factor of 1.0, whereas the evaluation team applied a CF of 0.3 based on the 2018 PSEG Long Island TRM. Realization rates are 42% for energy and 13% for demand.
  - Refrigerator/Freezer Recycling: Ex ante savings assumptions for the weighted average annual energy consumption of recycled refrigerators and freezers reflect 2016 tracking data, as recommended in the 2018 PSEG Long Island TRM. The difference between this annual consumption and the units' corresponding current federal standard[18] define the savings of the recycled units. The weighted average annual energy consumption of removed units manufactured before 2001 rose 8% in 2018 (compared to 2016 tracking data), while the consumption of units manufactured after 2001 fell 13%. Additionally, the corresponding federal standard weighted average energy consumption of the removed units rose 8% and 9% for pre-2001 and post-2001 manufactured units, respectively. These differences led to realization rates for recycled refrigeration units of 89% for energy and 90% for demand.
- Dehumidifiers: Differences in energy savings are a product of several differences in ex ante and evaluated savings assumptions. Program administrators assumed 1,632 annual operating hours, while the evaluation team applied the 1,679 annual operating hours recommended in the 2017

[17] ENERGY STAR, U.S. Environmental Protection Agency. (Undated). "Room Air Conditioner Turn-In and Recycling Programs." https://www.energystar.gov/sites/default/files/asset/document/RoomAirConditionerTurn-InAndRecyclingPrograms.pdf

[18] Federal Standard for Refrigerators, *Code of Federal Regulations,* 10 CFR 430.32(a).

Residential In-Home Study. Additionally, program administrators relied on 2016 program tracking data to develop assumptions, while the evaluation team used 2018 program tracking data, which showed slightly higher weighted average efficient unit capacity (10% larger in 2018 than in 2016) and conventional unit efficiency (2% more efficient in 2018 than in 2016). Combined, these differences resulted in an energy realization rate of 96%. On the demand side, ex ante calculations used 313 annual operating hours (4.6 hours per day at 68 days per year), resulting in an 18% realization rate for demand.

- Smart Thermostats: New to the 2018 EEP portfolio of measures, the program administrators and evaluation team applied deemed savings recommended by the evaluation team and based upon recent smart thermostat savings research conducted for similar programs.[19] The program administrators applied conservative savings assumptions from the memorandum and considered only cooling savings.[20] This approach assumes that all homes have central cooling. The evaluation team applied the recommended deemed savings values consistent with the percentage of Long Island homes with central cooling and heat pump heating from the 2017 PSEG Long Island Residential In-Home Study,[21] which states that 50% of homes are centrally cooled and 3% are heated with heat pumps. The realization rate for energy is 94%; there are no demand savings for this measure.
- Heat Pump Water Heaters: The program administrators and evaluation team applied the NY TRMv5 assumptions and methods in ex ante and evaluated savings calculations, respectively, with two notable deviations. First, the program-calculated demand savings used operational hours and an assumed CF of 0.23, in place of the NY TRMv5 deemed peak demand savings of 0.17 kW/unit. The program-calculated demand savings are, on average, 180% greater than NY TRMv5 deemed savings, leading to a demand realization rate of 55%. Second, for the most accurate savings estimation, the evaluation team used 2018 program tracking data in place of the default energy factors recommended in the NY TRMv5. In 2018, installed efficiencies of heat pump water heaters were, on average, 55% higher than the NY TRMv5 default values, leading to an energy realization rate of 131%.
- Air Purifiers: Program administrators used the 2016 per-unit evaluated savings of 391 kWh per the 2018 PSEG Long Island TRM, while the evaluation team applied 2018 program tracking data to the 2018 PSEG Long Island TRM savings algorithm. Due to differences in installed equipment between 2016 and 2018, the evaluation team calculated annual per-unit savings of 753 kWh from tracking data, an increase of 93% over the ex ante value. Realization rates reflect this discrepancy in savings with 193% for energy and 124% for demand.
- Clothes Washers: Program administrators applied 2016 program tracking data assumptions to calculate ex ante savings, which differed from the 2018 PSEG Long Island TRM. The evaluation team applied 2018 tracking data to the 2018 PSEG Long Island TRM savings algorithm and incorporated updates to federal standards effective January 1, 2018. The combination of 2018 program tracking data and updates to federal standards led to a realization rate of 125% for energy. Program administrators applied a CF of 0.06 based on NY TRMv4, and the evaluation team applied a CF of 0.029 based on the 2018 PSEG Long Island TRM, which is the primary reason for the 57% demand realization rate.

[19] The program and evaluation team applied the memorandum *Energy Savings Planning Estimate for PSEG Long Island's Smart Thermostat Offering* dated July 17, 2017, for smart thermostat measures.

[20] The memorandum provided a range of energy savings from smart thermostats seen in other programs. The lower values assumed a 10% reduction in cooling energy consumption and an 8% reduction in heat pump heating energy consumption. A weighted average was calculated from application of the lower scenario to four different heating and cooling systems, including central air conditioning (CAC), air-source heat pump (ASHP), ductless mini-split, and geothermal. Note, no heating savings are calculated from the CAC system.

[21] Opinion Dynamics. (October 2017). *PSEG Long Island Residential In-Home Study.*

- **Refrigerators:** Ex ante assumptions for refrigerators were based on 2016 tracking data, which included ENERGY STAR and ENERGY STAR "Most Efficient" units. In 2018, the program only installed ENERGY STAR Most Efficient units, which are at least 15% more efficient than ENERGY STAR units. The difference in rebated refrigeration units led to realization rates of 118% for energy and 119% for demand.
- **Clothes Dryers:** Differences between savings for clothes dryers reflect the use of different algorithms, coincidence factors, and average unit efficiencies. The program administrators used federal standards and 2016 program tracking data to calculate ex ante savings, while the evaluation team used 2018 program tracking data and 2018 PSEG Long Island TRM recommendations. Additionally, the program administrators applied a CF of 0.06 from an uncited source, but the evaluation team believes this is based on the NY TRMv4 *Clothes Washer* measure. The evaluation team applied the CF of 0.042 as recommended in the 2018 PSEG Long Island TRM. In 2018, weighted average efficiencies of ENERGY STAR dryers (98% of dryers rebated through the program) were similar to 2016 tracked efficiencies, while efficiencies of heat pump dryers (2% of dryers) increased by 69%. Differences in deemed savings algorithms and coincidence factors drove the realization rates of 115% and 79% for energy and demand, respectively.
- **Power Strips:** Ex ante assumptions followed the NY TRMv4 deemed savings for Tier 1 power strips and the Massachusetts TRM[22] for Tier 2 power strips, while the evaluation team applied 2018 PSEG Long Island TRM algorithms for all power strips. The 2018 PSEG Long Island TRM's Tier 1 power strip deemed savings are 70% lower than NY TRMv4 values, while Tier 2 power strip deemed savings are 7% lower than MA TRM values. Further, program administrators assumed 8,760 operating hours for Tier 1 power strips and a CF of 0.73, which do not align with the NY TRMv4, MA TRM, or 2018 PSEG Long Island TRM. Differences in assumptions among the NY TRMv4, MA TRM, and 2018 PSEG Long Island TRM resulted in realization rates of 42% for energy and 45% for demand.
- **Dishwashers:** Program administrators conducted an analysis of ENERGY STAR qualified products to estimate ex ante savings. The example calculation provided by the program administrator used the ENERGY STAR appliance calculator but did not provide sufficient detail to enable a thorough review of ex ante assumptions in relation to the evaluation team's assumptions. The program administrator's analysis resulted in over-estimations of savings in comparison to the 2018 PSEG Long Island TRM, potentially a result of the ex ante assumptions on annual operating hours or the portion of Long Island homes with electric domestic hot water (DHW) heating. These differences appear to be the primary contributors to realization rates of 61% for energy and 34% for demand.
- **Room Air Conditioners[23]:** In 2018, program administrators applied weighted averages for installed units' combined EER and capacity (Btu/hr) from federal standards and ENERGY STAR Key Product Criteria. Actual installed units' combined EER values were relatively similar to the planning assumptions, while capacities of installed units were slightly lower than planning assumptions. As a result, realization rates are 98% for energy and demand.

3.2.2 Ex Post Net Impacts for Cost-Effectiveness

Table 3-4 provides a program-level comparison of ex post net savings to ex ante savings by measure category. The evaluation team developed these 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

[22] Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures: 2016-2018 Program Years – Plan Version. (October 2015). Retrieved from http://ma-eeac.org/wordpress/wp-content/uploads/2016-2018-Plan-1.pdf
[23] Room air conditioners were not offered in the 2018 program. Any room air conditioners present in 2018 were carryover from 2017.

net savings. Overall, the EEP program achieved an ex post net realization rate of 100% for energy savings and 95% for demand savings. Ex post realization rates for energy savings ranged from 37% for dehumidifiers to 193% for air purifiers. Ex post realization rates for demand savings ranged from 7% for dehumidifiers to 124% for air purifiers.

Table 3-4. 2018 EEP Program Ex Post Net Impacts for Cost-Effectiveness

Category	N	Ex Ante Net Savings		Ex Post Net Savings		Realization Rate	
		kWh	kW	kWh	kW	kWh	kW
Lighting	4,738,328	124,918,541	24,166	124,451,587	23,312	100%	96%
Pool Pumps	3,015	6,549,573	4,050	7,173,481	4,554	110%	112%
Appliance Recycling	4,006	1,289,832	243	959,457	164	74%	67%
Dehumidifiers	5,559	1,096,235	1,084	410,620	76	37%	7%
Smart Thermostats	7,545	645,852	0	610,292	0	94%	N/A
Heat Pump Water Heaters	147	457,743	50	601,484	27	131%	55%
Air Purifiers	616	218,742	40	421,249	50	193%	124%
Power Strips	781	98,229	9.3	40,800	4.2	42%	45%
Clothes Washers - Most Efficient	2,983	94,561	21	117,861	12	125%	57%
Clothes Dryers	2,248	70,751	16	81,143	12	115%	79%
Refrigerators	1,369	70,367	8.2	82,832	10	118%	119%
Dishwasher	216	17,021	3.2	10,446	1.1	61%	34%
Room ACs	248	6,991	15	6,817	15	98%	98%
Totals	4,767,061	135,534,437	29,705	134,968,069	28,237	100%	95%

Note: Totals may not sum due to rounding.

3.3 Conclusions and Recommendations

Based on the results of this evaluation, the evaluation team offers the following key finding and recommendation for the EEP program moving forward:

- Key Finding #1: Planning assumptions and ex ante calculations are derived from previous years' program tracking data. For example, program administrators based 2018 planning assumptions on 2016 program tracking data. Beginning in 2018, the LM Captures database tracks measure-level data. This information is readily available and provides the opportunity for measure-level ex ante savings calculations, similar to the Cool Homes program method for ex ante savings.
  - Recommendation: The evaluation team recommends that program administrators use the measure-level data available in LM Captures to calculate ex ante savings, while still using the PSEG Long Island TRM for planning assumptions. Use of actual installed parameters, including LED wattages, water heater energy factors, and clothes washer capacities, will improve the accuracy of ex ante savings and reduce discrepancies with evaluated savings.

4. Cool Homes Program

4.1 Cool Homes Program Description

The Cool Homes program seeks to improve the energy efficiency of residential HVAC systems throughout Long Island. The program accomplishes this goal by providing customer rebates for the installation of a variety of high efficiency residential HVAC system types, including split central air conditioners (traditional CACs), ground-source heat pumps (GSHPs; also known as geothermal heat pumps), air-source heat pumps (ASHPs), and ductless mini-split systems. The Cool Homes program also develops and promotes a pool of contractors that are certified to perform Quality Installations (QI) of HVAC equipment.

4.1.1 Program Design and Implementation

From 2015 through 2017, the Cool Homes program rebate structure was divided into equipment-only and QI pathways. The QI pathway requires that a Cool Homes Preferred Contractor perform 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. Contractors must first apply to the program to be eligible for listing as a Preferred Contractor and to use the QI pathway. During the 2015-2017 period, customers selecting the QI option received a higher per-system rebate than those choosing the equipment-only pathway. Participating Preferred Cool Homes Contractors also received an incentive for each rebated QI system they installed.

In 2018, the program changed the rebate structure so that there are no longer differences in customer rebates depending on the selected pathway. Program materials advertised only a single set of customer rebates in 2018, while the program still promoted the benefits of choosing a participating contractor through the program website and marketing materials. In addition, preferred Cool Homes Contractors still received an incentive for QI pathway split CAC, ASHP, and GSHP systems. However, from the customer perspective, there was no upfront monetary difference depending on the contractor chosen in 2018.

The Cool Homes program changed rebate levels and efficiency requirements for some system types from 2017 to 2018, and added some new measures:

Split Central Air Conditioners

- Decreased rebates for Tier 1 systems from $300/system to $150/system.
- Decreased rebates for Tier 2 systems from $400/system to $250/system.
- Added Tier 3 systems to the program with efficiency levels of SEER ≥ 18 and a rebate of $350/system.

Smart Thermostats

- Added smart thermostats to the program to be installed primarily with split central air conditioners.
- Set the rebate level at $35/thermostat.

Air-Source Heat Pumps

- Decreased rebates for Tier 1 systems from $500/system to $350/system.
- Decreased rebates for Tier 2 systems from $650/system to $450/system.

Ductless Mini Split Heat Pumps

- Increased rebates from $150/system to $250/system and changed system efficiency required to SEER ≥ 18 and HSPF ≥ 8.5, compared to SEER ≥ 18 and HSPF ≥ 8.2 in 2017.

Ground-Source Heat Pumps

- Rebates remained the same for both Tier 1 and Tier 2 systems, but the efficiency levels were clarified on applications depending on exact system type (water to air closed, water to air open, water to water closed, water to water open, and direct ground exchange).

Program staff reported that the change in rebate levels for ductless mini-split heat pump systems was intended to drive additional uptake of this option compared to past years. This change corresponds to an increased focus on energy savings across the portfolio of PSEG Long Island programs that began in 2017. Prior to 2017, the Cool Homes program focused on reducing peak electric demand among residential customers.

4.1.2 Program Participation and Performance

PSEG Long Island's Cool Homes program performed well in 2018, with its verified ex ante savings reaching 109% of the energy savings goal and 99% of the peak demand goal. Table 4-1 presents 2018 Cool Homes program performance compared to goals.

Table 4-1. 2018 Cool Homes Program Verified Ex Ante Net Program Performance Against Goals

Metric	MWh	MW
Goal	3,234	2.4
Verified Ex Ante Net Savings	3,528	2.4
% of Goal	109%	99%

Note: Totals may not sum due to rounding.

Split CACs continue to account for the largest individual share of Cool Homes net energy and demand savings. As shown in Table 4-2, Split CAC projects accounted for 40% of ex ante net energy savings and 80% of ex ante net demand savings in 2018. Ductless mini-splits contributed 35% of ex ante net energy savings and 4% of ex ante net demand savings in 2018. Table 4-2 shows the distribution of ex ante net energy and demand savings by Cool Homes program measure. Below the table, we provide additional detail on program performance by measure category.

Table 4-2. 2018 Cool Homes Program Ex Ante Net Savings by Program Component

Program Component	Ex Ante Net Savings	
	MWh%	MW%
Split CAC	40%	80%
Ductless Mini-Split	35%	4%
Geothermal Heat Pump	17%	12%
Air-Source Heat Pump	7%	4%
Smart Thermostat	<1%	0%

The program rebated 5,951 measures in 2018, of which 57% were split CACs. The remaining rebated measures were ductless mini-split systems (32%), ASHPs (6%), GSHPs (3%), and smart thermostats (3%) as seen in Table 4-3.

Table 4-3. 2018 Cool Homes Program Count of Rebated Systems by Measure

Measure	Quantity	Percent
Split CAC	3,415	57%
Ductless Mini-Split	1,884	32%
ASHP	346	6%
GSHP	151	3%
Smart Thermostats	155	3%
Total	5,951	100%

Compared to the 2017 program, the 2018 Cool Homes program rebated 12% more total systems (as seen in Table 4-4), excluding Smart Thermostats, which were a new program addition in 2018. This overall increase is driven by the 57% increase in ductless systems and 91% increase in ASHPs compared to 2017. The program saw modest declines in the number of split CAC systems and GSHP systems rebated in 2018. Historically, split CAC systems are the most frequently rebated product, and they continued to be in 2018. Both ductless systems and ASHPs have been a particular focus for the program since 2017, and the program is realizing corresponding increases in the installations from those product categories compared to 2016. Beginning in 2017 the portfolio shifted its focus to technologies that can also provide energy savings through heating rather than peak demand savings solely during the summer cooling period.

Table 4-4. Difference in Number of Cool Homes Program Measures Installed, 2015–2018

Measure	2015	2016	2017	2018	Percent Difference 2017 to 2018
Split CAC	5,114	4,362	3,630	3,415	-6%
Ductless Mini-Split	894	814	1,200	1,884	57%
ASHP	249	90	181	346	91%
GSHP	166	125	187	151	-19%
Subtotal	6,423	5,391	5,198	5,796	12%
Smart Thermostat	-	-	-	155	N/A
Total	6,423	5,391	5,198	5,951	15%

Source: Cool Homes program tracking data, 2015, 2016, 2017, 2018.

Program staff reported that the change in rebate levels and reduced focus on the QI option had some impact on the number of contractors interested in the program, which partially explains the year over year decline in the number of contractors listed on the program website from 159 in 2017 to 88 contractors in 2018. Program staff also reported that the reduction in listed contractors was due to a programmatic decision to remove contractors who had issues with application submissions and those who had low levels of participation.

4.1.3 Program Marketing

In 2018, the Cool Homes program administrators continued to market the program in a fashion consistent with previous years. Program staff attended industry trade meetings to promote the program and to educate contractors, engineers, and architects about the benefits of participating in the program and the options that they can offer to their clients and customers.

As in the past, the program offered QI training programs four times during the year for Preferred Cool Homes Contractors.

4.1.4 Anticipated Changes in 2019

In 2019 the program will introduce Tier 3 cold climate, ducted, split ASHPs and cold climate, ductless, mini-split heat pumps. The program is also introducing packaged terminal heat pumps in 2019. This is part of an effort to continue to influence market adoption of these technologies. In addition, PSEG Long Island is changing the name of the program to the Home Comfort program. This new name better reflects the program's expansion from primarily a home cooling focus to both cooling and heating.

4.2 Cool Homes Program Impacts

The following sections provide the results of the engineering analysis for the Cool Homes program. Section 4.2.1 presents the evaluated net savings and Section 4.2.2 presents ex post net savings. Ex post net savings differ from evaluated net savings in that ex post net savings are developed using ex post NTGRs, while evaluated net savings are based on program planning NTGRs. For a list of NTGRs used in this evaluation, see Appendix A.

4.2.1 Evaluated Impacts

Table 4-5 provides a program-level comparison of evaluated net savings to ex ante savings by measure category.

Table 4-5. 2018 Cool Homes Program Evaluated Net Impacts

Category	Unit Installs	Ex Ante Net Savings		Evaluated Net Savings		Realization Rate	
		kWh	kW	kWh	kW	kWh	kW
Split CAC	3,415	1,358,728	1,864	1,425,129	1,708	105%	92%
Ductless Mini-Split	1,884	1,210,748	92	1,332,690	201	110%	218%
Geothermal Heat Pump	151	588,430	281	659,747	220	112%	78%
Air-Source Heat Pump	346	246,051	101	251,276	120	102%	119%
Smart Thermostat	155	20,801	0	27,687	0	133%	N/A
Totals	5,951	3,424,758	2,338	3,696,529	2,250	108%	96%

Note: Totals may not sum due to rounding.

Reasons for Differences in Impacts

To estimate evaluated energy and demand savings, the evaluation team used installed sizes and efficiencies of rebated equipment, as determined through examination of the program's 2018 tracking data. The evaluation team relied on the 2018 PSEG Long Island TRM, which references the 2015 International Energy Conservation Code (IECC) and NY TRMv5, for baseline efficiencies. The evaluation team conducted a measure-level savings approach for all installed equipment to calculate the total evaluated savings. Most measure-specific discrepancies between ex ante and evaluated savings are due to differences in program and evaluator assumptions, including baseline efficiencies and full load operating hours of equipment.

Below we describe the evaluation team's measure-specific savings calculations and reasons for discrepancies in savings.

- **Split Central Air Conditioners:** CACs achieved realization rates of 105% for energy savings and 92% for peak demand. The evaluated energy savings are higher than ex ante savings due to a difference in equivalent full load cooling hours (EFLCH) between ex ante assumptions and evaluation team recommendations. Ex ante calculations applied a combination of NY TRMv3 EFLCH values of 630 and NY TRMv4 EFLCH values of 649. NY TRMv4 full load hours match the 2018 PSEG Long Island TRM recommended values, which the evaluation team used. The evaluated demand savings are lower than the ex ante savings because the evaluation team employed a QI savings factor of 0.05 based on the 2018 PSEG Long Island TRM. In contrast, ex ante calculations applied a demand-specific QI savings factor of 0.096. Notably, ex ante calculations omitted QI savings factors for approximately 20% of projects where a quality installation occurred.
- **Ductless Mini-Split Systems:** Ductless mini-split systems achieved higher evaluated savings for both energy (110%) and demand (218%). The evaluation team observed two types of ductless mini-split installations in the tracking data: (1) "Cooling Only" and (2) "Heating & Cooling." To apply the appropriate baseline efficiency values and equivalent full load hours for the evaluation savings calculations, the evaluation team treated the "Cooling Only" type of units as air conditioners and "Heating & Cooling" type of units as heat pumps. The evaluated energy savings are higher than ex ante savings due to similar differences in EFLCH as described for split CACs above. In addition, we observed differences in equivalent full load heating hours (EFLHH) for the heat pump systems. For the "Cooling Only" units, the evaluation team referenced a baseline EER of 11.09 per NY TRMv5, while the ex ante savings calculations incorporated baseline EER values of 11.2. For the "Heating & Cooling" units, the evaluation team referenced a baseline EER of 11.0 per Federal Energy Management Program (FEMP) guidelines, while the ex ante savings calculations incorporated baseline EER values of 11.8. These differences in baseline EER assumptions resulted in significantly higher evaluated demand savings than ex ante.
- **Ground-Source Heat Pumps:** GSHPs achieved realization rates of 112% for energy savings and 78% for peak demand. The evaluation team used GSHP savings algorithms and assumptions from the 2018 PSEG Long Island TRM and Manual J[24] heating and cooling loads available in LM Captures to calculate evaluated savings. The program used a calculation methodology that did not incorporate Manual J heating and cooling loads. This difference between evaluation and ex ante savings algorithms is the primary cause of discrepancy for peak demand and energy savings. Additionally, the evaluated demand savings are lower than the ex ante savings because the evaluation team referenced a CF of 0.69 based on the 2018 PSEG Long Island TRM, whereas the ex ante calculations reflect a CF of 0.8.
- **Air-Source Heat Pumps:** ASHPs achieved realization rates of 102% for energy savings and 119% for peak demand. The discrepancy derives from the program's application of NY TRMv3 assumptions for 38% of measures and NY TRMv4 assumptions for the remaining projects, while the evaluation team applied the 2018 PSEG Long Island TRM assumptions in coordination with FEMP guidelines on unit efficiencies. The evaluation team also observed similar differences in EFLCH and EFLHH as described above for split CACs and ductless mini-splits, which accounted for some of the discrepancies in energy savings. For demand savings, differences in ex ante and evaluated assumptions include EER values applied in ex ante calculations of 11.09 (NY TRMv3) and 11.76 (NY TRMv4) in contrast to the FEMP baseline EER value of 11.0.
- **Smart Thermostats:** Smart thermostats achieved an energy realization rate of 133%. The evaluation team applied the deemed savings recommended in the 2017 Smart Thermostat Planning Estimates.[25]

[24] Air Conditioning Contractors of America published the Manual J Residential Load Calculation 2016 (8th Edition) for calculating HVAC equipment sizing loads for single-family detached homes, multi-family buildings, condominiums, town homes, and manufactured homes.

[25] *Energy Savings Planning Estimate for PSEG Long Island's Smart Thermostat Offering* dated July 17, 2017.

The memorandum recommends a cooling savings of 174 kWh/yr for homes with central cooling and a heating savings of 402 kWh/yr for homes with heat pumps. The evaluation team applied these savings assumptions to 2018 smart thermostat installations based on the HVAC equipment being controlled, which was available in 2018 Cool Homes tracking data. The ex ante savings reflected a deemed savings of 174 kWh/yr applied to all installations without accounting for heat pumps, resulting in lower ex ante energy savings than evaluated.

4.2.2 Ex Post Net Impacts for Cost-Effectiveness

Table 4-6 provides a program-level comparison of ex post net savings to ex ante savings by measure category. The evaluation team developed these 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 Cool Homes program achieved an ex post net realization rate of 97% for energy savings and 83% for demand savings. Ex post realization rates for energy savings ranged from 78% for the split CAC installations to 133% for smart thermostats. Ex post realization rates for demand savings ranged from 75% for the split CAC installations to 218% for ductless mini-splits.

Table 4-6. 2018 Cool Homes Ex Post Net Impacts for Cost-Effectiveness

Category	Unit Installs	Ex Ante Net Savings		Ex Post Net Savings		Cost-Effectiveness Realization Rate	
		kWh	kW	kWh	kW	kWh	kW
Split Central AC (CAC)	3,415	1,358,728	1,864	1,060,976	1,395	78%	75%
Ductless Mini-Split	1,884	1,210,748	92	1,332,690	201	110%	218%
Geothermal Heat Pump	151	588,430	281	659,747	220	112%	78%
Air-Source Heat Pump	346	246,051	101	251,276	120	102%	119%
Smart Thermostat	155	20,801	0	27,687	0	133%	N/A
Totals	5,951	3,424,758	2,338	3,332,375	1,937	97%	83%

Note: Totals may not sum due to rounding.

4.3 Conclusions and Recommendations

Based on the results of this evaluation, the evaluation team offers the following key findings and recommendations for the Cool Homes program moving forward:

- Key Finding #1: In 2018, ex ante savings assumptions were drawn from multiple NY TRM versions, specifically versions 3 through 5. For example, in the case of ASHP measures, program assumptions adopted parameters from NY TRMv4, for roughly a fifth of projects, and v5 for the remaining projects.
    - Recommendation: The evaluation team recommends that all ex ante savings assumptions for 2019 reflect the 2019 PSEG Long Island TRM assumptions and algorithms for all Cool Homes measures.
- Key Finding #2: Manual J calculations for ground-source heat pump measures were not documented in program tracking data for 2018.
    - Recommendation: The evaluation team recommends collection and documentation of Manual J values for both heating and cooling loads in the tracking data as separate fields for all GSHP installations.

- Key Finding #3: The program adopted a deemed savings value from the 2017 Smart Thermostat Planning Estimate memorandum that accounted for cooling savings only.
  - Recommendation: The evaluation team recommends adopting the smart thermostat deemed savings values appropriately based on HVAC equipment served by the thermostat.

5. Residential Energy Affordability Partnership Program

5.1 REAP Program Description

The REAP program assists low-income households with energy efficiency improvements. The program helps low-income customers save energy, improves overall residential energy efficiency on Long Island, and lowers PSEG Long Island's financial risk associated with bill collection by lowering utility bills for low-income customers. To be eligible to participate in the REAP program, household income must correspond with the United States Department of Housing and Urban Development low-income guidelines. In 2018 the income eligibility guidelines changed from 70% of median income to 80% of median income, allowing more customers to qualify.

5.1.1 Program Design and Implementation

The REAP program includes a free home energy audit, in addition to free energy-saving measures. In 2018, program measures included LED light bulbs, DHW measures, room ACs, dehumidifiers, and refrigerators. In addition, the program administrators added thermostatic valves, exterior lighting, and Tier 1 smart power strips to generate additional savings for program participants. Power strips are provided to customers at the time of their audit with instructions on how to use the new equipment, but they are not installed by the auditors.

In addition to providing program participants with energy-saving measures, the program includes a strong educational component. During the audit, the program staff work with participating customers to determine additional energy-saving actions and behavior changes that they are willing to undertake. These additional steps help the customer generate savings beyond those from the installed measures alone. By educating customers on the use and value of installed efficiency measures, and helping them identify additional opportunities to save, the program can achieve its goal of helping customers who have the greatest share of their income going to energy bills. During each audit, REAP technicians also inspect the customers' heating and hot water systems for safety.

5.1.2 Program Participation and Performance

In terms of verified ex ante savings, the REAP program performed well in 2018, reaching 99% of the energy savings goal and 96% of the peak demand goal. However, as presented in Section 5.2.1, evaluated net savings for 2018 were significantly lower than the verified ex ante savings for the program. Table 5-1 presents verified ex ante savings compared to goals for the 2018 REAP program.

Table 5-1. 2018 REAP Program Verified Ex Ante Net Program Performance Against Goals

Metric	MWh	MW
Goal	1,920	0.49
Verified Ex Ante Net Savings	1,907	0.48
% of Goal	99%	96%

Note: Totals may not sum due to rounding.

Interior lighting continues to account for the largest share of REAP net energy and demand savings. As shown in Table 5-2, interior lighting accounted for 63% of ex ante net energy savings and 58% of ex ante net demand savings in 2018.

Table 5-2. 2018 REAP Program Ex Ante Net Savings by Program Component

Program Component	Ex Ante Net Savings	
	MWh%	MW%
Interior Lighting	63%	58%
Domestic Hot Water	12%	0%
Power Strips	11%	5%
Refrigerator	3%	2%
Exterior Lighting	3%	0%
Dehumidifier	3%	11%
Window AC	3%	24%
Thermostatic Valve	2%	0%

The REAP program treated 2,106 unique participants during 2018 compared to 1,873 customers in 2017 for an increase of 12%. Of the participants, nearly all received lighting and power strips as shown in Table 5-3.

Table 5-3. Percent of REAP Participants Receiving each Measure Category

Measure Category	Percent Receiving[a]
Lighting	96%
Domestic Hot Water	17%
Refrigerator	11%
Dehumidifier	12%
Window AC	28%
Power Strips	98%

[a] Of the 2,106 unique REAP participants in 2018.

5.1.3 Program Marketing

The REAP program maintained the same marketing approach in 2018 as in prior years. The program continues to reach eligible customers through postcard mailings, door hangers, emails, and outreach events through community groups. Program staff conducted over 100 REAP outreach events across the PSEG Long Island service territory during 2018 to reach customers who may be best served by the program. One such event, the Energy Forum for Advocates, is an annual event where advocacy groups from across Long Island come together with PSEG Long Island staff to learn about the programs offered by PSEG Long Island. The REAP program has been featured in the Forum since program inception in 1999.

Due to a higher participation goal in 2018, the program administrators adjusted the recruitment strategy to bring more projects into the pipeline earlier in the year. Program administrators adjusted the postcard mailing strategy to send out 20,000 postcards per month to identified eligible customers. Typically, the program sends out 10,000 postcards per month. This enhanced outreach allowed the program to schedule more audits and further into the future. In this way, they were able to replace cancelled visits in the short term with customers scheduled for the future when necessary, keeping the program’s schedule full in the near term.

5.1.4 Anticipated Changes in 2019

In 2019, the implementation team plans to continue to implement the program consistent with past years; however, program managers reported that they will add LED candelabra bulbs, night lights, a 50-pint dehumidifier, and the option of a Tier 2 smart strip. They will also begin the year contacting 10,000 customers per month and will increase outreach as needed to meet participation goals through the year.

5.2 REAP Program Impacts

5.2.1 Evaluated Impacts and Ex Post Impacts

As in previous years, the evaluation team used two approaches to estimate savings for the REAP program in 2018: an engineering analysis and a consumption analysis. Because consumption analyses use actual customer electric usage to estimate savings, they are typically considered to be a more robust assessment of energy savings than engineering estimates. For this reason, the evaluation team primarily based the energy savings from the program on the results of the consumption analysis. However, the results of the engineering impacts analysis provide us with the energy to demand ratio, which allows us to develop demand savings from the energy consumption analysis. In addition, because the engineering analysis provides savings at the measure level, we gain insights into the relative savings contributions of the measures offered by the REAP program. Finally, these measure-level savings allow us to make recommendations to the implementation team for adjusting ex ante planning assumptions going forward.

Because the consumption analysis requires post-installation electricity usage data for approximately one year after treatment, our consumption analysis uses 2017 participants as the treatment group and uses the pre-participation period of the 2018 participants as the comparison group, which is consistent with prior evaluations. The energy use of the comparison group prior to their program participation acts as the counterfactual or point of comparison for the treatment group (2017 participants) in the post-participation period. With exterior lighting, thermostatic valves, and smart power strips added at the start of 2018, however, the consumption analysis does not capture any savings from these new measures. The consumption analysis resulted in an energy savings realization rate of 46% for all measures excluding smart power strips, exterior lighting, and thermostatic valves. For the participants who had these new measures installed in 2018, the measure-level savings calculated in the engineering analysis are added to the savings shown by the consumption analysis.

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

The combined consumption and engineering analyses found that the REAP program generated approximately 972 MWh in energy savings in 2018, or about 49% of the ex ante net energy savings. The program achieved evaluated demand savings of 197 kW, as presented in Table 5-4.

Table 5-4. 2018 REAP Program Evaluated and Ex Post Net Impacts for Cost-Effectiveness

Category	N[a]	Ex Ante Net Savings		Evaluated/Ex Post Net Savings	
		kWh	kW	kWh	kW
Interior Lighting	2,019	1,254,855	283	577,975	127
Domestic Hot Water	362	239,364	2.0	110,249	1.4
Refrigerator	231	69,555	8.6	32,036	3.8
Dehumidifier	257	54,323	54	25,021	4.6
Window AC	586	53,518	117	24,650	53
Power Strips[b]	2,057	225,859	27	68,127	7.0
Exterior Lighting[b]	445	63,309	0	82,356	0
Thermostatic Valve[b]	193	38,906	0	50,236	0
Total[c d]	**2,106**	**2,000,976**	**491**	**971,936**	**197**

[a] Number of REAP program participants with measures in 2018.

[b] These measures were not a part of the 2017 program and were therefore not represented by the impacts resulting from the consumption analysis. Engineering analysis results are reported in this table and are included in counts of total program participants, net savings, and realization rates.

[c] One project adjustment of 1,287 kWh and 0 kW is included in ex ante and ex post total net savings and overall realization rates, but not shown as a separate line item in this table.

[d] Total savings may differ slightly due to rounding.

Reasons for Differences Between Consumption Analysis and Ex Ante Savings

The 2018 combined consumption and engineering analysis resulted in substantially lower overall evaluated savings than ex ante savings, as shown by the 49% realization rate. With the addition of several new measures in 2018, the REAP program's planning assumptions and goals more than doubled compared to 2017 on a per-participant basis. The relatively low realization rate is primarily attributable to substantially higher ex ante savings assumptions for 2018 compared to prior years; however, the 2018 consumption analysis also resulted in significantly lower per-participant savings than observed in the consumption analysis used in the prior two years' evaluations. While consumption analyses do not allow us to quantify savings from individual measures, one possible reason for the observed decrease in per-participant savings is lower realized savings from lighting measures. In terms of ex ante savings, lighting is expected to account for more than half of REAP program savings. Recent studies have shown that savings from lighting retrofits is in flux as baseline efficiencies and the saturation of efficient lighting are increasing rapidly. While the program tracking data and engineering analysis show that actual baseline wattages do not account for the lower savings, it is therefore likely that the assumed hours of use of replaced bulbs is lower than expected.

Assessment of Treatment and Comparison Group Equivalency

Using future participants as a comparison group assures us that the treatment and comparison groups are equivalent because the criteria and process for program selection are equivalent between early and later participants. However, we perform whatever analyses are possible to confirm that both groups of participants are similar in other ways so that we can be confident in using 2018 participants 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 a justifiable point of comparison. We confirmed that the groups were similar in consumption and in weather experienced during the same calendar period, 2016, prior to either group's participation. We also verified that the income eligibility change from 70%

to 80% of median income did not substantially impact the comparability of the two groups at least in terms of usage. The 2018 cohort's pre-treatment usage was slightly lower than that of the 2017 cohort. We show these comparisons in Section 9.6.

Specification and Results of the Consumption Analysis Model

The consumption analysis model is a one-way linear fixed effects regression (LFER) model. The model allows all household factors that do not vary over time to be absorbed by (and therefore controlled for within) the individual constant terms in the equation. 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 difference in energy use that is associated with participating in the program. Interacting the pre-period usage with each of 12 months provides an extra control for the differences between the groups each month. We did not include terms for specific measures or end-uses.

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

Comparing the results of the consumption analysis to the ex ante savings allows us to determine the overall program realization rate. Table 5-5 presents the overall net program savings for 2018 REAP program participants based on the consumption analysis. As shown below, the 2018 REAP program realized 46% of its expected net savings at the participant level. These results reflect savings attributable to the program and the types of measures installed during 2017. As described above, additional savings for new 2018 measures are added based on engineering estimates.

Table 5-5. 2018 REAP Program Consumption Analysis Savings Compared to Ex Ante Savings

End-Use	N[a]	Observed Savings[b]		Ex Ante Savings		Realization Rate
		Household Daily Savings (kWh)	Household Annual Savings (kWh)	Household Daily Savings (kWh)	Household Annual Savings (kWh)	
REAP	2,106	1.20	437	2.60	949	46%

[a] Number of REAP Program participants with measures in 2018.

[b] Includes line losses.

Engineering Analysis

The evaluation team also performed a measure-level engineering analysis to estimate evaluated impacts. As described above, the results of the engineering impacts analysis provide us with the energy to demand ratio needed to develop demand savings from the energy consumption analysis, and an understanding of relative contribution of the measures offered by the program. 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.

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, due to limited financial resources and many other competing needs. Therefore, we used a NTGR of 1.0, which is typical for low-income programs. Table 5-6 shows the evaluated and ex post savings as determined by the engineering analysis for each measure category.

Table 5-6. 2018 REAP Program Measure-Specific Net Impacts: Engineering Analysis

Category	N[a]	Ex Ante Net Savings		Evaluated/Ex Post Net Savings		Realization Rate	
		kWh	kW	kWh	kW	kWh	kW
Interior Lighting	2,031	1,254,855	283	1,896,239	417	151%	148%
Domestic Hot Water	362	239,364	2.0	140,714	1.8	59%	91%
Refrigerator	231	69,555	8.6	67,302	8.0	97%	93%
Dehumidifier	257	54,323	54	51,550	9.5	95%	18%
Room AC	586	53,518	117	51,477	111	96%	95%
Power Strips	2,057	225,859	27	68,127	7.0	30%	26%
Exterior Lighting	445	63,309	0	82,356	0	130%	N/A
Thermostatic Valve	193	38,906	0	50,236	0	129%	N/A
Total[b c]	**2,106**	**2,000,976**	**491**	**2,409,288**	**555**	**120%**	**113%**

[a] Number of REAP program participants with measures in 2018.

[b] One project adjustment of 1,287 kWh and 0 kW is included in ex ante and ex post total net savings and overall realization rates.

[c] Total savings may differ slightly due to rounding.

Reasons for Differences in Engineering Impacts

The results of the engineering impacts analysis provide us with the energy to demand ratio needed to develop demand savings from the energy consumption analysis. In addition, because the engineering analysis provides savings at the measure level, we gain insights into the relative contribution of the measures offered by the REAP program. Finally, these measure-level savings allow us to make recommendations to the implementation team for adjusting ex ante planning assumptions going forward. The engineering analysis found that the REAP program realized 120% of expected net energy savings and 113% of net demand savings. The evaluation team performed a measure-level engineering analysis of ex ante savings to estimate evaluated impacts. Specifically, the evaluation team used program tracking data and applied either deemed savings estimates or calculated savings based on various parameters. Below we describe the evaluation team's measure-specific savings calculations and reasons for discrepancies in savings.

- Lighting: Based on the engineering analysis, interior and exterior lighting together accounted for approximately 83% of REAP's evaluated energy savings and 76% of evaluated demand savings. The evaluation team calculated a combined realization rate for interior and exterior lighting of 150% for energy savings and 148% for demand. The differences between ex ante and evaluated savings are due to the following:
  - Delta Watts: Program administrators incorporated the measure mix from 2016 REAP installation data and the delta watts (the difference between the replaced and installed lamp wattage) from 2016 EEP data to estimate savings. The evaluation team calculated a realized difference in lighting wattages from 2018 tracking data for each individual bulb type. This approach resulted in higher average delta watts for both standard and specialty lamps for 2018 in comparison to ex ante values, and subsequently an increase in the overall lighting realization rate for both energy and demand.
  - Bulb Type: The program assumed the mixture of installed lamps at a ratio of 71% common and 29% specialty based on 2016 program data. Based on actual installed lamps from 2018 program tracking data, evaluators calculated a ratio of 75% common to 25% specialty, though evaluated savings were calculated for each bulb type individually. Specialty lamps feature larger delta watts,

as indicated in the 2018 PSEG Long Island TRM. The difference in lamp type mixture slightly lowered demand and energy savings.

- Hours: The program calculated a weighted average of 1,172 annual operating hours using an assumed mix of 86% interior and 14% exterior sockets. The evaluation team applied the actual mix of interior and exterior bulbs based on 2018 tracking data, which resulted in 97% interior bulbs for a weighted average of 1,126 hours. The difference in hours led to slightly lower evaluated energy savings.
- Rounding: The 148% realization rate for demand savings is partially due to rounding limitations in LM Captures identified during the verified ex ante analysis. LM Captures rounds values to three decimals, and because unitary demand savings are small values on the order of 1/100th of a kW, rounding limitations are magnified and present more prominently for demand savings than for energy savings.

- Domestic Hot Water: DHW measures include showerheads, faucet aerators, pipe insulation, turndown of hot water heater temperature, and thermostatic valves. Based on the engineering analysis, DHW measures account for 8% of evaluated net energy savings. Below is a detailed discussion of differences between program assumptions and the evaluation findings.
  - Low-Flow Showerhead: Ex ante savings calculations included a throttle factor of 0.75, based on NY TRMv4, whereas the evaluation team applied the 2018 PSEG Long Island TRM specified throttle factor of 0.9. Additionally, the evaluation team incorporated actual delta flow rate (gallons per minute, GPM) values from 2018 program tracking data, which were 35% lower than the 2016 values applied by the program. These differences accounted for the majority of the energy savings discrepancy. Lastly, program planning assumed positive peak demand savings, while the evaluation team referenced the 2018 PSEG Long Island TRM, which specifies zero peak demand savings. Realization rates for savings are 79% for energy and 0% for demand.
  - Faucet Aerators and Flip Swivel Aerators: The ex ante savings calculations included an assumed 30 uses per day, based on NY TRMv4 recommendations, whereas the evaluation team applied 17 uses per day, based on the 2018 PSEG Long Island TRM. Additionally, the evaluation team incorporated actual delta flow rate values from 2018 program tracking data, which were 44% lower than the 2016 values assumed by the program. These are the primary contributors to the 25% energy realization rate. Program planning and evaluation both reported zero demand savings, but an error in the tracking data resulted in a small amount of ex ante demand savings, thus causing a demand realization rate of 0%.
  - Pipe Insulation: The 92% demand realization rate is due to rounding limitations in LM Captures identified during the verified ex ante analysis. Ex ante planning assumptions were correctly applied by program administrators and match those of the evaluation team.
  - Temperature Turndown: The difference in ex ante and evaluated savings is a product of the temperature differential between pre- and post-intervention set points, in addition to the differences in coincidence factors. The evaluation team applied 2018 program tracking data on pre- and post-intervention hot water heater temperatures, resulting in a 38% greater temperature differential than the program administrator's assumptions. This difference in assumptions led to realization rates of 136% and 126% for energy and demand, respectively.
  - Thermostatic Valve: The ex ante savings reflected a NY TRMv4 deemed savings value of 157 kWh/unit for a 2 GPM installed fixture. The evaluated savings are based on the algorithm recommended in the 2018 PSEG Long Island TRM and incorporated an average baseline and

installed GPM determined from the program tracking data, resulting in 26% higher evaluated energy savings than ex ante. There are no demand savings associated with this measure.

- Refrigerator: The program administrator and evaluation team applied the same algorithms for refrigerator savings calculations. A slight discrepancy in savings arose because the evaluation team estimated the efficient unit annual energy consumption using the ENERGY STAR Appliance Calculator[26] and federal energy standard algorithms,[27] whereas the program administrator applied the manufacturer-specified annual energy consumption. The program tracking data do not include installed model numbers or annual energy consumption values, so the evaluation team could not verify the manufacturer's rated energy consumption and was required to estimate annual consumption based on unit class and capacity. Based on the engineering analysis, the realization rates for refrigerators are 97% for energy and 93% for demand.
- Dehumidifier: Differences in energy savings are a product of differences in ex ante and evaluated savings assumptions. Program administrators assumed 1,632 annual operating hours, while the evaluation team applied the 2017 Residential In-Home Study recommended 1,679 annual operating hours. Additionally, program administrators relied on 2016 program tracking data to develop assumptions, while the evaluation team used 2018 program tracking data. In 2018, efficiencies of removed and rebated dehumidifiers are on average 4% and 8% lower than those applied by the program administrator. Combined, these differences resulted in an energy realization rate of 95%. On the demand side, ex ante calculations applied a CF of 1.0, while the evaluation team applied a CF of 0.3 in accordance with the 2018 PSEG Long Island TRM, resulting in an engineering analysis realization rate of 18% for demand.
- Room Air Conditioners: The program administrator and evaluation team applied the same savings algorithms. The 96% energy and 95% demand engineering realization rates are due to a slight increase in the baseline efficiency of the replaced units. The evaluation team applied the actual removed unit efficiencies from 2018 program tracking data, whereas the program planning assumptions are based on 2016 program tracking data on removed units.
- Power Strips: Program administrator assumptions followed the NY TRMv4 deemed savings for Tier 1 power strips, while the evaluation team applied the 2018 PSEG Long Island TRM. Deemed energy savings for Tier 1 APSs are 70% lower in the 2018 PSEG Long Island TRM than the NY TRMv4. Further, the program assumed 8,760 operating hours for Tier 1 power strips and a CF of 1.0. The evaluation team applied the 2018 PSEG Long Island TRM-specified 8,048 operating hours and a CF of 0.8. The differences resulted in engineering realization rates of 30% for energy and 26% for demand.

5.3 Conclusions and Recommendations

Based on the results of this evaluation, the evaluation team offers the following key findings and recommendations for the Residential Energy Affordability Partnership program moving forward:

- Key Finding #1: Due to the changing nature of the lighting market and increased saturation of LED lighting in households, including low-income households, the evaluation team expects lighting savings to decrease as fewer high use bulbs are available for retrofit by the program and subsequent lighting installations are in lower-use sockets. We believe the lower savings observed in the consumption analysis compared to prior years is reflecting these reduced lighting savings opportunities.

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[26] The ENERGY STAR Appliance Calculator used for estimating energy consumption of the incentivized refrigerator can be retrieved from www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx

[27] Federal Standard for Refrigerators, *Code of Federal Regulations,* 10 CFR 430.32(a).

  - Recommendation: The evaluation team recommends research on the current state of lighting retrofit opportunities available in income-qualified homes, including up-to-date hours of use estimates for sockets available for retrofit. Based on this research, the associated savings assumptions for REAP program lighting should be updated.
- Key Finding #2: The program administrator's approach for lighting measures is to use a mixture of EEP program tracking data for delta watts assumptions and REAP program tracking data for the mix of lamps incentivized.
  - Recommendation: The evaluation team recommends that program administrators apply REAP-specific lighting delta watts in place of EEP delta watt assumptions. This approach will improve accuracy of planning assumptions and subsequently ex ante savings calculations.
- Key Finding #3: Energy consumption calculations for refrigerators are conducted using the ENERGY STAR and federal energy standard algorithms, which are dependent on refrigerator class and configuration (e.g., icemaker characteristics, door mounting).
  - Recommendation: The evaluation team recommends that the refrigerator model configuration and icemaker characteristics be tracked in LM Captures in future program years to allow for more accurate savings estimations.
- Key Finding #4: DHW measures, which include aerators, showerheads, pipe insulation, thermostatic valve, and turndown of water heater temperature, rely on water heater characteristics, predominately energy factors and capacities, in calculating savings impacts.
  - Recommendation: The evaluation team recommends that program administrators begin tracking water heater type and capacity to support increased accuracy of savings calculations for the portfolio of DHW measures.

6. Home Performance Programs

PSEG Long Island's Home Performance programs are separated into two distinct tracks: Home Performance Direct Install (HPDI) and Home Performance with ENERGY STAR (HPwES). Both programs work in concert to provide homeowners with free and reduced-cost measures and information to encourage greater energy savings. Together, the programs consist of a full-home audit; a Home Energy Score; and possible free or rebated efficient equipment. The Home Performance programs' design and implementation did not change significantly in 2018 compared to 2017.

6.1 Home Performance Programs Description

6.1.1 Program Design and Implementation

Home Performance Direct Install

The HPDI program conducts free, full-home energy audits by a certified Building Performance Institute (BPI) contractor for homes with electric heat or homes with central air conditioning plus gas or oil heat. During the audit, the contractor checks for moisture problems, assesses insulation and building envelope sealing, and evaluates heating and cooling efficiency (where applicable). The BPI-certified contractor also provides participants with up to 20 free LED bulbs, power strips, and (for customers with central air conditioning) free duct sealing measures. For customers with electric hot water, the program provides efficient faucet aerators and efficient showerheads. Upon completion of the audit, HPDI program staff provide participants with an assessment report that includes an energy efficiency score for the home and suggested improvements, along with estimated energy savings (in dollars).

Implementation of the HPDI program changed minimally from 2017 to 2018. The HPDI program was open to PSEG Long Island customers with electrically heated homes and those with central air conditioning. Prior to 2017, the program was available only to those with central air conditioning. As with 2017, program staff captured all program tracking data in Lockheed Martin's LM Captures database.

The program made one minor change to measures in 2018. The program added a thermostatic shower valve as a DHW measure and changed the composition of the "thank you" kits mailed to home energy assessment recipients. The thank you kits changed from four LED bulbs to six LED bulbs and a Tier 2 smart strip in the middle of the year.

Home Performance with ENERGY STAR

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

As in previous years, HPDI customers seeking deeper retrofit opportunities may opt to participate in the HPwES program. With the shift in overall portfolio emphasis from demand to energy savings, and the inclusion of NYSERDA Home Performance customers, all PSEG Long Island customers are now eligible for HPwES measures, with the exception of those with non-electric heat and no central air conditioning.

PSEG Long Island continued with three tiers of rebates. Participants receiving the standard, or market rate, were eligible to receive rebates of up to 15% of HPwES measure costs, capped at $3,000. HPwES participants were also eligible for income-qualified rebates. Those with incomes of 60% to 80% of the state's median income level were eligible for Assisted Home Performance rebates at up to 50% of measure costs, and those at 60% or less of the state's median income level were eligible for rebates at up to 100% of measure costs, both capped at $4,000. Contractors also received an additional $200 incentive from PSEG Long Island in 2018 when administering HEAs for HPwES participants. As in previous years, HPwES customers were also eligible to repay the cost of their measure installation through on-bill repayment with PSEG Long Island.

6.1.2 Program Participation and Performance

Based on verified ex ante estimates, the Home Performance programs reached 94% of the energy savings goal and 80% of the peak demand goal in 2018. However, as presented in Section 6.2, evaluated savings for 2018 were significantly lower than the ex ante savings for the programs. Table 6-1 presents 2018 Home Performance programs verified ex ante savings compared to goals.

Table 6-1. 2018 Home Performance Verified Ex Ante Net Program Performance Against Goals

Metric	MWh	MW
Goal	3,682	2.7
Verified Ex Ante Net Savings	3,458	2.2
% of Goal	94%	80%

Note: Totals may not sum due to rounding.

In 2018, the HPDI program completed projects with 390 customers. Of these, 110 also went on to complete an HPwES project. In 2018 the HPwES program treated 1,712 unique customers. Overall, 1,992 customers were treated by the Home Performance programs in 2018.

6.1.3 Program Marketing

In 2018, the HPwES and HPDI programs continued with similar marketing approaches as in 2017. HPDI relies primarily on postcard mailings to generate interest and participation in the program. The program team sends between 10,000 and 15,000 postcards per quarter, specifically to homes that that have electric heat rate codes. HPwES relies on promotion by participating contractors and generates leads and participation through the program website. Program staff also attend trade and home shows to generate interest. Program staff also periodically provide support to contractors through marketing and sales training.

6.1.4 Anticipated Changes in 2019

In 2019, the HPDI program is adding several new measures. The program will add night lights, outdoor lighting, and Tier 2 smart strips. Program staff report that the exact composition of thank you kits provided to audit participants may also change over the course of the year.

6.2 Home Performance Programs Impacts

6.2.1 Evaluated and Ex Post Impacts

As with the REAP program, the evaluation team used two approaches to estimate savings for the Home Performance programs in 2018: an engineering analysis and a consumption analysis. Because consumption analyses use actual customer electric usage to estimate savings, they are typically considered to be more robust assessment of energy savings than engineering estimates. For this reason, the evaluation team primarily based the energy savings from the program on the results of the consumption analysis. However, the results of the engineering impacts analysis provide us with the energy to demand ratio needed to develop demand savings from the energy consumption analysis. In addition, because the engineering analysis provides savings at the measure level, we gain insights into the relative savings contributions of the measures offered by the Home Performance programs. Finally, these measure-level savings allow us to make recommendations to the implementation team for adjusting ex ante planning assumptions going forward.

Given the overlap between the HPDI and HPwES programs and the relatively small number of participants in each program, we estimated program savings by combining the two programs in a single consumption analysis. 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 HPDI and HPwES programs would significantly reduce 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 HPDI 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.

Because the consumption analysis requires post-installation electricity usage data for approximately one year after treatment, our consumption analysis uses 2017 participants as the treatment group and uses the pre-participation period of the 2018 participants as the comparison group, which is consistent with most prior evaluations. The energy use of the comparison group prior to their program participation acts as the counterfactual or point of comparison for the treatment group (2017 participants) in the post-participation period. With the addition of thermostatic valves, and the changes to the composition of the thank you kits to include smart power strips and additional bulbs in 2018, the consumption analysis does not capture any savings from these new measures. The consumption analysis resulted in an energy savings realization rate of 27% for all measures, excluding thermostatic valves and the additional kit measures. For the participants who had these new measures installed in 2018, the measure-level savings calculated in the engineering analysis are added to the savings shown by the consumption analysis.

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

The combined consumption and engineering analysis found that the Home Performance programs generated approximately 1,402 MWh in ex post net energy savings in 2018, or about 40% of the ex ante net energy savings. The program achieved evaluated demand savings of 254 kW.

Table 6-2. 2018 HPDI and HPwES Evaluated and Ex Post Impacts

Category	N[a]	Ex Ante Net Savings[b]		Evaluated/Ex Post Net Savings	
		kWh	kW	kWh	kW
HPDI					
LED Bulbs	4,780	212,191	48	56,756	11
DHW	532	169,420	0.93	45,316	0.18
Duct Sealing	248	149,159	58	39,896	34
Power Strips	379	41,589	4.9	11,124	1.1
Thermostatic Valve[c]	135	22,640	0	33,408	0
Smart Thermostat[c]	1	167	0	186	0
HPDI Subtotal[d]	**6,075**	**595,166**	**112**	**186,686**	**46**
HPwES					
Envelope	1,909	675,575	1,059	180,700	33
Air Sealing	1,320	229,558	353	61,401	9.1
Lighting	328	211,736	0	56,634	12
DHW[e]	192	190,345	95	60,237	1.1
HVAC[e]	1,017	-68,675	178	69,337	70
Thank You Kits	5,590	1,363,063	233	786,611	97
4-Bulbs[f]	5,590	444,964	89	119,017	21
Additional 2-Bulbs + 1 APS[c, f]	2,242	918,099	143	667,595	75
Project Adjustment[g]	88	276,418	151	0	0
HPwES Subtotal	**10,444**	**2,878,020**	**2,069**	**1,214,920**	**223**
Total	**16,519**	**3,473,186**	**2,181**	**1,401,606**	**269**

Note: Totals may not sum due to rounding.

[a] Count of measures installed through the HPDI or HPwES program.

[b] Reported ex ante net savings includes electricity savings and interactive electricity impacts from incentivized measures, in addition to beneficial electrification impacts from fuel switching measures.

[c] These measures were not a part of the 2017 program and therefore are not accounted for in the consumption analysis. Engineering analysis results are reported for these measures in this table. The measures are included in program total participant counts, net savings, and realization rates.

[d] HPDI ex post savings are slightly different (~1%) than evaluated savings because of a difference in NTGR applied. The evaluated savings are shown here categorized as evaluated/ex post for simplicity.

[e] DHW and HVAC measures include additional electric usage from beneficial electrification in ex ante values. To estimate evaluated savings, the evaluation team used 2018 program tracking data to disaggregate beneficial electrification from ex ante net savings, resulting in energy realization rates dissimilar to other measures in the consumption analysis. The negative realization rate for HVAC measures is due to beneficial electrification being included in ex ante net savings, resulting in negative ex ante net savings.

[f] A total of 5,590 thank you kits were distributed to audit participants in two waves, where the *first* wave (distributed through July 2018) contained 4 LED bulbs (3,348 measures) and a second wave (distributed starting in August 2018) contained 6 LED bulbs and a Tier 2 APS (2,242 measures). The consumption analysis results only include the savings from the first 4 LEDs of each wave, as the 4 LED kit was in place in 2017, which serves as the treatment group for the consumption analysis. Therefore, the evaluation team added incremental savings for the remaining 2 LEDs and APS from the second wave kit, to account for the additional savings from those kits.

[g] The project adjustment includes the 88 projects that were "zeroed out" in the program tracking database due to overall negative savings at the project level. The reported ex ante net savings are for the individual measures that had positive savings within the 88 projects. This is not applicable to the evaluation analysis and therefore is not included in evaluated or ex post reporting.

Beneficial Electrification Impacts

In 2018, the HPwES program completed 131[28] projects that resulted in negative electric savings. These projects resulted from the customer's switching their primary space or water heating system from a fossil fuel to electric; for example, from an oil furnace to an air-source heat pump. For comparison to program tracking goals, the implementation team zeroed out the negative savings for these projects when reporting ex ante savings. While these projects do not generate overall electric savings for the program, they generate non-electric energy savings through avoided fossil fuel consumption.

To ensure that evaluated impacts accurately inform the program cost-effectiveness assessment, the evaluation team has quantified these beneficial electrification impacts separately, as shown in Table 6-3. The energy savings of the removed fuel after electrification, and positive and negative impacts associated with energy efficiency measures, are expressed in millions of Btus (MMBtu). Additionally, any fuel savings associated with non-electric measures, which are primarily NYSERDA-incented measures, have not been evaluated.

Table 6-3. 2018 HPwES Savings from Beneficial Electrification

Category	Evaluated Electrification kWh	Evaluated Electrification MMBtu	Evaluated Fuel Savings MMBtu				Total Evaluated Beneficial Electrification Savings MMBtu
			Natural Gas	#2 Fuel Oil	Propane	Other Fuels	
HVAC	-137,216	-468	107	2,858	0	0	2,497
DHW	-7,916	-27	0	299	0	0	272
Total	**-145,132**	**-495**	**107**	**3,157**	**0**	**0**	**2,769**

Reasons for Differences Between Consumption Analysis and Ex Ante Savings

The 2018 consumption analysis resulted in substantially lower overall evaluated savings than ex ante net savings, as shown by the 40% realization rate. The relatively low realization rate is primarily attributable to substantially higher ex ante net savings assumptions for 2018 compared to prior years, due to the addition of the new measures to the program. The Home Performance programs' planning assumptions and goals more than doubled compared to 2017 on a per-participant basis. However, the consumption analysis also showed lower evaluated energy savings than observed in recent evaluations.

Treatment and Comparison Groups Equivalency Analysis

Using future participants as a comparison group assures us that the treatment and comparison groups are equivalent because the criteria and process for program selection are equivalent between early and later participants. However, we perform whatever analyses are possible to confirm that the both groups of participants are similar in other ways so that we can be confident in using 2018 participants 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 a justifiable point of comparison. We confirmed that the groups were sufficiently similar in consumption and in weather experienced during the same calendar period. We show these comparisons in Section 9.7.

[28] The program administrator may have treated more projects that involved fuel switching, but this value represents only those that resulted in negative overall project savings.

Consumption Analysis Model Specification Results

The consumption analysis model is a one-way LFER model. The model allows all household factors that do not vary over time to be absorbed by (and therefore controlled for within) the individual constant terms in the equation. The final model includes terms for treatment (which is an indicator variable for participation in the program), time, electric space heating (ESH), and weather. The treatment effect is the difference in energy use that is associated with participating in the program. Interacting the pre-period usage with each of 12 months provides an extra control for the differences between the groups each month. We did not include terms for specific measures or end-uses.

We did not attempt to calculate measure-level realization rates in the consumption analysis due to the considerable number of participants who installed multiple measures. Given the overlap in measure installations, it is impossible to estimate individual effects accurately, since parameters in the model are highly collinear, thus greatly increasing uncertainty around the estimates. As such, consumption analysis provides results only for the energy savings of 2017 participants.

We use the consumption analysis to estimate savings for the HPDI program, the HPwES program, and participants who completed both an HPDI and an HPwES project, with the exception of the newly added 2018 measures. These are accounted for via the engineering analysis and added to the consumption analysis results. Based on these individual program results we calculated a weighted average of all 2017 participant savings for the combined Home Performance programs. Table 6-4 presents the overall net program savings for 2017 HP program participants. As shown below, the 2018 Home Performance programs (not including the newly added 2018 measures) realized 27% of their expected net savings at the participant level. These results reflect savings attributable to the programs and the types of measures installed during 2018. As described above, additional savings for new 2018 measures are added based on engineering estimates.

Table 6-4. 2018 Home Performance Programs Consumption Analysis Savings Compared to Ex Ante Savings

Program	N[a]	Observed Savings[b]		Ex Ante Savings		Realization Rate
		Household Daily Savings (kWh)	Household Annual Savings (kWh)	Household Daily Savings (kWh)	Household Annual Savings (kWh)	
Combined Home Performance Programs	1,777	1.34	523	5.35	1,955	27%

[a] The total count of participants to which the consumption analysis results are applied omits 346 HPwES accounts. Of these accounts, 215 had no electric savings and 131 had negative electric savings. The accounts with negative savings completed a heating system change that shifted them from a fossil fuel to electric heating. Therefore, their electricity use will rise while their fossil fuel use declines, and the results of the consumption analysis will not apply to them.

[b] Includes line losses.

Engineering Analysis: HPDI

The evaluation team also performed a measure-level engineering analysis of ex ante savings to estimate evaluated impacts. As described above, the results of the engineering impacts analysis provide us with the energy to demand ratio needed to develop demand savings from the energy consumption analysis, and an understanding of relative contribution of the measures offered by the program. 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. Table 6-5 provides a comparison of evaluated net savings to ex ante net savings by measure category for the HPDI program as determined by the engineering analysis.

Table 6-5. 2018 HPDI Program Measure-Specific Net Impacts: Engineering Analysis

Category	N[a]	Ex Ante Net Savings		Evaluated/Ex Post Net Savings		Realization Rate	
		kWh	kW	kWh	kW	kWh	kW
LED Bulbs	4,780	212,191	48	307,849	58	145%	122%
DHW	532	169,420	0.93	167,066	0.68	99%	73%
Duct Sealing	248	149,159	58	73,281	63	49%	109%
Power Strips	379	41,589	4.9	12,552	1.3	30%	26%
Thermostatic Valve	135	22,640	0	33,408	0	148%	N/A
Smart Thermostat	1	167	0	186	0	111%	N/A
Total	6,075	595,166	112	594,342	123	100%	110%

[a] Count of measures installed through the HPDI program.

Reasons for Differences in Engineering Impacts: HPDI

In addition to providing the energy to demand ratio needed to develop demand savings from the energy consumption analysis and information on the relative contributions of each measure to overall savings, the engineering impact analysis allows us to make recommendations to the implementation team for adjusting ex ante planning assumptions going forward. The engineering analysis found that the HPDI program realized 100% of expected net energy savings and 110% of net demand savings. The evaluation team performed a measure-level engineering analysis of ex ante net 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. We highlight some of the discrepancies observed during the engineering analysis below.

- LED Bulbs: Based on the engineering analysis, LED bulbs account for approximately 47% of HPDI's evaluated demand savings and 52% of evaluated energy savings. The evaluation team calculated LED bulb realization rates of 145% for energy and 122% for demand savings. The differences between ex ante and evaluated savings are due to the following:
  - Delta Watts: Program administrators incorporated the measure mix from 2016 HPDI installation data and delta watts (the difference between the replaced and installed lamp wattage) to estimate savings, while the evaluation team utilized 2018 program tracking data. As a result, program administrators assumed a weighted average delta wattage 38% lower than the evaluation team's value for standard lamps and 1% lower for specialty lamps. This led to higher evaluated energy and demand realization rates.
  - Hours: The program administrators calculated a weighted average of 1,113 annual operating hours based on 3.05 hours per day of indoor lighting operation. The evaluation team applied the 2018 PSEG Long Island TRM-specified mix of 89% interior and 11% exterior sockets, based on the 2017 Residential In-Home Study,[29] for a weighted average of 1,159 hours. The difference in hours led to slightly higher evaluated energy savings.
  - Rounding: The 122% realization rate for demand savings is partially due to rounding limitations in LM Captures identified during the verified ex ante analysis. LM Captures rounds values to three decimals, and because unitary demand savings are small values on the order of 1/100th of a

[29] Opinion Dynamics. (October 2017). *PSEG Long Island Residential In-Home Study.*

kilowatt, rounding limitations are magnified and present more prominently for demand savings than for energy savings.

- Domestic Hot Water: DHW measures include showerheads, faucet aerators, pipe insulation, turndown of water heater temperature, and thermostatic restrictor valves. Based on the engineering analysis, the DHW measures account for 34% of evaluated net energy savings. Below is a detailed discussion of differences in ex ante and the evaluation savings assumptions.
  - Low-Flow Showerheads: The program administrator and evaluation team applied the savings algorithms in accordance with the 2018 PSEG Long Island TRM, but program administrators adopted a throttle factor of 0.75, based on NY TRMv4. Conversely, the evaluation team applied the 2018 PSEG Long Island TRM-specified throttle factor of 0.9, resulting in a 116% energy realization rate. There are no demand savings associated with this measure.
  - Aerators: The program administrator and evaluation team applied the savings algorithms in accordance with the 2018 PSEG Long Island TRM, but program administrators adopted an assumed 30 uses per day, based on NY TRMv4 recommendations. Conversely, the evaluation team applied 17 uses per day as recommended in the 2018 PSEG Long Island TRM. Additionally, the evaluation team incorporated actual flow rate values from 2018 program tracking data, which were 28% more efficient (i.e., lower flow rate in terms of water per minute) than the 2016 program tracking data values used in ex ante calculations. These are the primary contributors to the 41% energy realization rate. There are no demand savings associated with this measure.
  - Pipe Insulation: The program administrator and evaluation team applied the savings algorithms and assumptions in accordance with the 2018 PSEG Long Island TRM, leading to a 100% realization rate for energy savings. The 92% demand realization rate is due to the rounding limitations previously identified during the verified ex ante analysis.
  - Temperature Turndown: The program administrator and evaluation team applied the savings algorithms in accordance with the 2018 PSEG Long Island TRM, but the evaluation team applied the temperature change recorded in 2018 program tracking data, which was 2°F lower than the temperature reduction used in ex ante calculations. This resulted in realization rates of 72% for both energy and demand savings.
- Duct Sealing: Program administrators incorporated planning assumptions recommended by the evaluation team from the 2018 PSEG Long Island TRM but assumed that all homes are cooled with either heat pumps or CAC, not accounting for homes without cooling. This resulted in inflated ex ante energy savings. Since only homes with electric heat are eligible for the HPDI program, the evaluation team determined the percentage shares of different HVAC systems for electrically heated homes from the 2018 HPwES program tracking data. These shares differed from the program implementer's assumptions and contributed primarily to the 49% energy realization rate. To estimate ex ante demand savings, the program administrator applied a CF of 0.8 to the deemed peak demand savings assumptions from the 2018 PSEG Long Island TRM, which inherently already includes a coincidence factor. The evaluation team did not apply a coincidence factor to the deemed demand savings assumption. This resulted in 9% higher evaluated demand savings than ex ante.
- Power Strips: Ex ante calculations included a seven-outlet Tier 1 power strip with 103 kWh deemed annual savings as recommended in NY TRMv4. The evaluation team applied a deemed Tier 1 savings value of 31 kWh recommended in NY TRMv5, as it became applicable on January 1, 2018. Additionally, the ex ante demand savings reflected an assumed CF of 1.0, whereas the evaluation team applied a

CF of 0.8 based on the recommendations provided in the NY TRMv5. These factors led to the 30% energy and 26% demand realization rates.

- Thermostatic Restrictor Valves: The program administrator adopted the NY TRMv4 deemed savings value of 157 kWh/unit based on an installed fixture with a 2 GPM flow rate. The evaluation team applied savings algorithms specified in the 2018 PSEG Long Island TRM and incorporated 2018 program tracking data, resulting in 48% higher evaluated energy savings than ex ante. There are no demand savings associated with this measure.
- Smart Thermostats: New to the 2018 HPDI portfolio of measures, only one smart thermostat was installed through HPDI in 2018. The program administrators and evaluation team applied deemed savings recommended by the evaluation team and based upon recent smart thermostat savings research conducted for similar programs.[30] The program administrators applied conservative savings assumptions provided by the evaluation team and considered only cooling savings.[31] This approach assumes that all homes have central cooling. The evaluation team applied the recommended deemed savings values in coordination with the percentage of Long Island homes with central cooling and heat pump heating from the 2017 PSEG Long Island Residential In-Home Study,[32] which states that 50% of homes are centrally cooled and 3% are heated with heat pumps. The realization rate for energy is 111%; there are no demand savings for this measure.

Engineering Analysis: HPwES

The evaluation team also performed a measure-level engineering analysis of ex ante savings to estimate evaluated impacts. As described above, the results of the engineering impacts analysis provide us with the energy to demand ratio needed to develop demand savings from the energy consumption analysis, and an understanding of relative contribution of the measures offered by the program. 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. Table 6-6 provides a program-level comparison of evaluated net savings to ex ante net savings by measure category for the HPwES program as determined by the engineering analysis.

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[30] The program and evaluation team applied the memorandum *Energy Savings Planning Estimate for PSEG Long Island's Smart Thermostat Offering* dated July 17, 2017, for smart thermostat measures.

[31] The memorandum provided a range of energy savings from smart thermostats seen in other programs. The lower values assumed a 10% reduction in cooling energy consumption, and an 8% reduction in heat pump heating energy consumption. A weighted average was calculated from application of the lower scenario to four different heating and cooling systems, including CAC, ASHP, ductless mini-split, and geothermal. Note that no heating savings are calculated from the CAC system.

[32] Opinion Dynamics. (October 2017). *PSEG Long Island Residential In-Home Study.*

Table 6-6. 2018 HPwES Program Measure-Specific Net Impacts: Engineering Analysis

Category	N[a]	Ex Ante Net Savings		Evaluated/Ex Post Net Savings		Realization Rate	
		kWh	kW	kWh	kW	kWh	kW
Envelope	1,909	675,575	1,059	649,570	119	96%	11%
Air Sealing	1,320	229,558	353	405,423	60	177%	17%
Lighting	328	211,736	0	244,016	52	115%	-
DHW	192	190,345	95	136,705	2.5	72%	3%
HVAC[b]	1,017	-68,675	178	496,230	504	-723%	284%
Thank You Kits	5,590	1,363,063	233	1,110,259	155	81%	67%
Project Adjustment[c]	88	276,418	151	0	0	0%	0%
Total	10,444	2,878,020	2,069	3,042,204	893	106%	43%

Note: Totals may not sum due to rounding.

[a] Count of measures installed through the HPwES program.

[b] The negative ex ante net savings and realization rate for HVAC measures is due to beneficial electrification being included in ex ante net savings, resulting in negative ex ante net savings.

[c] The project adjustment includes the 88 projects that were zeroed out in the program tracking database due to overall negative savings at the project level. Ex ante net savings reported are for the individual measures that had positive savings within the 88 projects. This is not applicable to the evaluation analysis and therefore is not included in evaluated or ex post reporting.

Reasons for Differences in Engineering Impacts: HPwES

The evaluation team was provided access to the EnergySavvy database that stored all HPwES tracking data in 2018. EnergySavvy's system aggregates results from different residential building energy modeling software, specifically: CakeSystems, TREAT, Snugg Pro, and OptiMiser. EnergySavvy's database and the energy modeling software are approved by NYSERDA.[33]

Using the detailed program tracking data, the evaluation team was able to build customized reports to fit the needs to the evaluation analyses and calculate evaluated savings using the algorithms and methods outlined in the 2018 PSEG Long Island TRM. However, we did not have access to proprietary information and calculations used by the energy modeling software. For this reason, we cannot pinpoint the specific contributors to differences between evaluated and ex ante savings.

Below, we provide details behind the evaluation team's energy and demand savings calculations for each measure type. We reviewed and calculated savings for all participants for each measure type, comparing pre- and post-project conditions among all tracked fields.

- **Building Envelope:** The evaluation team observed that the ex ante net savings for building envelope measures within the EnergySavvy projects were in line with evaluated energy savings, but significantly higher for peak demand savings. Overall, the engineering-based realization rates for building envelope measures are 96% and 11% for energy and demand, respectively. Below is a review of methods applied by the evaluation team for insulation and other measures.
  - **Insulation:** Insulation measures, including attic, roof, floor, wall, and foundation wall insulation, were evaluated following the algorithms defined in the 2018 PSEG Long Island TRM. The evaluation team used the following fields from the tracking data in these calculations: existing and installed R-factor values, installed insulation area, insulation location, and HVAC system types and

[33] As of 2019 CakeSystems and Snugg Pro are no longer used in the program.

efficiencies. The combined engineering-based realization rates for insulation measures are 96% and 11% for energy and demand, respectively.

- Other Measures: Doors, windows, rim joist insulation, pipe insulation, and ventilation fan measures contributed to less than 0.2% of total project savings. Therefore, these measures were assigned 100% engineering-based realization rates by the evaluation team.

- Air Sealing: Evaluated savings were calculated using the 2018 PSEG Long Island TRM methodology. The systems report data contained sufficient data on pre- and post-project air flow rates in CFM, HVAC system types, and HVAC efficiencies to calculate the evaluated savings for each project. Engineering-based realization rates are 177% for energy and 17% for demand savings.

- Lighting: Sufficient tracking data were available for the existing and installed lighting wattages for the evaluators to independently calculate evaluated savings. The evaluation team applied coincidence factors and operating hours for installed bulbs based on the 2016 Residential In-Home Study at the measure level to differentiate by location. Program administrators did not calculate demand savings for lighting measures. Engineering-based realization rates are 115% for energy and cannot be calculated for demand since ex ante net savings are zero.

- Water Heaters: The tracking data contained information on energy factors of the incentivized and removed equipment, pre- and post- hot water temperature set points, water heater location, and the fuel used by the water heater in the pre- and post- cases. The evaluation team referenced the 2018 PSEG Long Island TRM and NY TRMv6 to calculate the evaluated energy savings resulting from this measure. Since multiple water heater measures resulted in electrification, we calculated pre- and post-energy use for all units, for both electric and fossil fuels, to capture energy efficiency, electrification, and fossil fuel savings accurately and independently. Engineering-based realization rates are 72% for energy and 3% for demand savings.

- HVAC Measures: Overall, HVAC measures achieved engineering-based realization rates of -723% for energy and 284% for demand savings. The negative realization rate for energy is a product of ex ante net savings including beneficial electrification impacts on electricity use from fuel switching measures, specifically heat pumps, leading to negative ex ante net savings. The evaluation team disaggregated beneficial electrification impacts from electricity savings at the measure level, resulting in positive savings and the negative realization rate for energy. The following paragraphs discuss differences between ex ante and evaluated savings.

  - HVAC Duct Sealing and Insulation: The measure tracking data did not differentiate between duct sealing and insulation in all instances, so we compared pre- and post-evaluation conditions for all applicable projects to determine the measure associated. The evaluation team used the 2018 Connecticut Program Savings Document's algorithms to calculate savings from duct sealing measures and NY TRMv5-based algorithms to calculate the savings from duct insulation measures.

  - HVAC Equipment: HVAC equipment measures include replacement of a heating or cooling system with an energy efficient unit or replacement of both units with a heat pump unit. The evaluation team used the algorithms recommended in the 2018 PSEG Long Island TRM to calculate savings for HVAC equipment installed as part of the program. The tracking data provided adequate information regarding system type, capacity, load fraction, and equipment efficiency to quantify evaluated impacts. An estimated 88% of heat pump measures were installed by participants who switched from fossil fuel-based heating systems through participation in the program. Due to this prevalence of beneficial electrification interventions, we carefully identified the pre- and post-heating fuels and heating and cooling loads across all HVAC system types to accurately quantify beneficial electrification impacts separately from energy efficiency savings. In all instances where new heat pumps were installed, the home did not previously have a cooling system. For these measures, we categorized the measures as new construction and referenced a baseline of an equivalent heat pump reflecting code efficiency per 2015 IECC requirements. This baseline efficiency was compared with the tracked installed efficiency to estimate the energy efficiency savings associated with the new heat pump installation.

  - **Programmable and Smart Thermostats:** The program tracking data initially reported that all installed thermostats were programmable. Upon further discussion, program staff identified that 8 out of 82 thermostats installed were smart thermostats. For programmable thermostats, the evaluation team calculated savings using the 2018 PSEG Long Island TRM's algorithms. For smart thermostat installations, we applied deemed savings from a 2017 memorandum.[34]

- **Thank You Kits:** For each HPwES audit completed by PSEG Long Island in 2018, a thank you kit was sent to the customer. For audits completed in January through July (3,348 in total), the kit contained four LED bulbs. For audits completed in August through December (2,290 in total), the kit contained six LED bulbs and one Tier 2 APS. The program administrator applied the planning assumptions for EEP to the light bulbs and power strips provided through the thank you kits. Power strips alone accounted for 52% of engineering-based evaluated energy savings and 38% of evaluated demand savings across the thank you kit savings. The overall engineering-based realization rates for thank you kits are 81% for energy and 67% for demand.

  - **Thank You Kit LED bulbs** resulted in a net engineering-based realization rate of 89% for demand and 99% for energy. To estimate the savings from LED bulbs, the evaluators used wattage of the LED bulbs provided (10 W) and assumed as baseline the EISA-equivalent halogen wattage of 43 W. The primary contributor to the difference in the light bulb energy savings is the program's assumption of 86% interior lights, while the evaluation team assumed 89% interior, based on the 2016 Residential In-Home Study. The larger demand savings discrepancy is a result of rounding—the applied per-unit demand savings values were rounded to three decimal places, whereas ex ante assumptions are based on formulas and therefore result in more precise values.

  - **Thank You Kit Power Strips:** The program administrator applied deemed power strips savings value from the MA TRM, whereas the evaluation team referenced the 2018 PSEG Long Island TRM. Additionally, the evaluation team applied an in-service rate of 75% from a study conducted on Massachusetts homes where Tier 2 APSs were offered through an upstream and online store and were self-installed by the homeowners.[35] The resulting engineering-based realization rates are 70% for energy and 47% for demand savings for power strips.

6.3 Conclusions and Recommendations

Based on the results of this evaluation, the evaluation team offers the following key findings and recommendations for the HPwES program moving forward:

[34] The program and evaluation team applied the memorandum *Energy Savings Planning Estimate for PSEG Long Island's Smart Thermostat Offering* dated July 17, 2017, for smart thermostat measures.
[35] NMR Group. (October 2018). *RLPNC 17-4 and 17-5: Products Impact Evaluation of In-service and Short-Term Retention Rates Study*, Table 7: Evaluated ISR and Short-term Retention Rates.

- Key Finding #1: The program administrators zeroed out HPwES projects that had negative overall energy savings and reported those projects as an adjustment. The evaluation team was unable to separate beneficial electrification impacts from other HPwES ex ante electricity savings because they are not recorded separately in the program tracking data. These two findings combined led to ex ante net savings that included beneficial electrification impacts.
  - Recommendation: We recommend that the program administrators provide increased granularity of measures resulting in non-electric energy savings. Further, we recommend that projects with overall negative savings should not be zeroed out, and instead should be reported the same way as other projects. This can be achieved by incorporating beneficial electrification impact fields into the program tracking data, which would allow both the program administrators and evaluation team to report beneficial electrification separately from other energy efficiency savings.
- Key Finding #2: The evaluation team found misalignment of wattages included in HPDI measure descriptions and the program tracking data.
  - Recommendation: We recommend that the program administrators ensure that the tracked installed wattage values appropriately match the bulb descriptions for all lighting measures.
- Key Finding #3: The evaluation team found that information on HVAC system type is collected by contractors but is not being incorporated into a unique field in the HPDI program tracking data.
  - Recommendation: We recommend that the program administrator continue recording information on the HVAC system and integrate the data into the LM Captures database to support increased accuracy of evaluated savings.
- Key Finding #4: The program claims significant ex ante savings through the thank you kits that are distributed to customers who complete an audit through the HPwES program. However, the program does not track the installation of the bulbs and power strips provided in the kits. Due to the ongoing changes in the lighting market and increasing saturation of LED lighting, there is reason to believe that the bulbs offered through the thank you kits are, over time, less likely to be installed in high use sockets. Further, there is no tracking of the installation of the Tier 2 advanced power strips. The evaluation team used recent research from Massachusetts to develop an ISR for these devices absent other information, but this research is not directly relevant to the PSEG Long Island program. In the Massachusetts case, customers purchased Tier 2 APSs from an online store, while in this program they are offered free of charge. There is reason to believe that the former situation would result in higher ISRs than in a free thank you kit. In addition, updates in the 2019 PSEG Long Island TRM include a 50% reduction in Tier 2 APS gross energy savings moving from 322.2 kWh/yr to 158.9 kWh/yr. This change also aligns with the NY TRMv6, meaning that savings from this measure will decline in 2019 and future years.
  - Recommendation: Conduct additional research to understand the installation and use practices of lighting and Tier 2 APSs offered through thank you kits and revise ex ante savings assumptions if appropriate.[36]

[36] As of 2019 Tier 2 APSs are no longer offered as part of the HEA thank you kits.

7. Home Energy Management Program

7.1 Home Energy Management Program Description

PSEG Long Island, in partnership with Tendril, administers the Home Energy Management (HEM) program as a part of its residential portfolio. The program aims to motivate and inspire PSEG Long Island customers to increase their understanding of all aspects of their energy needs and take active control of their energy usage. The specific objectives of the program are to have customers:

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

The program offers a set of intervention strategies to influence customers' energy use behaviors. The primary strategy is a Home Energy Report (HER) engagement campaign leveraging a randomized control trial (RCT) design.[37] HERs are sent to customers in the treatment group by mail and email and contain information including:

- Customer electric energy usage for the past month
- A comparison of the customer's energy usage to the energy usage of nearby homes with similar characteristics from the past month
- Information showing which energy use categories contribute the most to the customer's overall energy use (e.g., heating, cooling, kitchen, laundry)
- A chart showing the customer's energy usage over the past year
- Promotion of applicable PSEG Long Island programs and rebates
- Tips for reducing energy consumption

In addition to HERs, treatment customers can participate in "opt-in" interventions, such as High Usage Alerts, Home Energy Assessment Tools, Online Marketplace, and HEM Controls Pilot.

7.1.1 Program Design and Implementation

Treatment of customers began in September 2017 when Tendril initiated its plan to send periodic HERs to 341,570 customers. The program's initially established goal was to achieve over 30,000 MWh of behavior-based energy savings per year over a two-year period. The evaluation team refers to this group of customers receiving reports at the program's outset, and its control group counterpart, as Cohort 1. One of the selection

[37] In the context of a household-level behavioral program, Randomized control trial, or RCT, is a type of experimental design in which households in a given population are randomly assigned into two groups—a treatment group and a control group— and the outcomes for these two groups are compared, resulting in unbiased program savings estimates.

criteria for customers in Cohort 1 emphasized customers between 55 and 74 years old to improve satisfaction of customers in this segment. In addition, one-third of these customers are "My Account" participants.[38]

In August 2018, Tendril started to send periodic HERs to an additional 159,348 customers, who represent the treatment customers in Cohort 2. Not all of these customers received their first HERs in August 2018, as initial HERs were sent out on a rolling basis through the remainder of 2018. Cohort 2 treatment customers consist of a set of control customers drawn from Cohort 1, as well as additional customers who were not included in the HEM program previously but were selected using the same criteria as Cohort 1. A majority of Cohort 2 is made up of customers who were newly added to the program. Additionally, PSEG Long Island increased the HEM program goal to 40,000 MWh for the 2018 year.

This evaluation provides energy savings estimates of the HEM program for the 2018 calendar year from Cohort 1 and Cohort 2.

7.1.2 Program Participation and Performance

PSEG Long Island's HEM program performed well in 2018, with its verified ex ante energy savings reaching 120% of the goal of 40,000 MWh. Table 7-1 presents 2018 HEM program performance compared to goals.

Table 7-1. 2018 HEM Program Verified Ex Ante Net Program Performance Against Goals

Metric	MWh
Goal	40,000
Verified Ex Ante Net Savings	47,845
% of Goal	120%

Table 7-2 presents HEM program participation in Cohorts 1 and 2 in both treatment and control groups since treatment customers in both cohorts received reports during the evaluation period. Note that this table excludes the subset of customers who participated in the Super Saver Program. Super Saver Program customers receive HERs, but the reports differ in content and frequency in comparison to the HERs sent to HEM program participants. The team does include reports sent to Super Saver Program customers in the discussion below about verified ex ante savings because PSEG Long Island included these reports in their claimed ex ante numbers. Excluding these reports for verified ex ante savings would thus result in incomparable claimed and verified ex ante results. An impact analysis of the Super Saver Program is provided separately from this report.[39]

Table 7-2. 2018 HEM Program Participation Summary[a]

Cohort	Number of Treatment Customers	Number of Control Customers	Number of Customers per Cohort
Cohort 1	331,433	47,146	378,579
Cohort 2	158,714	34,754	193,468
Total	**490,147**	**81,900**	**572,047**

[a] Excludes treatment and control customers who closed their account before January 1, 2018.

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

[39] The Super Saver Program evaluation provides demand and energy impacts, but PSEG Long Island does not intend to claim peak demand reduction or electric energy savings in 2018.

Distribution of First Report Sent Dates

Tendril sent out the first reports to treatment customers on a rolling basis. This means that customers received reports at varying times throughout the year. The experiment start date, when customers were assigned to treatment or control groups for the program, was September 8, 2017, for Cohort 1 and August 27, 2018, for Cohort 2, based on the dates provided in the program tracking data from Tendril. Table 7-3 shows the distribution of treatment customers in the two cohorts who received HERs according to when their first reports were sent. Over 75% of treatment customers in Cohort 1 received their first reports within three months of the experiment start date in September 2017. A higher proportion of treatment customers in the second cohort received their first reports within three months (93%). It is notable that over 10% of Cohort 1 treatment customers received their first reports either more than six months after the experiment start date (8%) or not at all (3%). Since these customers did not receive HERs immediately, this set of treatment customers experienced a delay in receiving and responding to the information related to their energy usage. This trend is not as large for the treatment customers in Cohort 2, though the same percentage (3%) lacked a first report sent date in the program tracking data.

Table 7-3. Distribution of First Report Dates to Treatment Customers in HEM Program

Received First Report	% of Treatment Customers in Cohort 1	% of Treatment Customers in Cohort 2
Within 1 month after experiment start date	25%	67%
Within 2 months after experiment start date	27%	16%
Within 3 months after experiment start date	24%	10%
Within 4 months after experiment start date	1%	4%
Within 5 months after experiment start date	4%	0%
Within 6 months after experiment start date	7%	0%
More than 6 months and less than 1 year after experiment start date	7%	0%
More than 1 year after experiment start date	1%	0%
Never received a report	3%	3%
Total	100%	100%

Note: Totals may not sum due to rounding.

Claimed and Verified Report Counts

According to PSEG Long Island, the claimed number of paper HERs sent to customers during 2018 totaled 1,901,042.[40] Based on the program tracking data, the verified count of paper reports sent was slightly higher, equaling 1,902,418 paper HERs. The verified number of paper reports sent each month and the total for 2018 are presented in Table 7-4. Starting in August, when the implementer began to send HERs to treatment customers in Cohort 2 in addition to those in Cohort 1, the number of reports sent per month increased significantly.

40 PSEG Long Island, *December 2018 Monthly Report.* Note that the claimed ex ante savings are based on reports sent to both HEM and Super Saver Program participants. This is the only portion of the HEM program evaluation in which Super Saver participants are included.

Table 7-4. HEM Program Paper HERs Sent by Month in 2018

Month	Verified Report Count
January	129,826
February	160,769
March	76,047
April	102,611
May	122,823
June	115,134
July	123,007
August	199,322
September	178,389
October	210,172
November	274,661
December	209,657
Total	**1,902,418**

7.1.3 Program Marketing

The HERs sent to treatment customers include information to cross-promote programs offered by PSEG Long Island. For example, the HERs sent out in the summer months provide information to customers about rebates available on high efficiency air conditioning as well as energy efficient pool pumps. Other HERs include information about PSEG Long Island's Online Home Energy Analyzer, refrigerator and freezer recycling incentives, and its online marketplace where customers can purchase discounted lighting, smart thermostats, and other energy efficient equipment.

7.1.4 Anticipated Changes in 2019

The HEM program continues to send HERs to treatment customers in both Cohorts 1 and 2 in 2019; however, these customers will receive five HERs instead of the six that were planned for in 2018.

7.2 Home Energy Management Program Impacts

This section presents a summary of the ex ante and evaluated energy savings impacts for the 2018 HEM program. The evaluation team compares the claimed ex ante net savings of the HEM program to the verified ex ante net savings as well as the evaluated net savings estimated by the evaluation team. The verified ex ante net savings are estimated based on a deemed savings approach. For the 2017 program year, the evaluated net savings estimate also relied on a deemed savings approach due to the late program start and the lack of sufficient post-treatment billing data. For 2018, the evaluation team estimated evaluated net energy savings using a consumption analysis. The result of this approach is referred to as the unadjusted evaluated net energy savings because we have not yet removed any savings already counted under other PSEG Long Island residential efficiency programs.

Our savings analysis for the HEM program also accounts for the energy savings resulting from energy efficient actions taken through other PSEG Long Island programs. One would expect a base rate of participation in these programs from both the treatment and control customers; however, it is likely that the HEM program encourages an increase, or "uplift," in participation in other PSEG Long Island residential energy efficiency programs among the members of the treatment group by promoting these programs in the HERs. Increased participation in other PSEG Long Island energy efficiency programs by the treatment group would mean that some portion of savings from other programs may be counted by both the HEM program (through the consumption analysis savings estimate) and other energy efficiency programs (through deemed savings in their tracking databases or in their impact evaluations). To avoid double counting these savings, they are removed from the results of the consumption analysis to arrive at an adjusted evaluated net savings impact for the HEM program.

Because Cohort 2 began to receive reports relatively late in 2018, the focus of this year's consumption analysis is on the customers in Cohort 1 for whom we have sufficient post-participation billing data. The consumption analysis was based entirely on the savings achieved by treatment customers in Cohort 1. The average daily savings of the first year of participation for these customers was then applied to all HEM program treatment customers who participated in 2018.[41] Note that both Cohort 1 and Cohort 2 treatment customers are included in the count of customers who achieved average daily savings due to participation in the 2018 HEM program. As described in further detail below and in Section 9.8, the evaluation team assessed the equivalency of the treatment groups in Cohorts 1 and 2 and found them to be comparable. Hence, application of the savings from the consumption analysis using Cohort 1 to Cohort 2 treatment customers was reasonable. Note that even though the treatment customers in Cohort 2 did not receive reports throughout the full 2018 program year, they were assigned annualized savings for the year due to the application of the intent–to-treat (ITT) approach.[42] This method of estimating savings differs from the approach used in 2017, which applied an approved deemed savings value to estimate savings only for the portion of the year after treatment customers received their first report.

7.2.1 Evaluated Impacts

Table 7-5 presents a summary of the 2018 energy savings goal for the HEM program, the ex ante net savings associated with the claimed number of reports sent, ex ante savings estimated based on the verified report count, and unadjusted and adjusted evaluated net savings. Recall that unadjusted net savings are estimated using a consumption analysis and have yet to remove any double counting of savings that are already accounted for in other PSEG Long Island residential programs. Adjusted evaluated net savings are the program savings with the removal of double counted savings. Because we found a small amount of participant uplift as part of our joint savings analysis, the adjusted evaluated savings are slightly lower than the unadjusted savings. The realization rate of claimed ex ante savings to evaluated savings is 116%. In addition, the HEM program surpassed its goal by 15,662 MWh for 2018.

[41] Cohort 1 customers also started late in 2017, so a consumption analysis for them was not feasible last year, given the reporting schedule. As a result, the evaluated savings for the 2017 program year were based on approved deemed savings for this type of program.

[42] ITT estimates the impacts of the program for a group of customers the program intended to treat (i.e., customers to whom PSEG Long Island intended to send HERs or eHERs). Another method that evaluators may rely on is the average treatment effect of the treated, which estimates the impacts of the program for the group of customers that received HERs. These approaches differ in the number of customers used in the analysis.

Table 7-5. 2018 HEM Program Ex Ante and Evaluated Net Impacts

	Energy Savings (MWh)
Goal	40,000
Claimed Net Ex Ante	47,810
Verified Ex Ante	47,845
Unadjusted Evaluated Net Impacts	55,962
Uplift Adjustment	300
Adjusted Evaluated Net Impacts After Accounting for Uplift	55,662
Realization Rate of Claimed Ex Ante to Evaluated Savings	116%

7.2.2 Claimed and Verified Ex Ante Net Savings

PSEG Long Island indicated that its 2018 plan assumed that treatment customers in Cohorts 1 and 2 would receive six HERs over the course of the year. Consistent with the verified ex ante savings analysis conducted in 2017, PSEG Long Island and the evaluation team assumed that these reports would yield 1.5% annual savings (or 0.25% savings per report) relative to the average annual consumption per participant in PSEG Long Island's territory.[43] This assumption is in line with findings from evaluations of similar programs that show participants achieve on average approximately 1.0% to 1.5% net electric savings over the first year.[44] The evaluation team used the number of claimed and verified paper reports sent, along with the deemed savings per report and quantity of reports sent in 2018 to calculate the claimed and verified ex ante net savings from the HEM program from the 2018 program year (see Table 7-6).

Table 7-6. HEM Program Ex Ante and Verified Ex Ante Net Savings

	Number of Paper Reports Sent	Deemed Savings Per Report (kWh)	Ex Ante Net Savings (MWh)
Ex Ante	1,901,042	25.15	47,810
Verified Ex Ante	1,902,418	25.15	47,845

7.2.3 Attrition Analysis

Cohorts 1 and 2 experienced some attrition in 2018, as customers opted out, closed accounts, or never received a report. Table 7-7 shows the attrition rates for 2018 by cohort and the reason for attrition, based on a review of the HEM program participant data. When treatment customers in both cohorts are considered,

[43] Note that the PSEG Long Island 2016 average annual energy usage per participant value used of 10,060 kWh was the same value used for the 2017 HEM program verified ex ante savings estimate. When multiplied by 0.25% savings per report, the deemed savings per report equals 25.15 kWh.

[44] Behavioral programs are considered an "ongoing treatment" (e.g., customers receive reports on monthly basis for a year or longer), whereas equipment-based programs capture savings from a one-time installation of equipment. As a result, customers who receive reports may not at first recall receiving the report or take energy-saving actions immediately after the program begins. After subsequent months of receiving the reports, customers may be motivated to purchase energy-efficient equipment or habituate recommended behaviors like turning off the lights or setting more efficient set points on their thermostat. Research suggests that energy savings for behavioral programs ramps up over time, with first-year savings for electric customers typically around 1.0%–1.5% and growing into the second and third years, where they plateau between 2% and 3%. Treatment customers in Cohorts 1 and 2 have been in the program 16 months and 4 months, respectively, so the evaluation team supports the continued use of 1.5% savings for the 2018 program year for the ex ante net savings.

5.7% of participants moved out in 2018, 0.16% opted out, and 3.4% of Cohort 2 participants never received a report during 2018. The total rate of attrition in 2018 is 6.2%.

Table 7-7. 2018 HEM Program Attrition Rates by Cohort

Cohort	Moved Out	Opted Out	Accounts That Did Not Receive Reports and Started Experiment in 2018	Total Attrition
Cohort 1	6.20%	0.18%	0.00%	6.36%
Cohort 2	4.71%	0.13%	3.44%	5.90%
Total	5.73%	0.16%	1.09%	6.21%

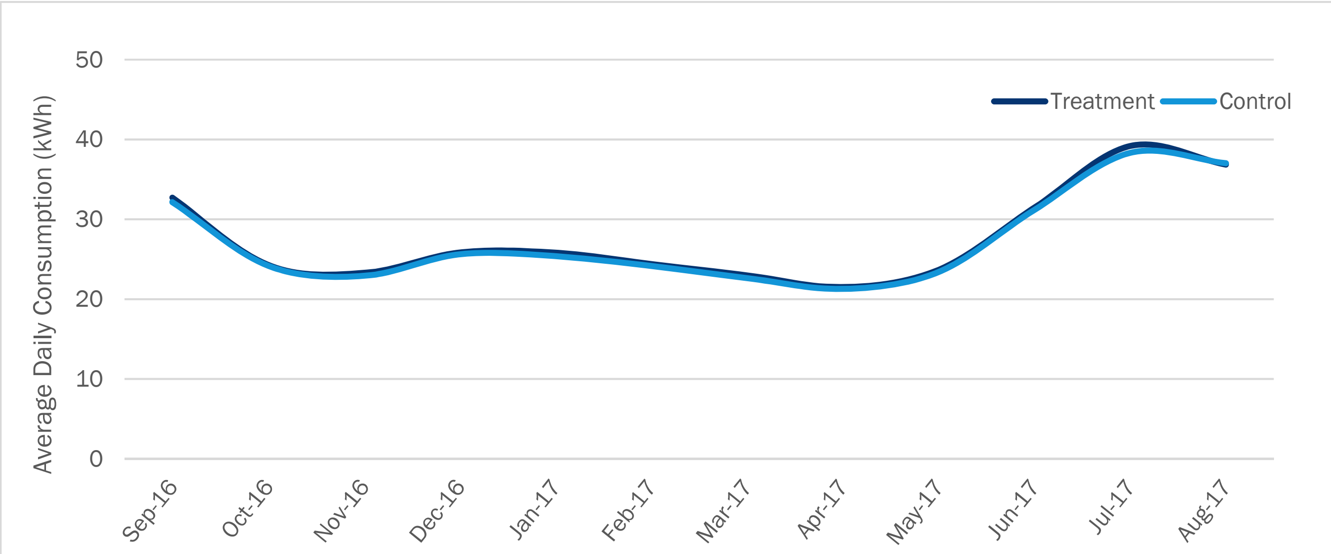
Note: Total attrition does not equal the sum of customers who moved out, opted out, or never received a report because some customers are reported in more than one category. The percentage of total attrition only counts customers once to ensure no double counting.

7.2.4 Equivalency Analysis

Prior to conducting the consumption analysis using an RCT approach to estimate savings for the HEM program, the evaluation team conducted an equivalency analysis between the treatment and control customers in Cohort 1. The equivalency analysis is used to verify that these two groups show equivalent energy consumption overall, and monthly, for the 12-month period prior to the start of report delivery for the treatment customers. This analysis ensures that the control group provides a reliable counterfactual for the treatment group of customers.

Last year, the treatment and control groups in Cohort 1 were subjected to a thorough equivalency analysis that included demographic information as well as pre-period energy and weather variables, which showed that the groups were equivalent. For 2018 the evaluation team repeated only the energy and weather comparisons to ensure that the participants who remain after further cleaning and attrition due to move-outs are still equivalent. Figure 7-1 shows the comparison of treatment and control group energy consumption for the period between September 2016 and August 2017. The two lines are very close and indicate very similar usage patterns supporting the validity of the experimental design.

Figure 7-1. Pre-Period Average Daily Consumption, Cohort 1 Treatment vs. Control



In the year prior to receiving reports from the HEM program (September 2016 through August 2017), the average daily consumption (ADC) for Cohort 1 was 27.7 kWh for treatment customers and 27.4 kWh for the control customers (see Table 7-8). Based on these findings, equivalence between these two groups was confirmed, as their pre-participation average daily consumption is close enough to warrant their comparability.

Table 7-8. HEM Program Pre-Participation Average Daily Consumption, Cohort 1 Treatment vs. Control

Treatment (Pre-Participation) Consumption	Control (Pre-Participation) Consumption
27.7	27.4

The evaluation team also examined the pre-participation average daily energy consumption of Cohort 2 treatment customers and found it comparable to the ADC of both Cohort 1 treatment and control customers. Details of this comparison are provided in Section 9.8 for the HEM program evaluation.

7.2.5 Consumption Analysis

The impact analysis relies on a statistical analysis of the billing data of HEM program customers in both the treatment and control groups in Cohort 1. As noted earlier, the evaluation could not include customers from Cohort 2 due to insufficient post-period usage data for the analysis. The savings from this analysis are, however, applied to treatment customers in both Cohorts 1 and 2 for the 2018 program year.

The evaluation team used an ITT approach, and in implementing this approach we estimated savings using a difference-in-differences model. The difference-in-differences refers to the model's implicit comparison of consumption before and after treatment of both treatment and control group customers (as shown in Table 7-9). The model includes customer-specific intercepts (i.e., fixed effects) to capture unobserved differences between customers that do not change over time and affect customers' energy use.

Table 7-9. Difference-in-Differences Estimator

	Pre-Participation	Post-Participation	Difference
Treatment (t)	Y_{0t}	Y_{1t}	$Y_{1t} - Y_{0t}$
Control (c)	Y_{0c}	Y_{1c}	$Y_{1c} - Y_{0c}$
T-C Difference	$Y_{0t} - Y_{0c}$	$Y_{1t} - Y_{1c}$	$(Y_{1t} - Y_{0t}) - (Y_{1c} - Y_{0c})$

Note: Y_0 = pre-participation usage; Y_1 = post-participation usage.

After testing various model specifications, the evaluation team used a lagged dependent variable (LDV) model that takes full advantage of the experimental design of the HEM program. This had the best model diagnostics including the highest adjusted R^2 and lowest Akaike Information Criterion (AIC) score. The LDV model is based on a comparison of the post-period only between treatment and control groups but adds variables that control for differences in pre-period usage characteristics. The purpose of the pre-period variables is to improve precision and increase model fit. Full details of the different model specifications and estimated coefficients is presented in Section 9.8 for the HEM program evaluation.

Table 7-10 provides the cohort-specific and total unadjusted, evaluated net energy savings per household; the program savings for 2018; and program savings as a percentage reduction of baseline ADC. Because the analysis uses an ITT approach, we estimated program savings and applied them to treatment customers in Cohorts 1 and 2 for all of 2018, even though Cohort 2 treatment customers received reports starting at the end of August 2018. As a result, this report claims annualized energy savings for the HEM program for Cohort 2 treatment customers, which essentially shifts their HEM program savings back by eight months. Notably, the HEM program will be truncated by eight months for this subset of customers should PSEG Long Island eventually stop offering the program to these cohorts.

Table 7-10. 2018 HEM Unadjusted Per-Household Net Energy Savings

Cohort	Number of Customers Treated in 2018[a]	Unadjusted Net Savings (% per household)	Unadjusted Net Energy Savings (kWh)(per household)[b]	Unadjusted Net Program Savings (MWh)[c]
Cohort 1	331,433	1.06%	113.6	37,661
Cohort 2	158,714	1.06%	115.3	18,301
Total	**490,147**	**1.06%**	**114.2**	**55,962**

[a] Refers to the number of customers whom PSEG LI selected to provide HERs and who received at least one monthly bill.
[b] Refers to the per-household, per-day savings multiplied by the average number of days that the participating households were in the HEM program in 2018.
[c] Prorated for participants whose accounts closed during 2018.

Confidence intervals and significance testing are usually provided when evaluating a sample from the participant population. However, this evaluation covers the entire participant population. Consequently, we do not provide confidence intervals, because any savings achieved through the program reflect actual population savings and do not require significance testing.

7.2.6 Joint Savings Analysis

The evaluation team conducted a joint savings analysis to answer the following research questions:

- Does the program treatment have an incremental effect on participation (i.e., "participation uplift") in other residential energy efficiency programs offered by PSEG Long Island?
- What portion of savings from the program treatment is double counted by other residential energy efficiency programs offered by PSEG Long Island?

The savings tips provided in the HERs could lead to additional participation in PSEG Long Island efficiency programs. If HER messaging is effective, the evaluation team would expect to see an uplift in participation in other PSEG Long Island residential energy efficiency programs among HEM treatment participants or a higher rate of participation among the treatment group compared to the control. Increased participation in other PSEG Long Island energy efficiency programs by the treatment participants would mean that some portion of savings from other programs may be counted by both the HEM program (through the consumption analysis savings estimate) and other energy efficiency programs (through deemed savings in their tracking databases or in their impact evaluations). As such, the team conducted a participation uplift analysis to calculate increased participation in PSEG Long Island's other residential energy efficiency programs due to the HEM program.

Additionally, to ensure that we do not double count savings across programs, the evaluation team calculated a savings adjustment to remove savings captured in the HEM program consumption analysis that are claimed by other programs. Applying this savings adjustment to the result of the HEM program consumption analysis produced adjusted evaluated net savings. Table 7-11 shows that based on the uplift analysis, there is a difference in participation of treatment and control customers and hence some participation uplift. As a result, the adjusted evaluated net savings are slightly less than the unadjusted evaluated net savings of the HEM program for the 2018 program year.

Table 7-11. 2018 HEM Program Savings Uplift Results

Unadjusted Evaluated Net Savings (MWh)	2018 Savings Uplift (MWh)	Percentage	Adjusted Evaluated Net Savings (MWh)
55,962	300	0.54%	55,662

7.2.7 Reasons for Differences in Impacts

Table 7-5 presented a 116% realization rate of the adjusted evaluated net savings (55,662 MWh) to the claimed ex ante net savings (47,810 MWh) for the 2018 HEM program. Despite higher absolute adjusted evaluated net savings, the evaluation team noted that the per-household percentage reduction in energy use is lower for the verified evaluated case (1.06%) than it is for the claimed ex ante case (1.5%). This difference stems from the assumed baseline ADC for the claimed ex ante case and the evaluated baseline ADC calculated from the participant bills.

The claimed ex ante net savings value of 47,810 MWh for the program is based on the deemed savings value of 0.25% per report using an average annual energy consumption of 10,060 kWh per household multiplied by the number of reports claimed by PSEG Long Island (1,901,042). This assumed value of 10,060 kWh energy consumption per year yields an ADC value of 27.6 kWh (10,060 divided by 365 days in a year).

Based on the consumption analysis and joint savings analysis, the evaluation team estimated an adjusted net energy savings of 55,662 MWh and an ADC value of 30.3 kWh (see Table 7-12). Based on this ADC, the percentage savings per household is 1.06%.[45]

Table 7-12. 2018 HEM Program Comparison of Ex Ante and Adjusted Evaluated Metrics

Metric	Claimed Ex Ante	Adjusted Evaluated
Baseline ADC (kWh)	27.6[a]	30.3
% Savings per Household	1.5%	1.06%
Total Savings (MWh)	47,810	55,662

[a] PSEG Long Island assumed average annual energy consumption divided by 365 days.

7.3 Conclusions and Recommendations

Based on the results of this evaluation, the evaluation team offers the following key findings and recommendations for the HEM program moving forward:

- Key Finding #1: The consumption analysis shows that the program reduced energy consumption among participants. Consumption analysis results indicate a net reduction of 55,662 MWh in 2018. Program participants achieved an average of 114.2 kWh savings per household, or 1.06% of usage. This is lower than the program planning deemed value of 1.5%. However, as is typical for such programs, the evaluation team anticipates a likely increase in savings as a percent of usage as the program matures and participants' energy-saving behaviors become habitual.
- Key Finding #2: The higher evaluated savings compared to ex ante savings stems from a higher actual ADC of 30.27 kWh compared to the assumed value used in the ex ante case of 27.6 kWh.
    - Recommendation: The consumption analysis conducted by the evaluation team provides actual annual energy consumption for the HEM program participants. The evaluation team recommends revising the assumptions used to estimate HEM program ex ante savings to a value closer to the 30.27 kWh determined through this evaluation.
- Key Finding #3: The joint savings analysis shows that there is some participation uplift.
    - Recommendation: PSEG Long Island should continue to cross-promote residential energy efficiency programs as they have an influence on customers treated by the program.

[45] Note that the percentage savings in energy usage appears the same for the unadjusted and adjusted evaluated net savings, but they are not identical. The percentage savings is 1.062% for the unadjusted evaluated net savings and 1.056% for the adjusted evaluated net savings.

8. Solar Photovoltaic Program

8.1 Solar Photovoltaic Program Description

In 2018, PSEG Long Island continued to offer rebates and financing to residential and non-residential customers to promote the installation of solar photovoltaic (PV) systems. These rebates served to encourage customer-sited electric generation, helping customers gain more control over their electric bills, and reduce their carbon footprint while also offsetting PSEG Long Island's energy and capacity requirements. Since August 2014, PSEG Long Island has facilitated the NYSERDA-funded NY-Sun Residential and Small Commercial initiative for Long Island customers. The NY-Sun program uses a MW block structure that allots successive tiers of incentive rates so that early adopters receive the highest rebates. Rebates can be offered for residential projects as large as 25 kW and for commercial projects of up to 750 kW. The final block of funding for Long Island residential rebates was fully allocated in April 2016, meaning no new residential rebate applications were accepted in 2018.[46] However, the program continued to accept applications for solar PV installations through the On-Bill Recovery Financing Program offered by Green Jobs – Green New York throughout 2018. NY-Sun funding for non-residential installations is still available.

8.1.1 Program Participation and Performance

PSEG Long Island's Solar PV program performed very well in 2018, with its verified ex ante savings reaching 147% of the energy savings goal and 147% of the peak demand goal. Table 8-1 presents 2018 Solar PV program performance compared to goals.

Table 8-1. 2018 Solar PV Program Verified Ex Ante Net Program Performance Against Goals

Metric	MWh	MW
Goal	9,948	4.0
Verified Ex Ante Net Savings	14,663	6.0
% of Goal	147%	147%

Note: Totals may not sum due to rounding.

In 2018, PSEG Long Island provided rebates or financing for 486 solar PV systems, amounting to just 32% of the number of projects completed in 2017, and just 7% of those completed in 2016. The proportion of leased systems fell significantly in 2018, both in absolute and relative terms, and now represents the smallest proportion of total program installations since leased systems were first allowed on Long Island in 2013. Program administrators expect this reversion of the Long Island PV market back to a mostly purchase-oriented market to spur competition and innovation in the solar financing market. Figure 8-1 illustrates changes in participation over the past seven years broken out by payment method.

[46] A small number of Affordable Solar incentives were processed in 2018, which are available for residential income-qualified customers on systems up to 6 kW.

Figure 8-1. PV Systems Installed per Year by Purchase Type (2012–2018)

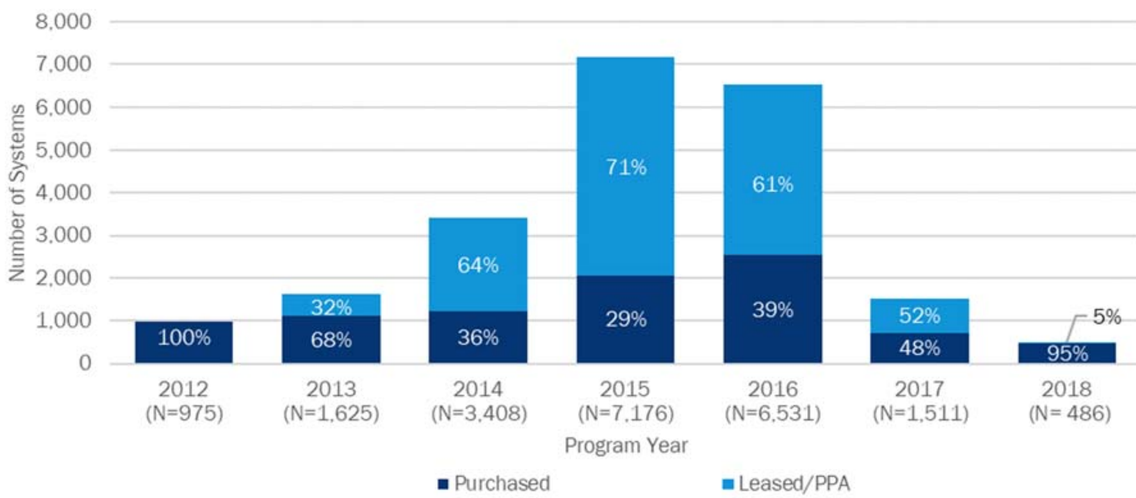
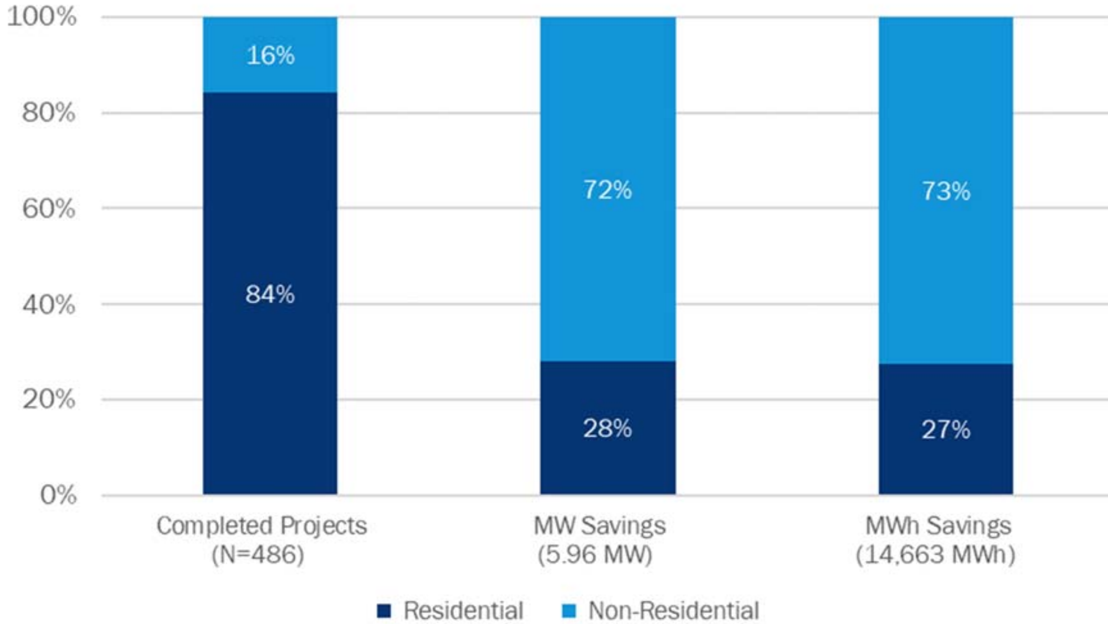


Figure 8-2 provides the 2018 completed projects and savings broken out by residential and non-residential sectors. Residential systems accounted for 84% of all installed systems in 2018, down slightly from 94% of installations in 2017. However, while non-residential projects accounted for only 16% of projects in 2018, they accounted for just under three-quarters of installed capacity and expected generation (i.e., demand and energy savings). By comparison, in 2017, non-residential installations accounted for 6% of installations and 50% of MW and MWh savings.

Although the program experienced a notable shift toward non-residential system installations as the residential incentive blocks ran out, program administrators contend that switching from the net metering compensation model to a Value of Distributed Energy Resources (VDER) model for non-residential systems tempered this trend. The VDER compensation model, which was applied to all new demand-metered projects submitted after May 1, 2018, takes into account the temporal and locational value of electricity sold to the grid. Program administrators estimate that the "all-in" value of compensation for most commercial customers under the VDER is roughly two-thirds of what they would have received under a net metering model.[47] As a result, the program experienced a rush of applications before the shift to the VDER model and saw the number of commercial systems interconnected in the second half of the year decrease dramatically.

[47] According to NYSERDA, compensation under VDER will vary by project, but "in many cases, compensation will be lower under the value stack than under [net metering]." (https://www.nyserda.ny.gov/-/media/NYSun/files/VDER-Frequently-Asked-Questions.pdf)

Figure 8-2. 2018 Solar PV Projects and Associated Savings by Sector



Despite the steep decline in the number of completed projects in 2018, program administrators anticipated this reduction, and lowered the program's 2018 goals substantially in comparison to 2017. Still, the program far exceeded expectations, achieving nearly a 50% increase over its energy and demand savings goals. According to program administrators, one reason for the higher-than-expected savings is the healthy solar market on Long Island, which continues to exhibit a high demand for solar PV and supports a robust supply chain and delivery infrastructure. Program administrators note that PSEG Long Island receives approximately 500 applications per month for solar interconnection, indicating the healthy demand for solar PV systems even without incentives or financing from PSEG Long Island.

8.1.2 Anticipated Changes in 2019

Under the Utility 2.0 process, PSEG Long Island expects to begin promoting energy storage in 2019, using the existing Dynamic Load Management tariffs as the implementation mechanism. Program administrators expect to offer energy storage with and without associated solar PV or other distributed energy resources, although program administrators stated that the structure of the solar PV investment tax credit strongly encourages installation of solar PV along with associated energy storage. Residential energy storage is expected to be offered only in conjunction with a new solar PV installation while non-residential energy storage is expected to be offered with or without an associated solar PV installation.

8.2 Solar Photovoltaic Program Impacts

8.2.1 Evaluated Impacts

For the 2018 evaluation, the evaluation team completed a desk review of PSEG Long Island's solar PV tracking data to arrive at evaluated net savings. The evaluated net savings resulted in slightly lower energy and demand savings (by 7% and 4%, respectively). Table 8-2 provides a program-level comparison of evaluated net savings to ex ante savings by measure category.

Table 8-2. 2018 Solar PV Evaluated Net Impacts

Category	N	Ex Ante Net Savings		Evaluated Net Savings		Realization Rate	
		kWh	kW	kWh	kW	kWh	kW
Commercial Solar Installs	77	10,661,486	4,294	9,784,153	4,136	92%	96%
Residential Solar Installs	409	4,001,552	1,666	3,811,308	1,611	95%	97%
Total	486	14,663,038	5,960	13,595,461	5,747	93%	96%

Similar to the previous evaluation of the Solar PV program, the evaluation team independently verified the accuracy of program estimated performance test conditions (PTCs) output. Sufficiently granular data were available for all 486 projects; therefore, the evaluation team independently calculated the PTC estimates using inverter efficiencies, panel quantities, and PTC ratings per panel for all projects. This verification showed only a slight difference between the program's tracked PTC outputs and the evaluation team's calculations. Therefore, the evaluation team was comfortable using the program's PTC estimates for all 2018 installations to determine evaluated savings for projects completed in 2018.

Reasons for Differences in Impacts

The evaluated and ex post demand savings differed from ex ante savings for two reasons. First, the evaluation team applied an average rated DC demand to actual AC demand 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 0.891 used for ex ante savings estimates. Additionally, the evaluation team applied an averaged rated DC demand to actual AC energy factor of 1,071, again based on the performance of 124 solar PV projects in 2012. The evaluated savings are lower as a result because ex ante calculations assumed a DC demand to AC energy factor of 1,234. The program did not provide the evaluation team with the source of this assumption.

8.2.2 Ex Post Net Impacts for Cost-Effectiveness

Based on research conducted in 2012 to assess the NTGR for this program, we found that the program had substantially influenced the market for solar PV on Long Island, and the evaluated NTGR was set to 1.0 (equal to the program planning value).[48] Table 8-3 shows the savings by program for the cost-effectiveness calculations. Because the NTGRs for both the evaluated and ex post savings are the same value, this table is identical to Table 8-2 above, as are the reasons for the differences in impacts.

Table 8-3. 2018 Solar PV Ex Post Net Impacts for Cost-Effectiveness

Category	N	Ex Ante Net Savings		Ex Post Net Savings		Realization Rate	
		kWh	kW	kWh	kW	kWh	kW
Commercial Solar Installs	77	10,661,486	4,294	9,784,153	4,136	92%	96%
Residential Solar Installs	409	4,001,552	1,666	3,811,308	1,611	95%	97%
Total	486	14,663,038	5,960	13,595,461	5,747	93%	96%

[48] 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.

8.3 Conclusions and Recommendations

The evaluation team offers the following key findings and recommendations for the Solar PV program moving forward:

- Key Finding #1: Planning and evaluation assumptions are based on limited production data from a relatively small number of systems. Since the 2013 evaluation, both planning and evaluation savings calculations have used key input assumptions based on interval data from 124 solar PV installations on Long Island in 2012.
  - Recommendation: Beginning in 2019, we recommend updating solar PV parameter assumptions to reflect the results of the Solar PV Output Study conducted by Opinion Dynamics in 2018. In this study, based on 295 systems, Opinion Dynamics employed a mix of qualitative and quantitative research activities to understand the output of solar PV systems installed on Long Island. We will include the specific parameters from this study in the next version of the 2019 PSEG Long Island TRM.

9. Detailed Methods

9.1 Overview of Data Collection

Our 2018 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 2018 was limited mainly to in-depth interviews with program and implementation staff to provide context for our impact evaluation and to assess program processes. The evaluation team also conducted some secondary research to support limited process evaluations for several of the energy efficiency programs.

9.2 Overview of Analytical Methods

Table 9-1 provides an overview of the main analytical methods used in the evaluation of each of the PSEG Long Island programs in 2018. 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. Engineering Analyses by Program Component

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

9.3 Commercial Efficiency Program

We performed two specific data collection activities within the CEP:

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

Below we describe each effort in greater detail.

9.3.1 Program Staff Interviews

As part of the 2018 CEP evaluation, we conducted in-depth interviews in January 2019 with five 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 2018 and planned in 2019, to gather program staff perspectives on program performance and effectiveness of processes, and to understand any challenges that the program experienced in 2018.

9.3.2 Engineering Analysis

The evaluation team performed two types of engineering analysis: a review of LM Captures program tracking data and calculation of savings using engineering algorithms, and a review of a sample of projects and calculation of savings using detailed information from each sampled project (Table 9-2). We conducted engineering desk reviews of a sample of 42 projects across three program components.[49] In addition, we performed detailed desk reviews for four CHP projects. We did not perform desk reviews for custom projects because the small percentage of energy savings attributed to custom projects did not warrant desk reviews for 2018. Instead, we relied on the realization rates determined through on-site M&V work completed as part of the 2012 evaluation. The evaluation team performed desk reviews for refrigeration measures only within the standard program component. We performed a database review for the remaining measure types (compressed air, building envelope, and motors and VFDs) within the standard program component.

Table 9-2. 2018 CEP Engineering Analysis by Program Component

Program Component	Database Review	Desk Review	On-Site M&V
Comprehensive Lighting		X	
Fast Track Lighting	X		
Custom (non-lighting)			X (2012)
Standard	X	X	
Exterior Lighting	X		
Custom (CHP)		X	X (2017)
HVAC	X		
Custom (lighting)			X (2012)
Other Program Components [a]	X	X	

[a] Includes savings from Building Operator Trainings, Online Marketplace, and legacy Prescriptive Lighting installations.

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.[50] We can calculate 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 samples 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.

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

[50] 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., non-response bias in surveys).

We used a stratified random sample and simple random sample to draw samples for the Comprehensive Lighting and Standard (refrigeration only) projects, respectively. For the CHP and Prescriptive Lighting desk reviews, we reviewed a census of the available projects due to the small population size.

We employed a stratified random sample to draw the sample for the Comprehensive Lighting projects to increase the efficiency of our sample and the precision of our results by oversampling the projects with the largest contribution to portfolio energy savings. 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 units, f(y), is calculated. Next, the square root of f(y), $\sqrt{f(y)}$, is calculated and the cumulative of $\sqrt{f(y)}$ is formed. The total of cumulative $\sqrt{f(y)}$ is then divided by the number of desired strata to determine the division points on the cumulative $\sqrt{f(y)}$ scale.

The above rule assumes equal widths, d, for the class intervals, and it must be modified when the class intervals have variable widths d. The approach recommended by Kish[51] 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.[52]

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

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 strata that is larger than the corresponding Nh. This problem can arise in the plan for the verification of rebate program savings since the overall sampling

[51] Kish, L. (1995). *Survey Sampling.* Wiley Classics Library Edition.
[52] Cochran, W. G. (1977). *Sampling Techniques.* Hoboken: John Wiley & Sons, Inc.

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

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

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 the equation is revised as follows:

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

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

Engineering Review Sample Design

Table 9-3 shows the sample designs for Comprehensive Lighting, Standard (refrigeration projects only), Prescriptive Lighting,[53] and CHP projects. As can be seen in the table, we drew either a simple random, stratified random sample, or completed a census review for each program component. We relied on the simple random sample approach in cases with high homogeneity in project sizes and savings. In those cases, stratified random sampling does not help improve the efficiency of the 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. In 2018 only four prescriptive lighting legacy projects and four CHP projects were completed. As a result, the evaluation team completed desk reviews for all (census) projects for those program components.

Table 9-3. 2018 CEP Desk Review Sample Design by Program Component

Program Component	Sample Design	Total Ex Ante Savings (kWh)	Projects in Population	Projects in Sample
Comprehensive Lighting	Stratified Random	57,069,849	842	25
Standard [a]	Simple Random	3,916,930	42	13
Other Program Components [b]	Census	398,724	4	4
Combined Heat and Power	Census	4,375,197	4	4
Total		65,760,699	892	46

Note: Totals may not sum due to rounding.

[a] Refrigeration projects only.

[b] Desk reviews for legacy prescriptive lighting projects only.

Table 9-4 provides the strata boundaries for the Comprehensive Lighting program component.

Table 9-4. 2018 CEP Comprehensive Lighting Strata Boundaries

Stratum	Boundaries (kWh)	Total Ex Ante Savings (kWh)	Projects in Population	Projects in Sample
1	0.0 – <55,000	10,332,174	564	7

[53] Prescriptive lighting legacy projects fall under the broader “Other Program Components” category in report tables.

Stratum	Boundaries (kWh)	Total Ex Ante Savings (kWh)	Projects in Population	Projects in Sample
2	>=70,000 – <200,000	21,556,682	211	7
3	>=200,000 – <1,000,000	24,407,098	67	11
Total		56,295,954	842	25

For each desk review, the evaluation team:

- 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, CFs, and NTGRs 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, the team used the ratio adjustment method[54] to extrapolate results for the sampled sites back to the overall 2018 component population. The sampling and results calculation approach we took varied by program component. For Standard projects, we did simple random sampling and used a method for calculating estimates, ratios, standard errors, confidence intervals, and precisions appropriate to that sampling approach. For Comprehensive Lighting projects, the team used a stratified random sampling approach and calculated ratios and associated statistics using a stratified ratio estimator-combined method. Below, the team describes the ratio-simple random sampling method first, followed by the stratified ratio-combined method.

$$r = \frac{y}{x}$$

Where:

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

y = sample ex post mean

x = sample ex ante mean

The standard error of the ratio estimate is given by:

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

Where:

54 Levy, P.S. & S. Lemeshow. (2008). *Sampling of Populations: Methods and Applications* (4th Ed). Wiley: Hoboken, New Jersey.

N = Population of Participants

n = Sample of Participants

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

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

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

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

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

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

Where:

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

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

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

The variance of the ratio is given by:

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

N_h = Number of participants in population of stratum h

n_h = Number of participants in sample of stratum h

$\bar{y}_h$ = Estimated ex post sample mean in stratum h

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

And

$$\sigma_{hz}^2 = \sigma_{hy}^2 + R^2\sigma_{hx}^2 - 2R\rho_{hxy}\sigma_{hy}\sigma_{hx}$$

Where:

R = Ratio or realization rate

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

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

$\hat{\rho}_{hxy} =$ Estimated correlation between X and Y in stratum h

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

9.4 Energy Efficient Products Program

The evaluation team conducted an in-depth interview with the EEP program manager, reviewed program materials, and reviewed program tracking data for the 2018 EEP program evaluation.

9.5 Cool Homes Program

The evaluation team conducted an in-depth interview with the Cool Homes program manager, reviewed program materials, and reviewed program tracking data for the 2018 Cool Homes program evaluation.

9.6 Consumption Analysis Methods for the REAP Program

This section presents the methods the Opinion Dynamics evaluation team used in conducting the consumption analysis supporting the REAP program impact evaluation. As described in Section 5, we based our 2018 savings estimates on the 2017 REAP participants and used the pre-participation period of the 2018 participants as a comparison group.

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

Preparing and Cleaning the Data

PSEG Long Island provided participation and measure data for all customers who participated in the REAP program in 2017 and 2018. PSEG Long Island also provided a consumption history going back 60 months from November 2014 to December 2018 for both 2017 and 2018 program participants. Prior to carrying out the statistical modeling, we matched, cleaned, and conducted quality assurance for all data. We used the same data-cleaning procedures for both 2017 and 2018 participants.

Cleaning Participant Data

The evaluation team used the customer account numbers associated with each site identifier from the program tracking database as the source of the participants to be analyzed. Program tracking records provided in January 2019 included complete 2017 and 2018 participant data.

The evaluation team's cleaning procedures were consistent with those employed in prior years' evaluations. First, we checked to make sure that all accounts had measure data. In the combined 2017–2018 REAP program tracking data, we found two project adjustment measures listed without account numbers, one in 2017 and one in 2018. These two records were dropped from the consumption analysis. We also dropped 209 accounts from the tracking data because their projects began earlier than 2017. For purposes of the consumption analysis, projects were assigned to a year based on their start date. Furthermore, we kept only accounts with electric measure (kWh) savings. We also checked for records with missing savings or zero quantities in the participant tracking data. One account had a measure listed as installed with zero savings and zero quantity.

The evaluation team's analysis plan called for estimating savings on participants who did not participate in other programs during the evaluated year, with the intent to apply those per-participant average daily savings estimates to those dropped from this analysis. 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 (2016), HPDI (2016–2018), HPwES (2016–2018), and Cool Homes (2016–2018). We identified 187 cross-participation accounts and removed them from the analysis (101 in the treatment group and 86 in the comparison group).

After cleaning the measure data, we calculated annual expected savings for each participant based on the sum of gross deemed energy 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 REAP program tracks participation with PSEG Long Island customer account numbers. Therefore, we were able to use the customer account numbers provided with the participant data to match billing histories to program participants.

Cleaning Billing Data

We merged 2017 and 2018 participants' billing data and then took a two-step approach to cleaning the data. This approach is consistent with the approach used in previous evaluations of the program. First, we removed individual billing periods (i.e., meter reads that were duplicative, cancelled, or had 0 billing days). Second, we cleaned the data for customer accounts with anomalous or insufficient data for consumption analysis. We describe each billing data cleaning sub-step below.

- **Cleaning of Individual Billing Periods:** 2,138 total bill records were removed due to a billing period lasting less than one week or longer than 90 days, as well as those billing periods with 0 kWh of energy usage. The removal of these billing records did not result in the removal of whole accounts. We did not include billing periods occurring after a 2018 participant's first installation date, as the 2018 participants served as the comparison group.
- **Extremely High or Low Average Daily Consumption:** We checked for customers with entire pre- or post-participation periods having very high (more than 300 kWh daily) or very low average usage (less than 2 kWh daily) on average. We dropped two households due to low usage (one from the treatment group and one from the comparison group) and dropped one household from the treatment group due to very high usage. These households are likely to contain odd usage patterns that we cannot easily control statistically and that 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, nine months (or the 270-day equivalent) before the first day of program participation for both the 2017 and 2018 program participants, and nine months (or the 270-day equivalent) after participation for 2017 participants. We dropped 37 treatment customers and no comparison customers based on the post-participation period criterion, and 232 treatment group and 273 comparison customers based on insufficient pre-participation period bills.

- **Inadequate Billing History in the Cooling Season before and after Program Participation:** We also required participants to have a minimum billing history of 60 days in the summer (cooling season), both before and after participation. This is because we expected the measure installations to be generally weather sensitive, especially during the summer where electric usage is higher. By ensuring sufficient billing data in the months of June, July, and August, we were able to provide more rigorous savings estimates. We dropped six treatment customers but no comparison customers based on the summer period criterion after participation, and 11 treatment group and two comparison customers based on insufficient summer bills before participation.

Table 9-5. Summary of Data Cleaning Results by Group

Reason for Drop	Treatment		Control	
	Total Accounts	Percent of Accounts	Total Accounts	Percent of Accounts
Total Unique Accounts	1,816	100.0%	1,673	100.0%
Billing Periods Longer Than 90 Days	-		-	
Accounts Remaining	1,816	100.0%	1,673	100.0%
Billing Periods Under a Week	-		-	
Accounts Remaining	1,816	100.0%	1,673	100.0%
No Usage	-		-	
Accounts Remaining	1,816	100.0%	1,673	100.0%
Usage Over 10,000 kWh	-		-	
Accounts Remaining	1,816	100.0%	1,673	100.0%
High Overall Average Usage (over 300kWh/day)	1		-	
Accounts Remaining	1,815	99.9%	1,673	100.0%
Low Overall Average Usage (under 2kWh/day)	1		1	
Accounts Remaining	1,814	99.9%	1,672	99.9%
Too Few Pre-Participation Period Summer Bills	11		2	
Accounts Remaining	1,803	99.3%	1,670	99.8%
Too Few Post-Participation Period Summer Bills	6		N/A	
Accounts Remaining	1,797	99.0%	1,670	99.8%
Too Few Post-Participation Period Bills (Less than 9)	37		-	
Accounts Remaining	1,760	96.9%	1,670	99.8%
Too Few Pre-Participation Period Bills (Less than 9)	232		273	
Accounts Remaining	1,528	84.1%	1,397	83.5%

In total, our final REAP program dataset includes 2,925 accounts. Approximately 84% of the total participant population was available for analysis after data preparation and cleaning.

Assigning Time Periods to Billing Data

PSEG Long Island provided the billing data in billing cycle format, which means that customers have different cycle lengths depending on their meter billing 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 15 and ended on July 20, we assigned that period to July). In cases where two shorter read periods occurred within the same month, we combined energy usage for both periods and recalculated average daily consumption for the combined period.

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 data from the weather station closest to each account's geographic location based on zip code. By using multiple sites, we increase the accuracy of the weather data that we apply to each account. We obtained these data from National Climatic Data Center (NCDC) of the National Oceanic and Atmospheric Administration (NOAA).

The weather data consist of hourly temperatures for each day. We calculated cooling degree days (CDDs) and heating degree days (HDDs) for each day (in the evaluated and historical periods) based on daily temperatures using a base temperature of 65°F for HDDs and 75°F for CDDs. We merged daily weather data into the billing dataset 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.

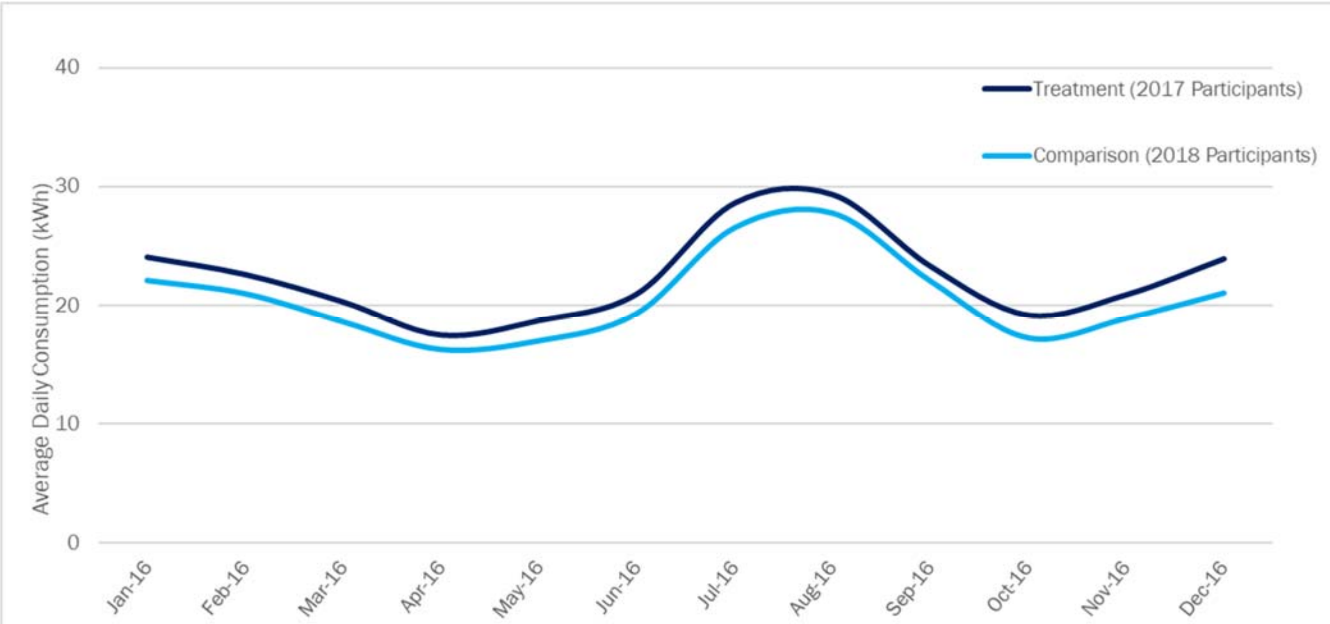
Some participants have multiple installation dates. The evaluation team set the post-participation period to start after the last bill date in the installation period. The evaluation team excluded months between their first participation date and last installation. For customers with a single date of participation, our team excluded only one billing month from the model as a "deadband." The treatment effect is the change in energy use that participating in the program causes, and as such cannot overlap with time before customers' participation in the program.

Assessing Comparison Group Equivalency

Before performing any modeling, the evaluation team assessed the comparability of our treatment and comparison groups. If the comparison group were not very similar to the treatment group on important variables, the comparison group could not act as an effective point of comparison for the treatment group. To assess the comparability of the groups, we determined the overall average baseline daily energy 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 when both were in a pre-treatment period—we used 2016 due to the need to exclude the year 2017 (as well as 2018) since the evaluated treatment group began their post-participation period sometime during 2017.

Graphing average energy consumption during the baseline period makes the similarities and differences between the groups visible. Figure 9-1 shows the ADC for January through December 2016 to determine how similar households in the two groups are in terms of energy consumption patterns prior to their participation in the program. We see some similarity in pre-participation usage patterns between the treatment and comparison groups, but the treatment group appears to consistently use slightly more energy than the comparison group.

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



The evaluation team completed t-tests for the differences between two independent means (for ADC) for 2015, 2016, and 2017 (including only pre-participation usage). The results of such tests confirmed what Figure 9-1 illustrates; the mean ADC between the two groups varies statistically significantly during the pre-period baseline. For 2016, a two-sample Wilcoxon rank-sum test produced a z-score of -6.593, indicating statistical significance at the 95% confidence level. Our assessment was that the groups were similar enough to warrant use of the comparison group in the analysis, but with statistical controls that model the observed differences. The differences between the groups are very consistent across time. This makes modeling the difference, and therefore controlling for it statistically, straightforward. The fixed-effects model deals adequately with differences among households that are consistent across time.

Figure 9-2 and Figure 9-3 demonstrate striking similarities in the weather patterns experienced by both groups over the course of the period covered by the consumption analysis. Thus, the groups likely occupy similar geographic areas and are affected by similar weather. The usage differences will therefore be due to individual household factors rather than locational differences.

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

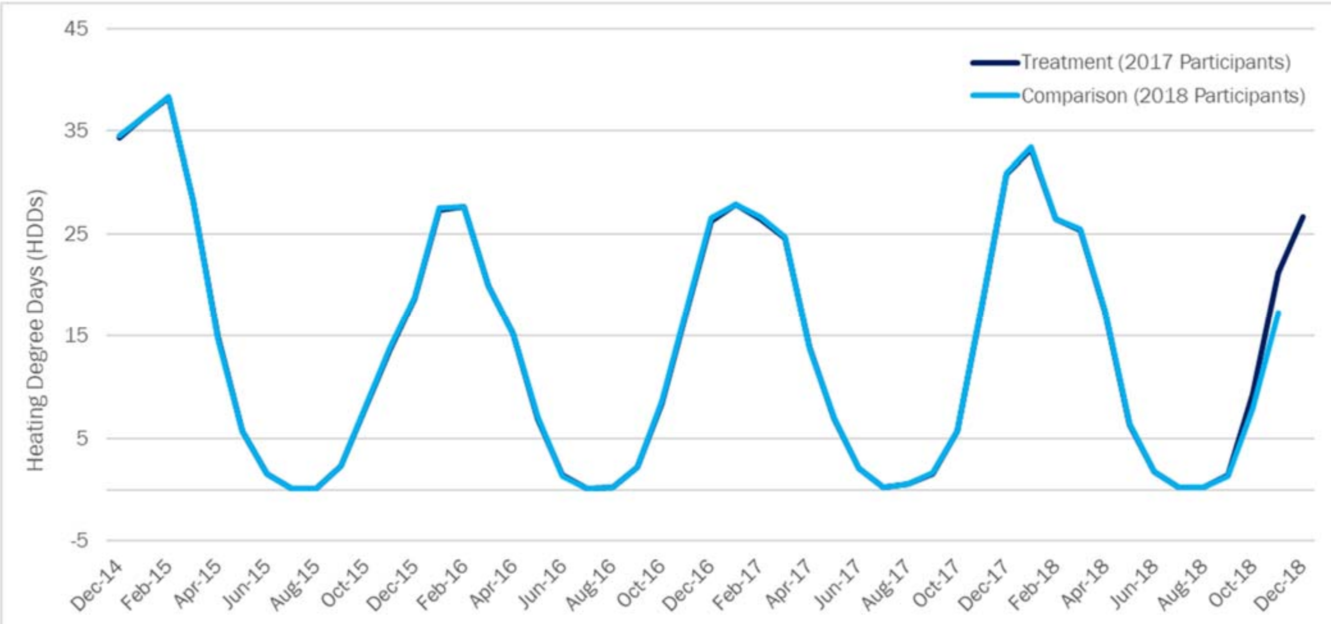
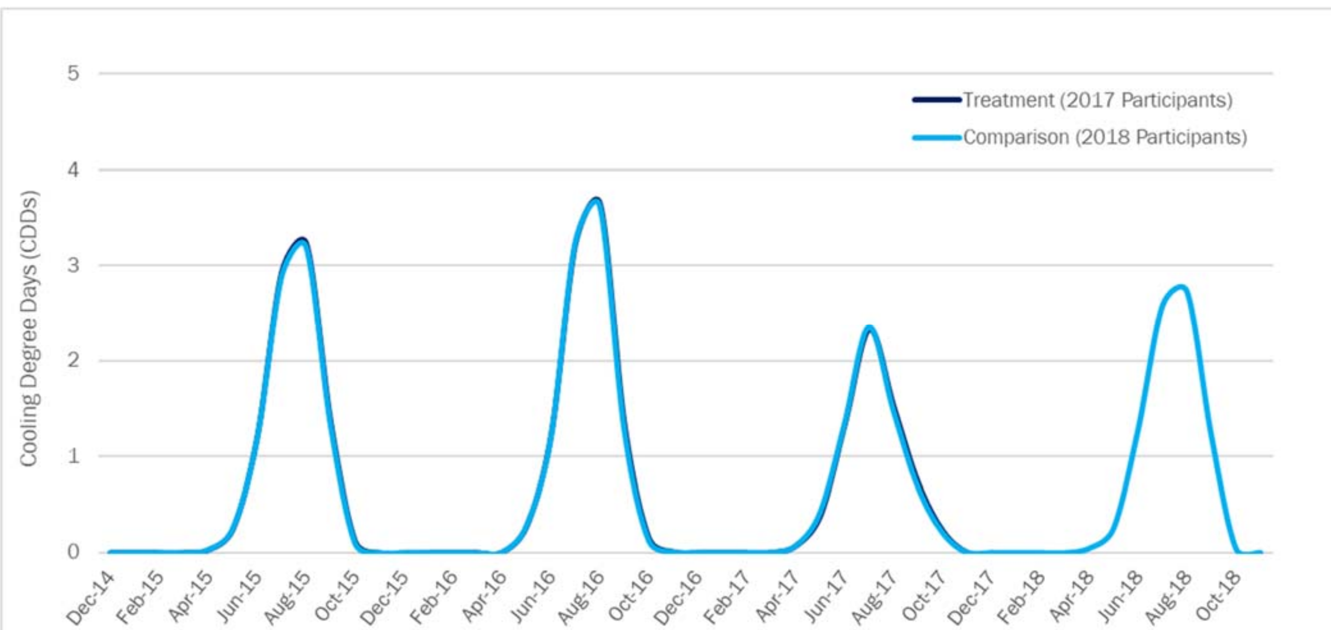


Figure 9-3. REAP Program Analysis: CDDs by Sample Group



In Table 9-6, we compare the treatment and comparison groups on the basis of the measures that program staff installed in customer homes during 2017 and 2018. The most important aspect of exploring equivalency is similarity in energy usage in the pre-treatment period. As detailed above, we found that the groups were comparable in energy usage. An additional, but perhaps somewhat less important, equivalency check can be completed here given the nature of the two groups. We can compare how each group was actually treated by the program in terms of the percentage of each group that received program measures. If the installed measures are roughly equivalent, it tells us that both groups had similar energy efficiency opportunities prior to their participation in the program. Therefore, this is a good indication that the comparison group (i.e., 2018 participants' pre-treatment usage) is a good proxy for what the treatment group's (i.e., 2017 program participants') energy use would have been absent the program.

As discussed earlier, we can see that the measure mix changes between 2017 and 2018, with the addition of exterior lighting, thermostatic valves, and power strips. While the measure mix changed between years, the overall levels of installed measures and their contribution to overall ex ante savings were similar between years. These changes resulted from the adjustment in the program measure mix and not from changes in the program participants from one year to the next or in the criteria or process used for recruiting or selecting program participants. The evaluation team is confident that the groups are comparable and that the per-household savings for 2017 are an accurate proxy for 2018 participants. This, in addition to our comparison of actual pre-participation energy use, bolsters our confidence that (1) 2018 participants' pre-participation usage is a useful comparison, and (2) related to this, that the savings determined from our analysis (derived from 2017 participants) is an accurate proxy for 2018 participants. The addition of deemed savings values for newly added measures increases our confidence in the representativeness of the evaluated savings.

Table 9-6. REAP Program Installations by Program Year for Consumption Analysis Groups

Measure Installed	Consumption Analysis Treatment Group (2017 Participants n=1,873)		Consumption Analysis Comparison Group (2018 Participants n=2,106)	
	Percentage with Measure	Percentage of Ex Ante Net kWh	Percentage with Measure	Percentage of Ex Ante Net kWh
Lighting	96.9%	71.0%	96.4%	65.9%
Interior Lighting	96.9%	71.0%	95.9%	62.8%
CFLs	2.9%	3.1%	0.0%	0.0%
LEDs	94.0%	68.0%	95.9%	62.8%
Exterior LED Lighting	N/A	N/A	21.1%	3.2%
Domestic Hot Water	11.4%	11.8%	17.2%	13.9%
Thermostatic Valves	N/A	N/A	9.2%	2.0%
Refrigerator	10.5%	8.8%	11.0%	3.5%
Dehumidifier	14.8%	3.5%	12.2%	2.7%
Window AC	34.5%	4.8%	27.8%	2.7%
Power Strips	N/A	N/A	97.7%	11.3%

Developing the Model

Opinion Dynamics' evaluation design includes a comparison group consisting of households that participated in 2018 to construct a point of comparison for the treatment group. We included weather variables in the form of HDDs and CDDs. We added indicator variables for each of the 12 calendar months, which provide information on seasonal trends not captured by the degree days variables. These variables affect both the comparison and treatment groups. We also entered interaction terms between weather and the post-participation period for the treatment group, to model the likelihood that efficient equipment tends to save more energy during more extreme weather.

In the development of the final model, we tested a series of progressively inclusive specifications. Some models tested included month-year fixed effects to control for the changes that occur for everyone over time, such as weather and economic factors, and others. The final model controlled only for seasonality by using a dummy variable for each of the 12 calendar months. This helps to model seasonal effects not perfectly captured by the degree days variables. Also, because there were differences in usage between the treatment and comparison groups in their common pre-participation period, average pre-participation usage was interacted with several variables related to time and weather. Finally, we tested interaction terms of the treatment variables with both CDDs and HDDs to model how participation effects change with weather, especially at the extremes. The team did not include measure variables, as there are not enough instances of each measure installed without others to capture the effects of any measure alone. The final model was selected based on a combination of measures of fit, model diagnostics, and inspection of the patterns of residuals.

The model that performed best by our tests and that we judged most reasonable given the measures of fit, diagnostics, and residual distributions was a one-way fixed-effects model with several weather terms and interactions. The following equation reflects that model:

Final REAP Program Model Equation

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

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

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

M = Month indicator for each month in the model

$PreADC$ = Pre-participation period ADC

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

ε_{it} = Error term for household i at time t

This model differs from the model used in the 2017 evaluation, particularly in the way that time variables are treated. In the prior year's evaluation, the set of month-year dummy variables functioned as an additional control on weather. For this evaluation period, the same set of dummy variables acted to capture influential negative savers (i.e., participants who greatly increased their energy use) and potentially remove their effects from the program. These participant usages and change values appeared to be real and could not justifiably be removed from program impacts. The evaluation team is careful with the use of these types of variables because they can cause estimates to be highly sample specific or volatile. When they make a difference in overall estimates of savings, they should be checked to see what the mechanism of influence is, and whether the effect is justified.

9.6.2 REAP Program Estimation of Savings Using Consumption Analysis

In this section, we present the methods used to translate the results of a consumption analysis to REAP program savings.

Preliminary Assessment of Potential Savings

Examining some basic facts of the participants, their usage, and the weather for the analysis period can help us see in what general range a program's savings are likely to fall. Thus, we show the pre- and post-period average daily energy consumption for the evaluated cohort, as well as the heating and cooling degree days for those periods in Table 9-7. We see that average usage went down from 22.114 to 21.47 kWh from pre- to post-participation periods. However, both heating and cooling degree days went down as well, meaning that the reduction in usage could be due to weather as well as to the program. The billing analysis will give us the program effect, net of the weather changes.

Table 9-7. REAP Program Analysis: Average Values of Key Variables by Time Period for 2017 Treatment Group

Variable	Statistic	Period	
		Pre-Participation	Post-Participation
Daily kWh	Mean	22.14	21.47
	SD	19.50	18.98
HDDs	Mean	13.67	12.65
	SD	11.89	11.78
CDDs	Mean	0.74	0.69
	SD	1.19	0.98

Note: SD = standard deviation.

Table 9-8 shows the final model results. The model is meant to show changes in electricity use after participation in the REAP program, controlling for weather and the household characteristics (reflected in the account or household constant term) in both the treatment and comparison groups. The program effects term (Treatment) is negative, indicating that program participants did reduce energy consumption in the post-participation period (after controlling for weather). Because customers who participated in other PSEG Long Island energy efficiency programs were not included in this analysis, we can be confident that this reduced energy consumption is attributable to participation in the REAP program.

Table 9-8. REAP Program Consumption Analysis: Final Model

Predictor	Coefficient	Robust Std. Err.	T	P > |t|	95% Confidence Interval	
					Lower	Upper
Treatment x Post	-1.1991	0.2876	-4.1696	<0.001	-1.7630	-0.6352
HDD	0.5976	0.2300	2.5984	<0.001	0.1466	1.0486
CDD	3.7479	0.4920	7.6181	<0.001	2.7833	4.7126
Post-Participation Period HDD	-0.0024	0.0186	-0.1276	0.8985	-0.0388	0.0341
Post-Participation Period CDD	0.1553	0.1193	1.3020	0.1930	-0.0786	0.3891
Constant	21.3941	1.3851	15.4456	<0.001	18.6781	24.1100

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 x post variable (0 or 1) by the actual mean heating and cooling degree days during the post-participation period. Table 9-9 shows the estimate of per-household savings based on these calculations.

Table 9-9. Adjusted Estimate of Daily REAP Program Savings

Savings Estimate (kWh)	Std. Err.	T	P > |t|	90% Confidence Interval	
				Lower	Upper
-1.1222	0.1746	-6.4264	<0.001	-1.4096	-0.8349

The value of the estimate represents the energy change in ADC given a one-unit change in the treatment status, i.e., treatment moving from 0 (pre-treatment and comparison group) to 1 (post-treatment for the treatment group). These results can also be expanded to estimate the decrease in electricity usage over all participants for the evaluation period. There is a 90% probability, or confidence, that overall program savings fall between 0.84 kWh and 1.41 kWh per day per participant.

Consumption Analysis Compared to Expected Savings

Table 9-10 compares the observed (evaluated) savings from the consumption analysis to the expected (ex ante) savings for REAP program participants based on PSEG Long Island's program planning estimates. The results of the comparisons are the associated realization rates, without line loss factors added. Evaluated participants in the REAP program saved an estimated 410 kWh per year. This compares to 950 kWh per year expected savings, for a realization rate of 43%. For application to the program evaluation, the realization rate is slightly higher because line loss factors are applied.

Table 9-10. Savings from the REAP Program Consumption Analysis Compared to Savings Expected from Program Planning Estimates

End-Use	N[a]	Observed Savings		Program Planning Savings [b]		Realization Rate
		Household Daily Savings	Household Annual Savings	Household Daily Savings	Household Annual Savings	
Overall Program	2,106	1.12	410	2.60	950	43%

[a] This is the number of unique accounts that completed a REAP project in 2018, including those dropped from the billing analysis for insufficient data.
[b] The line loss factor is not applied to the program planning savings.

9.7 Consumption Analysis Methods for the Home Performance Programs

PSEG Long Island runs two Home Performance programs that work in tandem, Home Performance Direct Installation and Home Performance with ENERGY STAR. Some customers that participate in the HPDI will go on to do more through the HPwES program. Thus, there are customers who participate in HPDI, HPwES, and both programs. Because the programs work in concert and there is crossover between the programs, it is useful to conduct a joint billing analysis with separate terms for each of three participation situations (HPDI, HPwES, Both) so that savings can be estimated and reported for each situation.

A second factor that defines the approach we took to cleaning and modeling is that we estimated savings through billing analysis on the 2017 program participants and used the 2018 participants' pre-participation bills as the comparison group for the 2017 participants. Then we applied the savings derived from this analysis to the 2018 participants. Therefore, data cleaning and preparation included the 2017 and 2018 participants. Further, since a substantial number of customers participated in both programs, some complexities involving the time between the two participations had to be taken into consideration in our analysis.

9.7.1 Data Cleaning and Model Development for Consumption Analyses of the Home Performance Programs

Preparing and Cleaning the Data

PSEG Long Island provided participation and measure data for all customers who participated in the Home Performance Direct Install and Home Performance with ENERGY STAR programs in 2017 and 2018. PSEG Long Island also provided a consumption history going back 60 months from December 2014 to December 2018 for both 2017 and 2018 program participants. Prior to carrying out the statistical modeling, we matched, cleaned, and provided quality assurance for all data. We based our savings estimates on the 2017 participants and used the pre-participation period of the 2018 participants as a comparison group. We used the same data-cleaning procedures for both 2017 and 2018 participants.

Cleaning Participant Data

The evaluation team used the customer account numbers associated with each site identifier from the program tracking database as the source of the participants to be analyzed. Program tracking records provided in January 2019 included complete 2017 and 2018 participant data with the exception of a small group of participants from early 2017. These participants were tracked in a legacy data system that did not contain their account number. Therefore, they could not be matched to billing records and were omitted from the analysis.

During the participant data cleaning process, we identified 94 participants in the treatment group and 125 participants in the comparison group with negative savings. We also identified 93 participants in the treatment group and 194 participants in the comparison group with zero savings. Participants with negative savings had measures installed that resulted in increased electric consumption due to fuel switching; for example, replacing an oil furnace with a heat pump. Because these participants will have increased energy consumption following their participation due to their fuel switching, they were flagged for omission from the consumption analysis. In addition, the team identified one project adjustment record and two projects with no installed measures that were dropped from the population of participants. We also dropped any accounts from the tracking data that had projects originating earlier than 2017. For purposes of the consumption analysis, projects were assigned to a year based on the start date of their project.

Our analysis plan called for estimating savings on participants who did not participate in other programs during the evaluated year, with the intent to apply those per-participant average daily savings estimates to those dropped from this analysis. As part of controlling for energy savings not influenced by the Home Performance programs or influenced by previous Home Performance program participation, we compiled a list of unique account numbers from HPDI (2016–2018), HPwES (2016–2018), REAP (2016–2018), EEP (2016–2018), HEM (2017–2018), Cool Homes (2016–2018), and Solar[55] (2016–2018). Table 9-11 indicates the drops for cross-participation.

Matching Participant Information with PSEG Long Island Account Information

The Home Performance programs track PSEG Long Island customer account information within the LM Captures system. As a result, we were able to use the customer account numbers provided with participant data to match billing histories to program participants, except for the small number of projects from early 2017 that contained no account numbers because they came from a legacy system.

Cleaning Billing Data

Our cleaning process started with 3,519 participant accounts, 1,832 from 2017 (the treatment group) and 1,687 from 2018 (the comparison group). Of those participants, 3,469 found matches in the billing data: 1,660 from the treatment group, and 1,809 from the comparison group. These matches included 71,952 billing records for the treatment group, and 61,300 for the comparison group (see Table 9-11 for a summary of all billing drops). Overall, the number of dropped records was modest; the biggest loss was from having insufficient data in the pre-period bills. The evaluation team dropped 145 accounts from the treatment group for this reason.

[55] We used PSEG Long Island's database of solar interconnections to flag cross-participation of solar-equipped households because all households installing solar PV systems are reported to PSEG Long Island at the time of interconnection. Most solar installations on Long Island have been through PSEG Long Island-administered programs, but not all. Therefore, interconnection data are more complete.

Table 9-11. Summary of Data Cleaning Results for Home Performance Billing Data

Reason for Drop	Treatment		Control		Total	
	Records	Accounts	Records	Accounts	Records	Accounts
Starting counts	-	1,687	-	1,832	-	3,519
Accounts finding billing data matches	-	27	-	23	-	50
# Remaining	71,952	1,660	61,300	1,809	133,252	3,469
% Remaining	0%	98%	0%	99%	0%	99%
Bills with negative kWh usage	-	-	-	-	-	-
# Remaining	71,952	1,660	61,300	1,809	133,252	3,469
% Remaining	100%	100%	100%	100%	100%	100%
Bills with zero kWh usage	201	1	209	-	410	1
# Remaining	71,751	1,659	61,091	1,809	132,842	3,468
% Remaining	100%	100%	100%	100%	100%	100%
Low average usage (under 2 kWh/day)	36	-	38	2	74	2
# Remaining	71,715	1,659	61,053	1,807	132,768	3,466
% Remaining	100%	100%	100%	100%	100%	100%
High average usage (over 300 kWh/day)	-	-	-	-	-	-
# Remaining	71,715	1,659	61,053	1,807	132,768	3,466
% Remaining	100%	100%	100%	100%	100%	100%
Less than 9 months post data for Treatment	1,133	31	-	-	1,133	31
# Remaining	70,582	1,628	61,053	1,807	131,635	3,435
% Remaining	98%	98%	100%	100%	99%	99%
Less than 9 months pre data for Treatment	3,204	145	-	-	3,204	145
# Remaining	67,378	1,483	61,053	1,807	128,431	3,290
% Remaining	94%	89%	100%	100%	96%	95%
Less than two summer months in post-period	-	-	-	-	-	-
# Remaining	67,378	1,483	61,053	1,807	128,431	3,290
% Remaining	94%	89%	100%	100%	96%	95%
Less than two summer months in pre-period	322	11	-	-	322	11
# Remaining	67,056	1,472	61,053	1,807	128,109	3,279
% Remaining	93%	89%	100%	100%	96%	95%
Less than two winter months in post-period	115	3	-	-	115	3
# Remaining	66,941	1,469	61,053	1,807	127,994	3,276
% Remaining	93%	88%	100%	100%	96%	94%
Less than two winter months in pre-period	134	5	-	-	134	5
# Remaining	66,807	1,464	61,053	1,807	127,860	3,271
% Remaining	93%	88%	100%	100%	96%	94%

Note: Totals may not sum due to rounding.

Because our evaluation plan called for determining savings for each program's participants based only on those who did not participate in other residential programs, and applying those savings estimates to all program participants, we also dropped a subset of accounts for purposes of creating an analysis dataset (see Table 9-12). For some participants there was a delay between the installation of their first measure and their last measure within the program. Bills were marked as part of the post-period when the billing period was completely after the first measure install date. In most cases, no bills were dropped from the analysis for being in the "deadband" of time between the install dates for first and last measures. This is because the deadbands were generally short for participants in this program. For 30% of the participants, this delay was 15 days or less. For another 47% of participants the delay was less than 45 days. The exception to this rule was for participants in both HPDI and HPwES. These participants often had a longer deadband period, so bill periods that were completely after the first measure install date and completely before the last measure install date were dropped from the analysis. This drop step affected four records and two accounts in the comparison group (see Table 9-12).

Table 9-12. Drops for Estimating Savings on Customers Not Cross-Participating

Reason for Drop	Treatment		Control		Total	
	Records	Accounts	Records	Accounts	Records	Accounts
Starting Point	66,807	1,464	61,053	1,807	127,860	3,271
Cool Homes	2,833	63	1,980	63	4,813	126
# Remaining	63,974	1,401	59,073	1,744	123,047	3,145
% Remaining	96%	96%	97%	97%	96%	96%
Energy Efficient Products	5,289	117	5,753	162	11,042	279
# Remaining	58,685	1,284	53,320	1,582	112,005	2,866
% Remaining	88%	88%	87%	88%	88%	88%
Residential Energy Affordability Partnership	3,483	78	3,453	105	6,936	183
# Remaining	55,202	1,206	49,867	1,477	105,069	2,683
% Remaining	83%	82%	82%	82%	82%	82%
Solar Photovoltaic Interconnection	4,042	89	2,745	76	6,787	165
# Remaining	51,160	1,117	47,122	1,401	98,282	2,518
% Remaining	77%	76%	77%	78%	77%	77%
Beneficial Electrification	1,774	40	3,070	85	4,844	125
# Remaining	49,386	1,077	44,052	1,316	93,438	2,393
% Remaining	74%	74%	72%	73%	73%	73%
Drop deadband months for participants in both HPDI and HPwES	728	-	4	2	732	2
# Remaining	48,658	1,077	44,048	1,314	92,706	2,391
% Remaining	73%	74%	72%	73%	73%	73%

Assigning Time Periods to Billing Data

Because billing cycles begin at varying times rather than the first of each month, usage information is assigned to the month in which the majority of billed usage days falls. If the majority of the days included in the bill fall in March, then March is assigned to that bill cycle. The Opinion Dynamics team calculated average daily usage for each billing cycle by dividing the billing period usage value by the number of days in the cycle.

The evaluation team also identified other time period issues, including overlapping billing periods and estimated bills. These two issues often occurred together, and the team corrected the problem by dropping the estimated bill record. The team checked that this was the best approach by inspecting the records to be sure every day was covered by the most appropriate bill.

Incorporating Weather Data

The evaluation team acquired daily weather data from the NOAA NCDC website and matched this information by zip code to all customers included in the consumption analysis. We checked the weather data for issues including missing days. When issues were identified they were usually fixed by choosing the next best weather station if there were too many missing values for the originally assigned station.

The team calculated HDDs and CDDs using a base of 65°F for HDDs and 75°F for CDDs. These weather variables were then appended to the consumption analysis file, according to the time periods covered by the analysis.

Conducting Preliminary Analyses

PSEG Long Island targeted homes with ESH for the HPDI program in both 2017 and 2018. It was reasonable to assume that all participants in the HPDI and the HPDI plus HPwES program conditions had ESH. However, it was not reasonable to assume that all HPwES-only participants had ESH. The Opinion Dynamics team used the load shapes of the participants in the dataset to determine which customers likely had ESH. We then tested each definition of ESH to see which better predicted usage, and the new calculated measure of ESH did a better job. Therefore, we used the ESH variable in the modeling. Because there was some difference in the proportion of participants having ESH between the years, it was essential to capture ESH in the model while estimating savings.

Next, the evaluation team examined the similarity of the treatment and comparison groups. Figure 9-4 shows the comparison of the treatment and comparison groups on usage over the pre-participation period. We compared on as many months as possible prior to 2017. We can see that there are differences, especially in the winter months, when the treatment group (2017 participants) tends to use more than the comparison group (2018 participants). This is at least partially explained by the fact that there is a higher proportion of 2017 participants that include HPDI participation, and correspondingly, a lower rate of HPwES-only participation. Sixty-two percent of the treatment group (2017 participants) were in the HPwES-only category compared to 80% of the comparison group (2018 participants).

Figure 9-4. Pre-Period Energy Use—All Participants

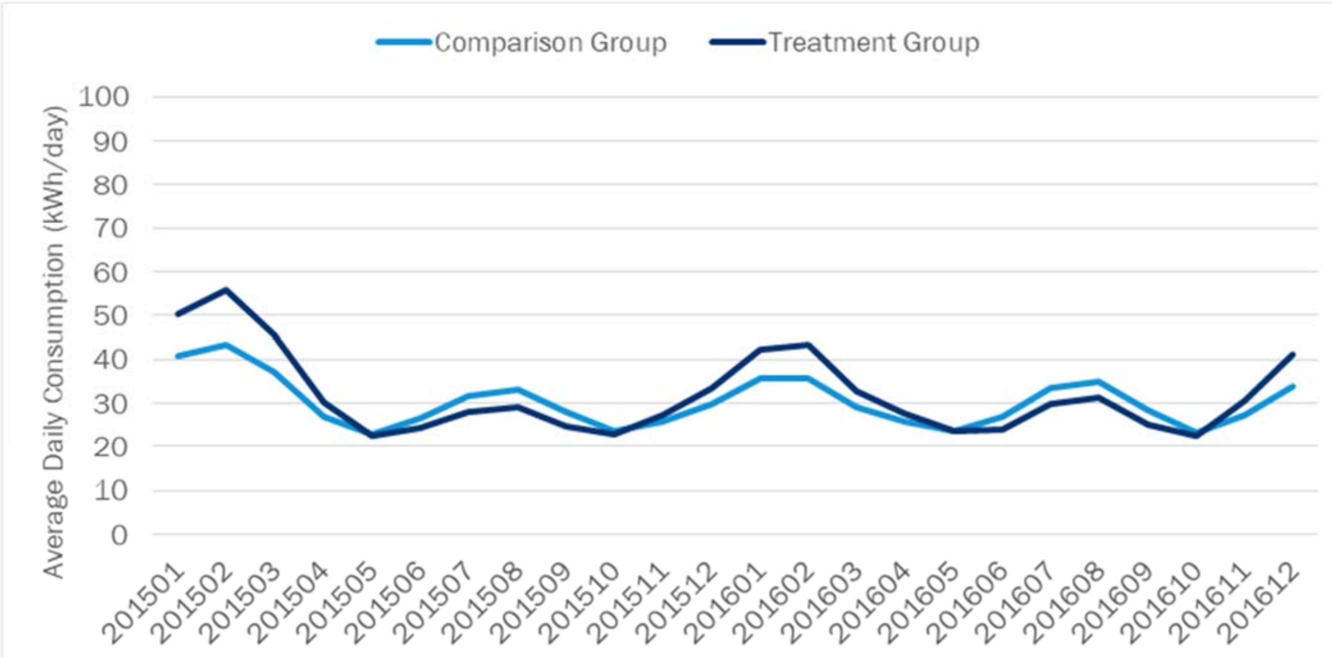


Figure 9-5 and Figure 9-6 show the comparison of pre-period energy usage for non-ESH and ESH customers, respectively. In Figure 9-6 we can see that differences in usage are minimal for the non-ESH participants. There are slight differences within the ESH participants, as shown in Figure 9-6, but the nature of the difference is different than for the participants overall. The comparison group (2018 participants) with ESH is slightly and consistently higher in usage than the treatment group (2017 participants). Since the difference is similar across the period, it indicates something consistently different about the 2018 households compared to the 2017 households. For example, the 2018 households may be larger. Regardless of the source of differences between the groups, the fixed-effects model can correct for this type of pattern.

Figure 9-5. Pre-Period Energy Use—Non-ESH Participants

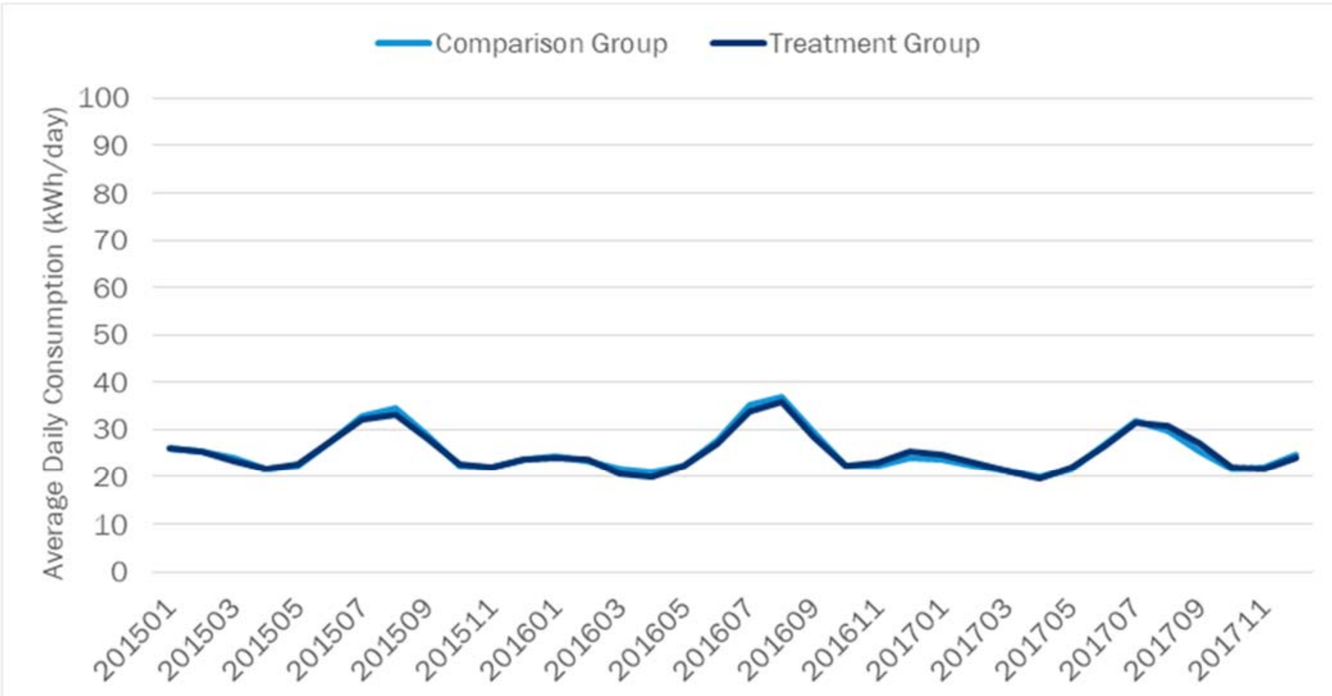
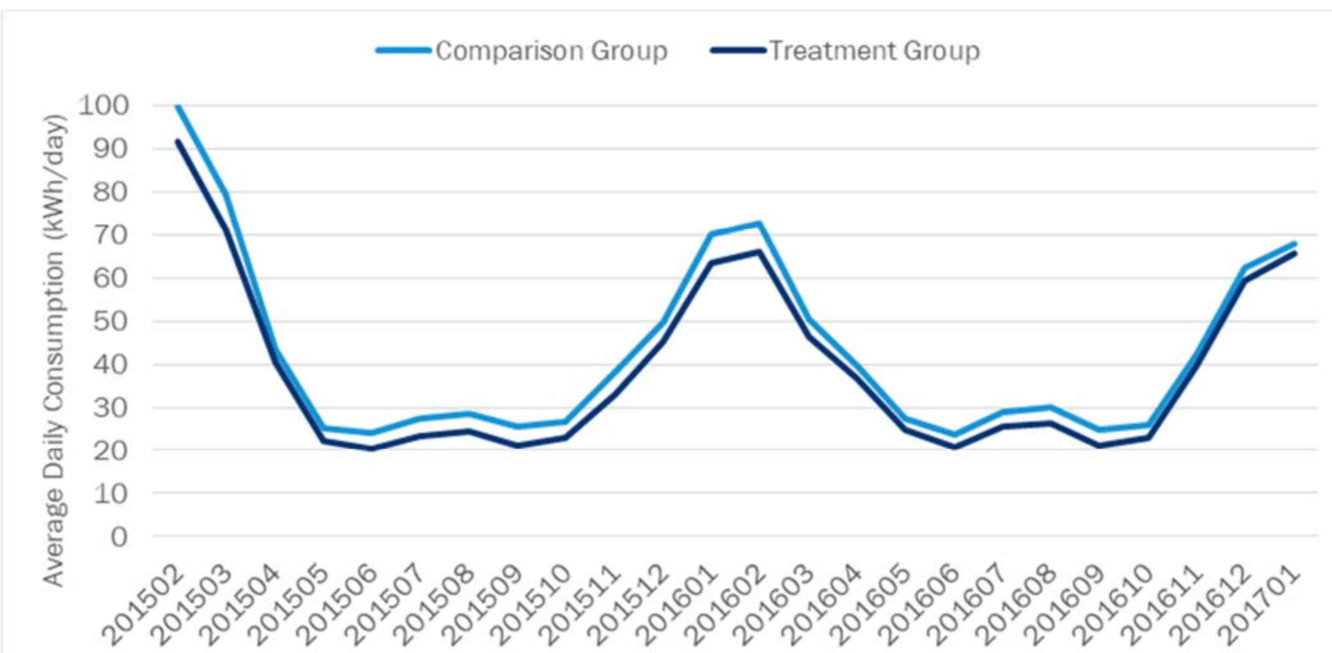


Figure 9-6. Pre-Period Energy Use—ESH Participants



Weather is another possible area of difference between groups and could explain the difference in usage between treatment and comparison groups in the ESH category. However, as we can see in Figure 9-7 and

Figure 9-8, the two groups appear to have virtually the same weather patterns. Therefore, the difference in usage among ESH participants must have to do with individual household differences.

Figure 9-7. Home Performance Program Analysis: HDDs by Sample Group

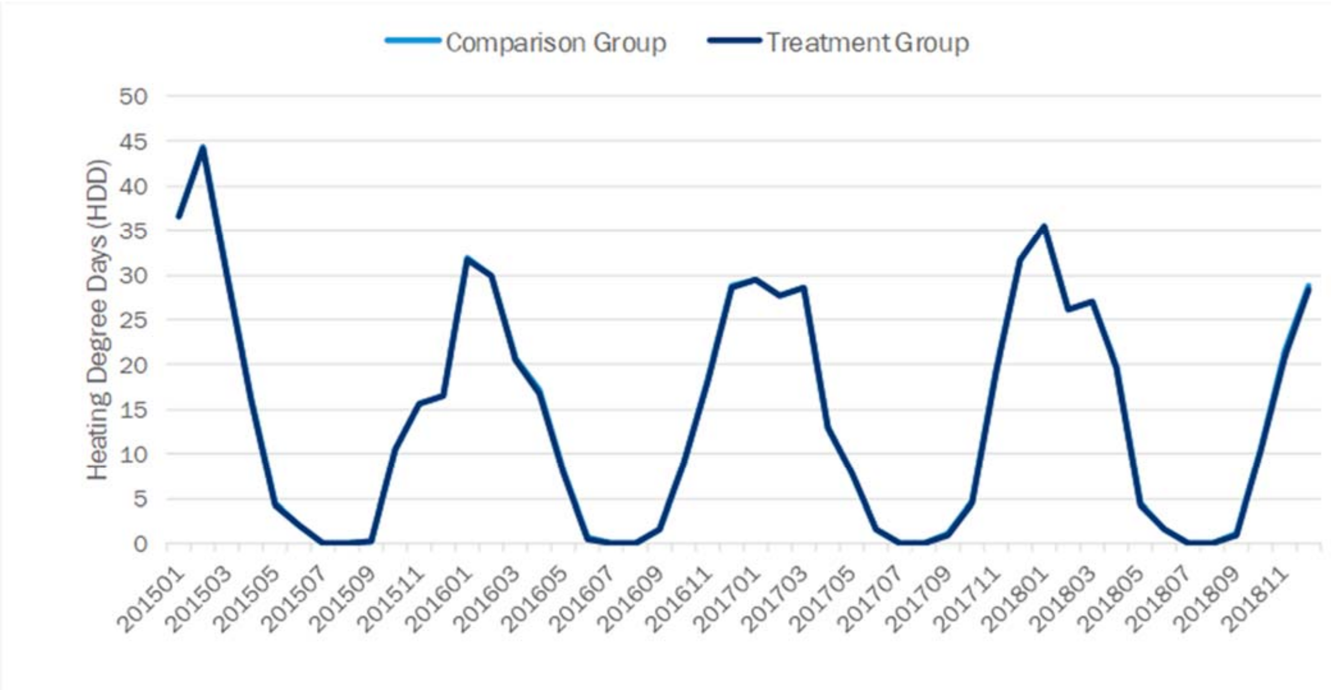
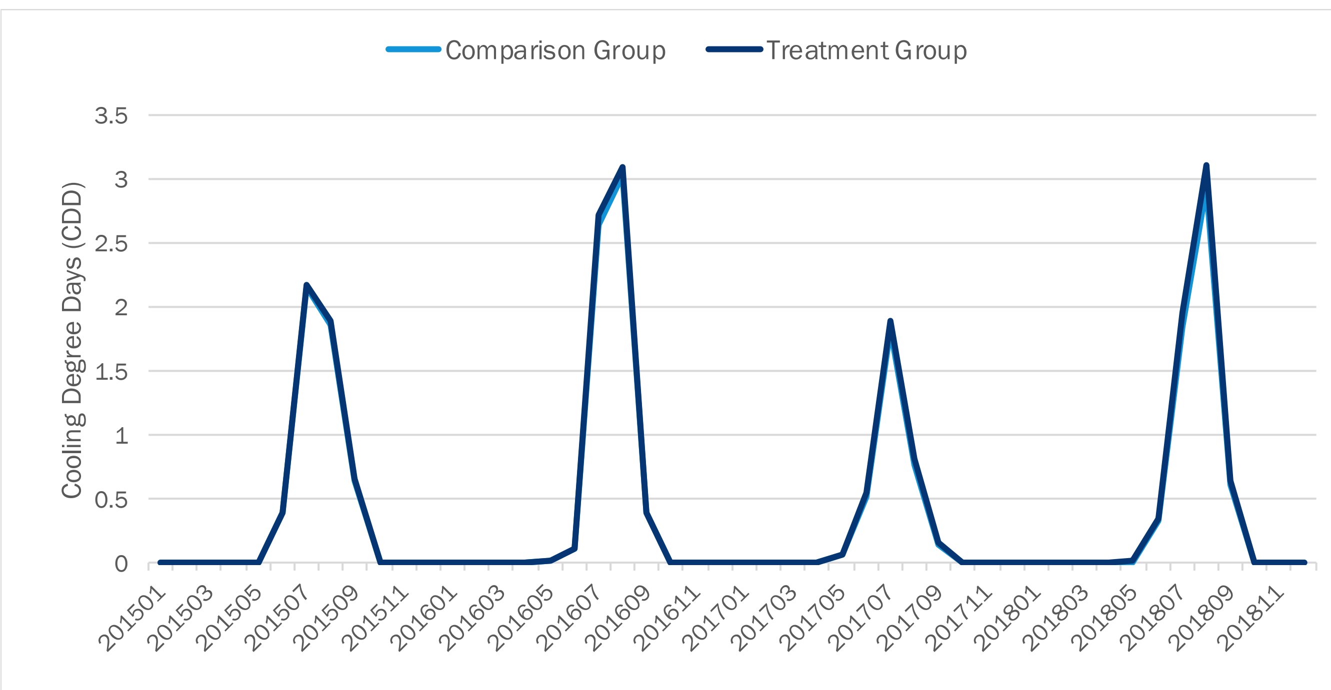


Figure 9-8. Home Performance Program Analysis: CDDs by Sample Group



Developing the Model

The Opinion Dynamics team tested multiple models to arrive at the most appropriate specification. We chose the fixed-effects model due to the small, but systematic, differences in usage between treatment and comparison groups. In addition, we identified a need to model the ESH factor. So those systematic differences were included in all of the models we tested, as were the main effects of ESH, and the interactions of ESH and weather. However, the models we tested differed in terms of their interaction effects. We interacted HDD and CDD with program type and post-period plus program type. We also tested models that controlled for seasons or months of the year, using different representations of them. While HDD and CDD measures capture a lot of the weather effects, other measures of time, such as indicators for the 12 months of the year, or month-year combinations can capture more of those influences possibly left over from the weather controls.

Our final model specification, which produced an adjusted R^2 of 0.76, is shown in the following equation.

Final Home Performance Model

$$\begin{aligned} ADC_{it} = {} & \alpha_i + \beta_1 HPDI_i \cdot Post_t + \beta_2 HPwES_i \cdot Post_t + \beta_3 HPDES_i \cdot Post + \beta_4 HDD_{it} + \beta_5 HDD_{it} \cdot ESH_i \\ & + \beta_6 CDD_t + \beta_7 CDD_t \cdot ESH_i + \beta_8 HPDI_i \cdot Post_t \cdot HDD_t + \beta_9 HPwES_i \cdot Post_t \cdot HDD_t \\ & + \beta_{10} HPDES_i \cdot Post_t \cdot HDD_t + \beta_{11} HPDI_i \cdot Post_t \cdot CDD_t + \beta_{12} HPwES_i \cdot Post_t \cdot CDD_t \\ & + \beta_{13} HPDES_i \cdot Post_t \cdot CDD_t + \beta_{14-24} M_t + \varepsilon_{it} \end{aligned}$$

Where:

ADC_{it} = Average Daily Consumption for household i at time t

α_i = Intercept for household i

β_1 = Coefficient for the change in consumption between pre- and post-participation periods for the HPDI program participants only (where Post=1 if in the post-period, and 0 if not)

β_2 = Coefficient for the change in consumption between pre- and post-participation periods for the HPwES program participants only (where Post=1 if in the post-period, and 0 if not)

β_3 = Coefficient for the change in consumption between pre- and post-participation periods for the HPDI+HPwES program participants only (where Post=1 if in the post-period, and 0 if not)

β_4 = Coefficient for effect of HDD (Base 65° F) at time t

β_5 = Coefficient for effect of HDD at time t for ESH household i

β_6 = Coefficient for effect of CDD (Base 75° F) at time t

β_7 = Coefficient for effect of CDD at time t for ESH household i

β_8 = Coefficient for change in consumption between pre- and post-participation for HPDI participant i for HDD at time t

β_9 = Coefficient for change in consumption between pre- and post-participation for HPwES participant i for HDD at time t

β_{10} = Coefficient for change in consumption between pre- and post-participation for HPDI+HPwES participant i for HDD at time t

β_{11} = Coefficient for change in consumption between pre- and post-participation for HPDI participant i for CDD at time t

β_{12} = Coefficient for change in consumption between pre- and post-participation for HPwES participant i for CDD at time t

β_{13} = Coefficient for change in consumption between pre- and post-participation for HPDI+HPwES participant i for CDD at time t

β_{14} = Set of coefficients for monthly dummy variables

ε_{it}= Error term for household i at time t

9.7.2 Home Performance Programs Estimation of Savings Using Consumption Analysis

Electric Savings Results

Table 9-13 presents the results of the consumption analysis described above for HPDI participants, HPwES participants, and those who participated in both programs.

Table 9-13. Program Savings Calculations

Program	2018 Participant Count[a]	Per-Participant ADC Savings (kWh)	% of Baseline	Daily Program Savings (kWh)	Annual Savings (kWh)
HPDI only	280	0.3605927	0.92%	100.97	36,853
HPwES only	1,387	1.313696	4.68%	1,650.00	602,251
Both	110	4.174779	11.89%	459.23	167,617
Total	1,777	1.340623522	4.53%	2,382.29	869,535

[a] The total count of participants to which the consumption analysis results are applied omits 346 HPwES accounts. Of these accounts, 215 had 0 electric savings and 131 had negative savings. The accounts with negative savings completed a heating system change in their project that shifted them from a fossil fuel to electric heating. Therefore, their electricity use will rise while their fossil fuel use declines, and the results of the consumption analysis will not apply to them.

Table 9-14 shows the final model coefficients.

Table 9-14. Final Home Performance Programs Model Coefficients

Equation Terms	Coefficient	Robust Std. Err.	T	P > |t|
HPDI-Only * Post	-1.895837	0.7570106	-2.5	0.012
HPwES-Only * Post	0.8369463	0.3659022	2.29	0.022
HPDI+HPwES * Post	-1.1626	0.74814	-1.55	0.12
HDD (Base 65)	0.0450085	0.0148116	3.04	0.002
HDD * ESH	1.674864	0.0284426	58.89	0
CDD (Base 75)	1.814325	0.2622936	6.92	0
CDD * ESH	0.1127326	0.2210664	0.51	0.61
HPDI-Only *Post * HDD	0.1074982	0.0522988	2.06	0.04
HPwES-Only * Post * HDD	-0.1364211	0.0197701	-6.9	0
HPDI+HPwES* Post * HDD	-0.1773839	0.0463156	-3.83	0
HPDI-Only * Post * CDD	-0.0496034	0.3037948	-0.16	0.87
HPwES-Only * Post * CDD	-0.4807105	0.1598639	-3.01	0.003
HPDI+HPwES* Post * CDD	-1.090121	0.2442009	-4.46	0
February	-0.4648323	0.1223886	-3.8	0
March	-2.626439	0.1849313	-14.2	0
April	-4.293606	0.2654859	-16.17	0
May	-2.277721	0.402067	-5.67	0
June	2.548158	0.4908204	5.19	0
July	5.314984	0.7087714	7.5	0
August	5.855577	0.7005853	8.36	0
September	3.113616	0.4967494	6.27	0
October	-3.427425	0.3898409	-8.79	0
November	-4.014317	0.2551479	-15.73	0
December	-0.2676567	0.1547625	-1.73	0.084
Average Intercept	21.06443	0.4736623	44.47	0

Consumption Analysis Compared to Ex Ante Savings

Table 9-15 compares the observed (ex post) savings from the consumption analysis to the expected (ex ante) savings for the Home Performance programs participants based on PSEG Long Island’s program planning estimates. The results of the comparisons are the associated realization rates, without line loss factors added. Evaluated participants in the Home Performance programs saved an estimated 489 kWh per year. This compares to 1,955 kWh per year ex ante net savings, for a realization rate of 25%. For application to the program evaluation, the realization rate is slightly higher because line loss factors are applied.

Table 9-15. Savings from the Home Performance Program Consumption Analysis Compared to Savings Expected from Program Planning Estimates

End-Use	N[a]	Observed Savings		Program Planning Savings [b]		Realization Rate
		Household Daily Savings (kWh)	Household Annual Savings (kWh)	Household Daily Savings (kWh)	Household Annual Savings (kWh)	
Combined Home Performance Programs	1,777	1.34	489	5.35	1,955	25%

[a] The total count of participants to which the consumption analysis results are applied omits 215 HPwES accounts with 0 electric savings.

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

9.8 Consumption Analysis Methods for the Home Energy Management Program

This section presents a summary of the methods used to estimate the evaluated net energy savings impacts for the 2018 HEM program. Implementation of the HEM program relies on a Home Energy Report (HER) engagement campaign leveraging an RCT design.[56] Given this design, we used a consumption analysis approach to estimate evaluated net energy savings impacts of the program. The result of this approach is referred to as the unadjusted evaluated net energy savings.

Our savings analysis for the HEM program also considers energy savings resulting from energy efficient actions taken through other PSEG Long Island programs. One would expect a base rate of participation in these programs from both the treatment and control customers; however, it is likely that the HEM program encouraged an increase, or "uplift," in participation in other PSEG Long Island residential energy efficiency programs among the members of the treatment group by promoting these programs in the HERs. Increased participation in other PSEG Long Island energy efficiency programs by the treatment group would mean that some portion of savings from other programs may be counted by both the HEM program (through the consumption analysis savings estimate) and other efficiency programs (through deemed savings in their tracking databases or in their impact evaluations). To avoid double counting these savings, they are removed from the results of the consumption analysis to arrive at an adjusted evaluated net savings impact for the HEM program.

Treatment of customers began in September 2017 when Tendril initiated its plan to send periodic HERs to 341,570 customers. The evaluation team refers to this group of customers receiving reports at the program's outset, and its control group counterpart, as Cohort 1. In August 2018, Tendril started to send periodic HERs to an additional 159,348 customers, who represent the treatment customers in Cohort 2. Not all of these customers received their first HERs in August 2018, as initial HERs were sent out on a rolling basis through the remainder of 2018. Cohort 2 treatment customers consist of a set of control customers drawn from Cohort 1, as well as additional customers who were not included in the HEM program previously but were selected using the same criteria as Cohort 1. A majority of Cohort 2 is made up of customers who were newly added to the program.

Because the new 2018 program participants began receiving reports relatively late in the year (late August) and had insufficient post-participation consumption data, it was not feasible to complete a consumption

[56] In the context of household behavioral programs, Randomized control trial, or RCT, is a type of experimental design in which households in a given population are randomly assigned into two groups—a treatment group and a control group— and the outcomes for these two groups are compared, resulting in unbiased program savings estimates.

analysis using Cohort 2 for 2018. Therefore, the 2018 consumption analysis relies on Cohort 1 customers, for whom we had sufficient post-participation billing data. The average daily savings of Cohort 1 were then applied to both Cohorts 1 and 2 to estimate savings for the 2018 program year.

9.8.1 Data Cleaning and Model Development for Consumption Analysis of the HEM Program

Preparing and Cleaning the Data

The evaluation team followed a rigorous and systematic process of inspecting the data received from PSEG Long Island and the HEM program implementer. We began with the participant data (treatment and control) file and billing data for all program participants, and then conducted an extensive cleaning process based on the billing data after merging the billing data with the participant file. Following this, the team obtained weather data and appended it to the merged file.

Cleaning Participant Data

2017 Participant Counts

Opinion Dynamics received HEM participant files for customers in Cohorts 1 and 2. The Cohort 1 file began with 392,245 accounts, which included 341,570 treatment and 50,675 control customers (see Table 9-16). The evaluation team did not remove any accounts from the Cohort 1 file due to participation in the Super Saver program since none were in the program. The team did remove five control participants because they were Net Energy Meter solar PV customers, 68 control participants who were tracked as receiving HEM reports, and 13,593 treatment and control customers who closed their accounts before the start of the 2018 program year.

Table 9-16. Summary of Data Cleaning Results Based on Cohort 1 Participant File

Reasons for Drops	Cohort 1			
	Treatment		Control	
	Total Accounts	Percent of Accounts	Total Accounts	Percent of Accounts
Total Unique Accounts	341,570	100.0%	50,675	100.0%
Super Saver Participants	-		-	
Accounts Remaining	341,570	100.0%	50,675	100.0%
Net Energy Meter Participants	-		5	
Accounts Remaining	341,570	100.0%	50,670	100.0%
Control Participants that Received Reports	-		68	
Accounts Remaining	341,570	100.0%	50,602	99.9%
Closed Account Before 2018 Program Year	10,137		3,456	
Accounts Remaining	331,433	97.0%	47,146	93.0%

Midway through 2018, PSEG Long Island moved some customers from the Cohort 1 control group to the Cohort 2 treatment group. However, since many of the customers moved to the Cohort 2 treatment group did not receive reports in 2018, the evaluation team increased the size of the Cohort 1 control group by 56,330 to

103,476 by including Cohort 2 treatment customers who did not receive reports. The larger control group provided additional rigor to our consumption analysis.

The Cohort 2 customer dataset began with 199,499 accounts, which included 159,765 treatment and 39,734 control customers (see Table 9-17). Notably, the team did not conduct the analysis using Cohort 2 customers because post-participation data were insufficient to perform a rigorous consumption analysis for that cohort. Table 9-17 shows the data cleaning results. The number of Cohort 2 treatment group customers that received savings based on the Cohort 1 consumption analysis is 158,714.

Table 9-17. Summary of Data Cleaning Results Based on Cohort 2 Participant File

Reasons for Drops	Cohort 2			
	Treatment		Control	
	Total Accounts	Percent of Accounts	Total Accounts	Percent of Accounts
Total Unique Accounts	159,765	100.0%	39,734	100.0%
Super Saver Participants	409		4,853	
Accounts Remaining	159,356	99.7%	34,881	87.8%
Net Energy Meter Participants	8		5	
Accounts Remaining	159,348	99.7%	34,876	87.8%
Control Participants Who Received Reports	-		2	
Accounts Remaining	159,348	99.7%	34,874	87.8%
Closed Account Before 2018 Program Year	634		120	
Accounts Remaining	158,714	99.3%	34,754	87.5%

Experiment Start Dates

Consistent with the ITT approach,[57], one experiment start date was used for all participants in Cohort 1, using the earliest, most frequent date that reports were sent, September 8, 2017. Some Cohort 1 customers had no experiment start date in the participant file either because the data was missing for these customers or because they never received a report. The experiment start date was missing for 5,937 participants found in both Cohort 1 and Cohort 2 customer files. They were included in the Cohort 1 file with the experiment start date of September 8, 2017 because they did appear in the participant files we received, an indication that there was an intent to treat these customers.

Assigning Time Periods to Billing Data

Typically, bills for electricity usage are sent to customers monthly. However, usage data received for some customers indicated a 2-month billing cycle due to PSEG Long Island's practice of conducting meter reads every other month. For these customers, every other month usage values were assigned missing values in the billing data.

The evaluation team calculated average daily usage for each billing cycle by dividing the billing period usage value by the number of days in the cycle. In some cases, the number of days field was missing, and the team

[57] ITT estimates the impacts of the program for a group of customers the program intended to treat, (i.e., customers to whom PSEG Long Island intended to send HERs or eHERs). Another method that evaluators may rely on is the average treatment effect of the treated, which estimates the impacts of the program for the group of customers that received HERs. These approaches differ in the number of customers used in the analysis.

imputed it based on the end date of the previous cycle. However, in a substantial number of the cases with missing bill days, the missing value occurred on the first cycle that appeared for the customer. In these cases, the first cycle (record) was dropped because making an assumption about the number of days in the first cycle could result in substantial measurement error. In most cases, this did not result in the loss of the entire account from the analysis.

In addition, if the billing cycle was longer than 90 days, the record was dropped. Similarly, if the first or last bill covered less than 10 days, the record was dropped.

The evaluation team also identified other time period issues, including overlapping billing periods and estimated bills. These two issues often occurred together, and the evaluation team corrected the problem by dropping the estimated bill record. We checked that this was the best approach by inspecting the records to be sure every day was covered by the most appropriate bill.

Cleaning Billing Data

The evaluation team found 204 control group customers who only had billing records for the period before the analysis period began. These customers were not suitable for the consumption analysis and were removed from the file. If these customers did not close their accounts during the evaluation time frame, we applied savings to them at the program level.

The evaluation team found that some billing records were represented more than once in the billing data received from PSEG Long Island. One of each set of perfect duplicates were dropped. This resulted in removing 5,135 treatment and 1,443 control customers' billing records but did not result in any account losses.

After reviewing duplicate records, the evaluation team completed further cleaning by removing accounts with insufficient pre- or post-period coverage, meaning less than nine months in either period, or less than two summer months in the post-period or less than 30 summer days in the pre-period.

Another set of reasons for removing accounts is having no usage or extremely low average daily consumption (less than 2 kWh). Additionally, the team also dropped a small number of accounts for extremely high usage (over 10,000 kWh).

A summary of the records and accounts that the team removed is shown in Table 9-18.

Table 9-18. Billing Record Removal for Cohort 1 Treatment and Control Groups for Consumption Analysis

Reasons for Drops	Accounts		Records	
	Treatment	Control	Treatment	Control
Total Unique Records	331,433	103,272	6,457,050	1,919,841
Perfect Duplicates	0	0	5,135	1,443
# Remaining	331,433	103,272	6,451,915	1,918,398
% Remaining	100.0%	100.0%	99.9%	99.9%
Over 90 Day Bill Period	0	12	83,823	31,587
# Remaining	331,433	103,260	6,368,092	1,886,811
% Remaining	100.0%	100.0%	98.6%	98.3%
Bill Period Under a Week	0	0	1,242,371	339,763
# Remaining	331,433	103,260	5,125,721	1,547,048

Reasons for Drops	Accounts		Records	
	Treatment	Control	Treatment	Control
% Remaining	100.0%	100.0%	79.4%	80.6%
No Usage	3	3	3,483	1,176
# Remaining	331,430	103,257	5,122,238	1,545,872
% Remaining	100.0%	100.0%	79.3%	80.5%
High Usage (Above 10K kWh)	9	1	2,345	710
# Remaining	331,421	103,256	5,119,893	1,545,162
% Remaining	100.0%	100.0%	79.3%	80.5%
Multiple Bills within Month	0	0	134,973	47,741
# Remaining	331,421	103,256	4,984,920	1,497,421
% Remaining	100.0%	100.0%	77.2%	78.0%
Less Than 9 Months in Post-Period Days	54,467	20,647	622,964	230,119
# Remaining	276,954	82,609	4,361,956	1,267,302
% Remaining	83.6%	80.0%	67.6%	66.0%
Less Than 9 Months in Pre-Period Days	829	2,487	11,241	16,074
# Remaining	276,125	80,122	4,350,715	1,251,228
% Remaining	83.3%	77.6%	67.4%	65.2%
Less Than 60 Summer Days Post-Period	21,453	5,218	336,668	81,357
# Remaining	254,672	74,904	4,014,047	1,169,871
% Remaining	76.8%	72.5%	62.2%	60.9%
Less Than 30 Summer Days Pre-Period	347	72	5,769	1,153
# Remaining	254,325	74,832	4,008,278	1,168,718
% Remaining	76.7%	72.5%	62.1%	60.9%
Low Overall ADC	8	2	139	24
# Remaining	254,317	74,830	4,008,139	1,168,694
% Remaining	76.7%	72.5%	62.1%	60.9%
Low Overall Pre ADC	60	11	914	154
# Remaining	254,257	74,819	4,007,225	1,168,540
% Remaining	76.7%	72.4%	62.1%	60.9%

The largest losses of accounts came from having insufficient post-period coverage. This was an issue overall and for summer months. However, the losses occurred similarly across treatment and control groups.

Incorporating Weather Data

The evaluation team acquired daily weather data based on Cohort 1 customers' ZIP codes from the NOAA website, and matched this information by ZIP code to all customers included in the consumption analysis. We checked the weather data for quality issues, such as missing days, and fixed any problems, usually by selecting the next best weather station if there were too many missing values for the originally assigned station.

The evaluation team calculated heating and cooling degree days using a base of 65°F for HDDs and 75°F for CDDs. We then appended these weather variables to the consumption analysis file, according to the time periods covered by the analysis.

Final Analysis Dataset

The final consumption analysis dataset included 254,257 treatment and 74,819 control group customers from Cohort 1, totaling 329,076. The analysis period covered 12 months before the experiment start date, and 12 months after it, with the pre-period beginning in September 2016 and ending in August 2017, and the post-period beginning in October 2017 and ending in September 2018. This was the only time frame (pre- and post-) that was practically available for a valid consumption analysis, given the constraints of the experiment start dates and the available billing data. The average daily savings estimated from this dataset were applied to appropriate 2018 treatment participants from Cohorts 1 and 2.

9.8.2 HEM Program Estimation of Savings Using Consumption Analysis

Attrition Analysis Results

Cohorts 1 and 2 experienced some attrition in 2018, as customers closed accounts, opted out, or never received a report. Table 9-19 shows the attrition rates for 2018 by cohort and reason for attrition, based on a review of the HEM program participant data. The overall attrition rate for Cohort 1 is 6.36%, which is driven mostly by customer move-outs. For Cohort 2, the overall attrition rate is 5.9% and is driven by both customers moving out and the share of customers who never received a report in 2018 after the experiment start date of August 27, 2018. When treatment customers in both cohorts are considered, the total rate of attrition in 2018 is 6.21%.

Table 9-19. 2018 HEM Program Attrition Rates by Cohort

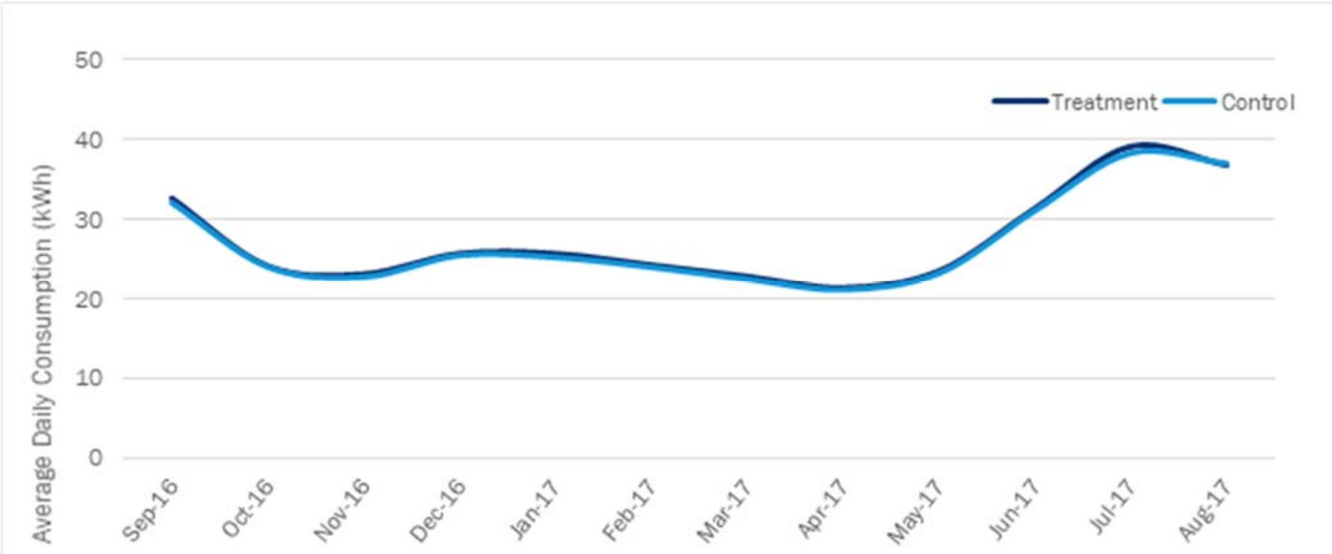
Cohort	Moved Out	Opted Out	Never Received a Report	Total Attrition
Cohort 1	6.20%	0.18%	0.00%	6.36%
Cohort 2	4.71%	0.13%	3.44%	5.90%
Total	5.73%	0.16%	3.44%	6.21%

Assessment of Treatment and Control Group Equivalency

Prior to conducting a consumption analysis to estimate savings for the HEM program, which uses an RCT approach, the evaluation team analyzed equivalency between the treatment and control customers in Cohort 1. The purpose of the equivalency analysis was to verify that these two groups show equivalent energy consumption overall, and monthly, for the 12-month period prior to the start of report delivery for the treatment customers. This analysis ensures that the control group provides a reliable counterfactual for the treatment group of customers.

Last year, the treatment and control groups in Cohort 1 were subjected to a thorough equivalency analysis that included demographic information as well as pre-period energy and weather variables. For 2018 the evaluation team repeated only the energy and weather comparisons to ensure that the participants who remain after further cleaning and attrition are still equivalent. Figure 9-9 shows that comparison for the period between September 2016 and August 2017. The two lines are very close and indicate very similar usage patterns.

Figure 9-9. Pre-Period Average Daily Consumption, Cohort 1 Treatment vs. Control



It is not surprising, then, that the weather conditions experienced by the two groups are also very similar, as shown in Figure 9-10 and Figure 9-11.

Figure 9-10. Pre-Period HDDs, Cohort 1 Treatment vs. Control

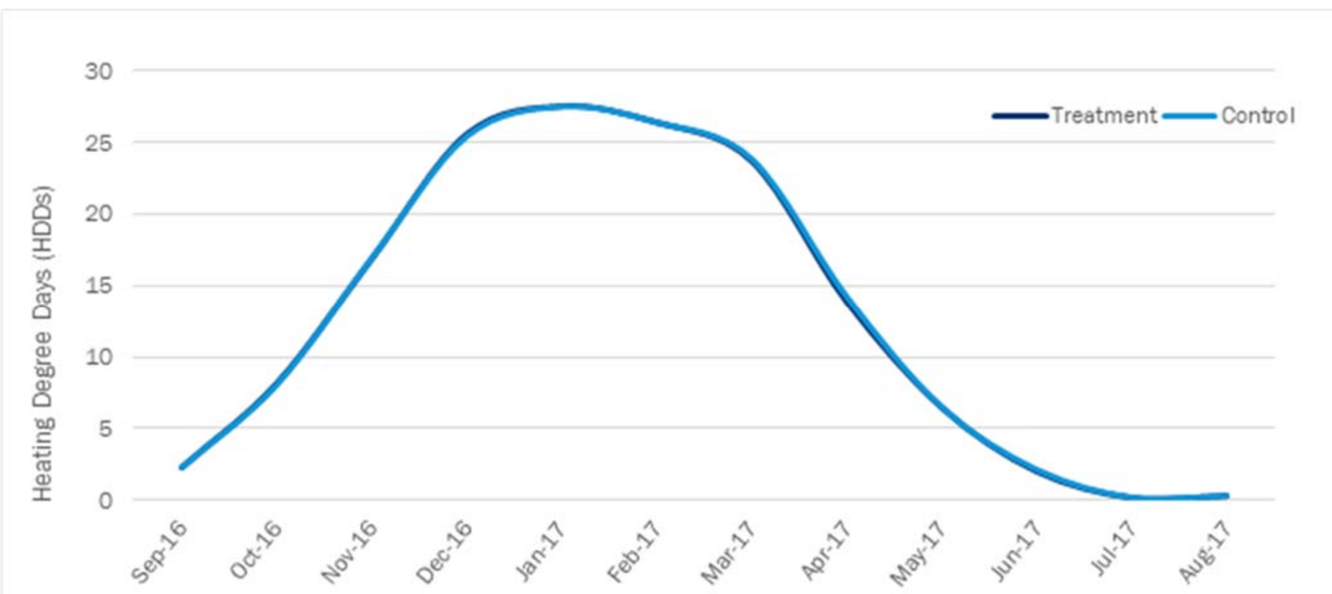
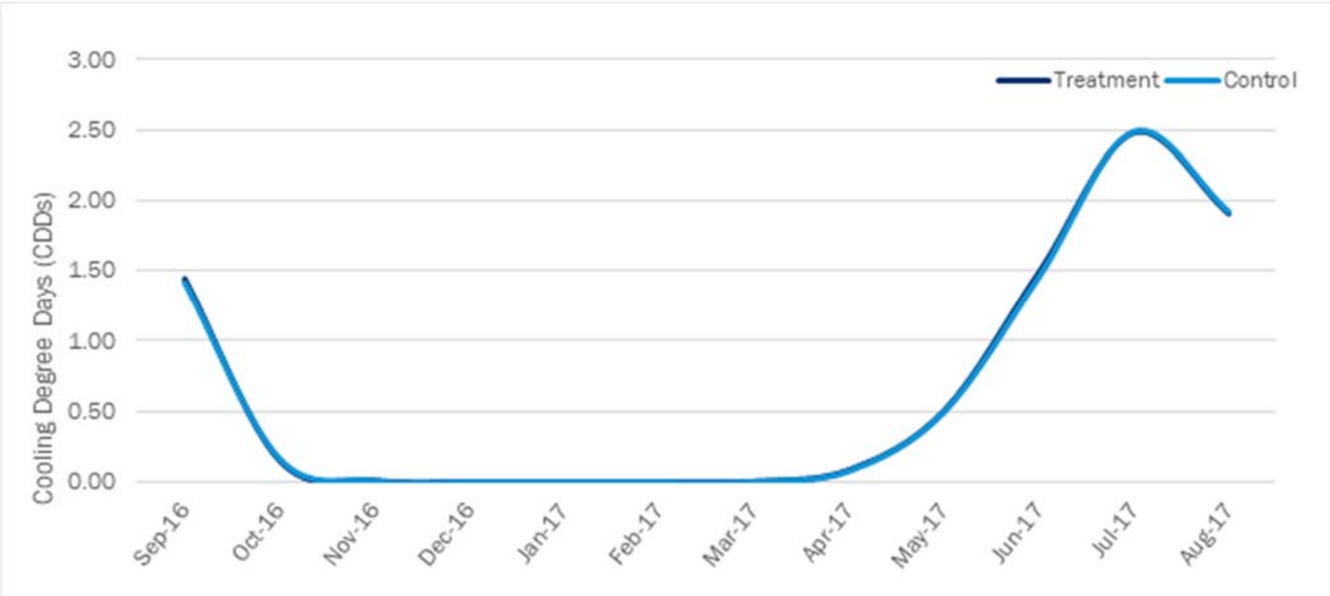


Figure 9-11. Pre-Period CDDs, Cohort 1 Treatment vs. Control



In the year prior to receiving reports for the HEM program (September 2016 through August 2017), the average daily consumption for Cohort 1 was 27.7 kWh for treatment customers and 27.4 kWh for the control customers (see Table 9-20).

Table 9-20. Pre-Participation Average Daily Consumption, Cohort 1 Treatment vs. Control

Treatment (Pre-Participation) Consumption	Control (Pre-Participation) Consumption
27.7	27.4

Comparability of Cohort 1 and Cohort 2 Treatment Customers

Because this evaluation applies a savings estimate based on a consumption analysis of customers in Cohort 1 to both Cohorts 1 and 2, the evaluation team assessed whether treatment customers in Cohorts 1 and 2 were similar in terms of their usage and weather patterns. We found the two groups to be equivalent in terms of pre-period energy consumption, justifying the application of savings modeled for Cohort 1 to Cohort 2. The evaluation team constructed several graphs that assist in identifying any differences between the two groups. Figure 9-12 shows that the two groups are very similar in terms of energy use but diverge slightly in the summer season. Figure 9-13 reveals that the groups are also very similar in terms of HDDs. Figure 9-14 shows some CDD differences in the summer, which is consistent with the slight energy use differences seen in the summer months. This corresponds to the small divergence in usage during the summer, as shown in Figure 9-12. It is worth noting that this analysis is based on the summer of 2017 (during the pre-period for both groups).

Figure 9-12. Energy Usage Comparison Between Treatment Customers in Cohorts 1 and 2

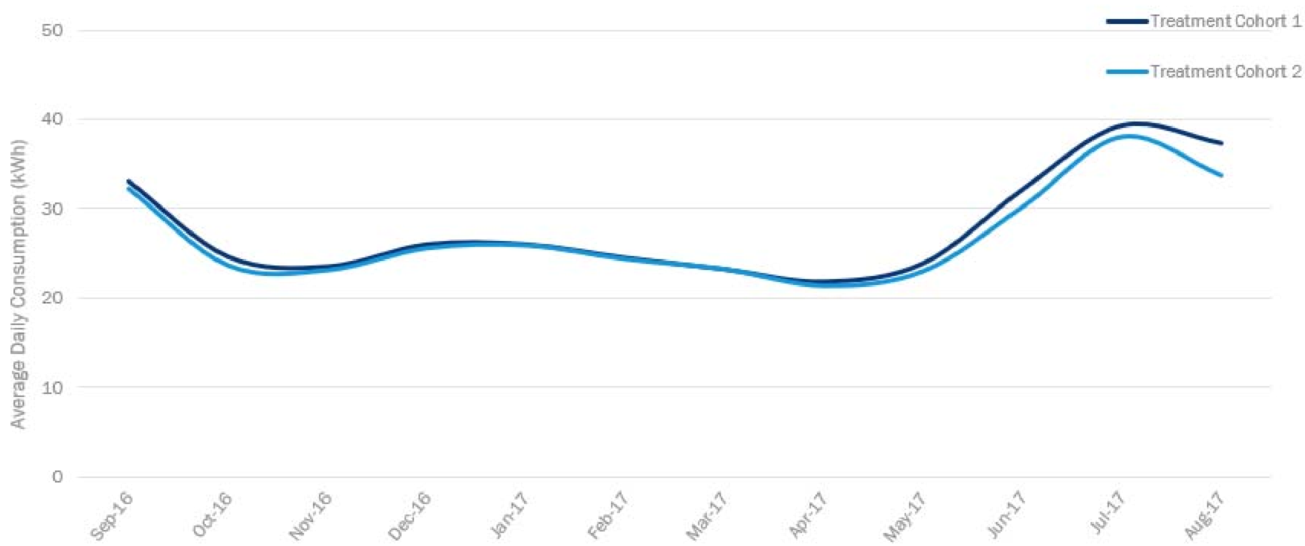


Figure 9-13. HDD Comparison Between Treatment Customers in Cohorts 1 and 2

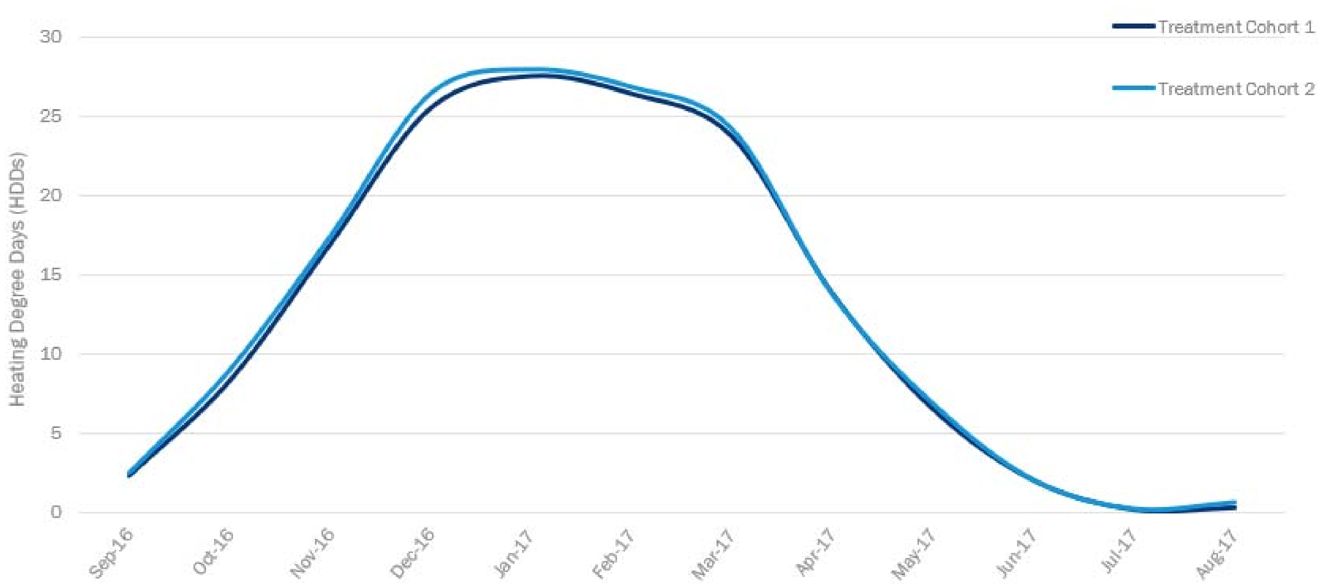
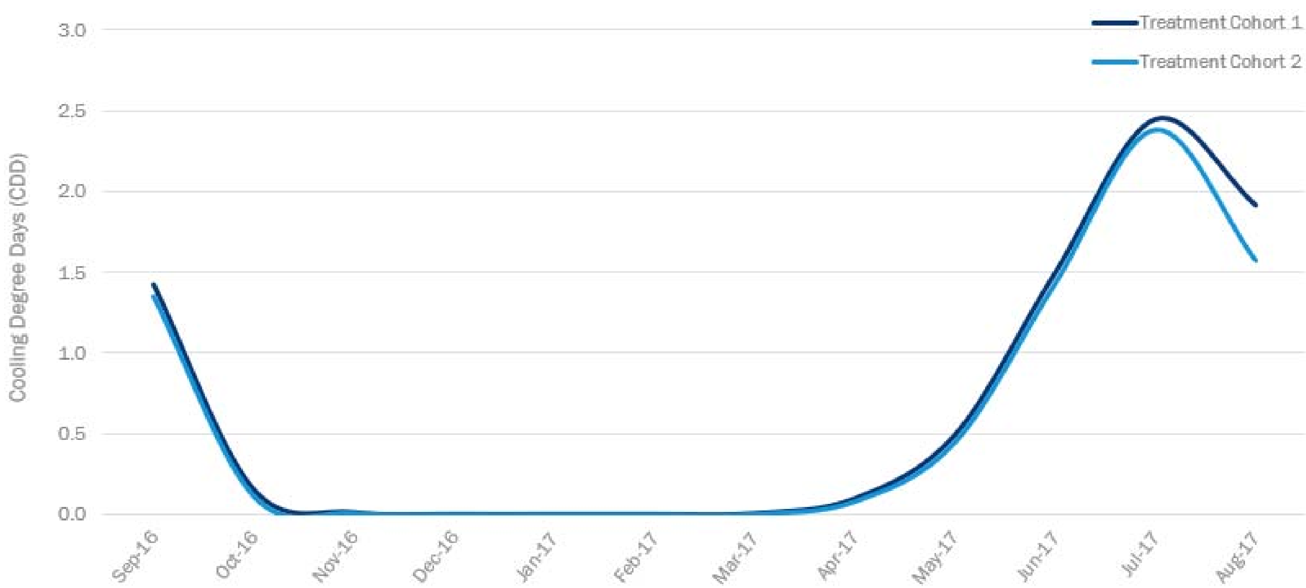


Figure 9-14. CDD Comparison Between Treatment Customers in Cohorts 1 and 2



Though there are minor differences in consumption and CDDs for the treatment customers in Cohorts 1 and 2, the results show that these customers are comparable, and the application of the savings estimate based on the consumption analysis using Cohort 1 is applicable to the Cohort 2 treatment customers.

Statistical Method Used

Opinion Dynamics estimated three models. The first is a very simple, one-way, fixed-effects model as the most basic difference-in-differences approach. We call this the base model. Its specification is shown in the following equation.

Base Model

$$ADC_{it} = \alpha_i + \beta_1 Post_t + \beta_2 Treatment_i \cdot Post_t + \varepsilon_{it}$$

Where:

ADC_{it} = Average daily consumption (kWh) for household i at time t

α_i = Household-specific intercept

β_1 = Coefficient for the change in consumption between pre- and post-participation periods

β_2 = Coefficient for the change in consumption for the treatment group in the post-participation period compared to the pre-participation period and to the control group estimate

$Post_t$ = Variable to represent the pre- and post-participation periods (0 = pre-participation period, 1 = post-participation period)

Treatment$_i$ = Variable to represent treatment and control groups (0 = control group, 1 = treatment group)

ε_{it} = Error term for household i at time t

A second specification adds weather terms HDD and CDD so that it is weather-adjusted, also representing a difference-in-differences approach. The following equation shows that model.

Weather-Adjusted Model

$$ADC_{it} = \alpha_i + \beta_1 Post_t + \beta_2 Treatment_i \cdot Post_t + \beta_3 HDD_{it} + \beta_4 CDD_{it} + \varepsilon_{it}$$

Where:

ADC_{it} = Average daily consumption (kWh) for household i at time t

α_i = Household-specific intercept

β_1 = Coefficient for the change in consumption between pre- and post-participation periods

β_2 = Coefficient for the change in consumption for the treatment group in the post-participation period compared to the pre-participation period and to the control group estimate

β_3 = Coefficient for HDD

β_4 = Coefficient for CDD

$Post_t$ = Variable to represent the pre- and post-participation periods (0 = pre-participation period, 1 = post-participation period)

$Treatment_i$ = Variable to represent treatment and control groups (0 = control group, 1 = treatment group)

HDD_{it} = Sum of HDDs (base 65°F)

CDD_{it} = Sum of CDDs (base 75°F)

The final model is a lagged dependent variable model that takes full advantage of the experimental design. It is based on comparison of the post-period only between treatment and control groups but adding variables that control for pre-period usage characteristics. The purpose of the pre-period variables is to improve precision and increase model fit. Their addition should not affect the savings estimate given that the participants were randomly assigned to the treatment and control conditions. This was the best-fitting model, the one selected for the analysis. The evaluation team tested other LDV models, varying the weather and time specifications. All of the LDV models showed similar savings, but they varied in terms of model fit. The R^2 for this model was 61%. It had the lowest AIC and highest adjusted R^2 of any of the models. The model is shown in the following equation.

Lagged Dependent Variable Model

$$ADC_{it} = \alpha + \beta_1 Treatment_i + \beta_2 PreUsage_i + \beta_3 PreWinter_i + \beta_4 PreSummer_i + \beta_5 MonthYear_t + \beta_6 PreUsage_i \cdot MonthYear_t + \beta_7 PreWinter_i \cdot MonthYear_t + \beta_8 PreSummer_i \cdot MonthYear_t + \varepsilon_{it}$$

Where:

ADC_{it} = Average daily consumption (kWh) for household i at time t

α = Intercept

β_1 = Coefficient for the change in consumption for the treatment group

β_2 = Coefficient for the average daily usage across household i available pre-treatment meter reads

β_3 = Coefficient for the average daily usage over the months of December through March across household i available pre-treatment meter reads

β_4 = Coefficient for the average daily usage over the months of June through September across household i available pre-treatment meter reads

β_5 = Vector of coefficients for month-year dummies

β_6 = Vector of coefficients for month-year dummies by average daily pre-treatment usage

β_7 = Vector of coefficients for month-year dummies by average daily winter pre-treatment usage

β_8 = Vector of coefficients for month-year dummies by average daily summer pre-treatment usage

$Treatment_i$ = Variable to represent treatment and control groups (0 = control group, 1 = treatment group)

$PreUsage_i$ = Average daily usage for household i over the entire pre-participation period

$PreWinter_i$ = Average daily usage for household i over the pre-participation months of December through March

$PreSummer_i$ = Average daily usage for household i over the pre-participation months of June through September

$MonthYear_t$ = Vector of month-year dummies

ε_{it} = Error term for household i at time t

Savings Results

Below the evaluation team presents the results from the three models with their coefficients and standard errors.

Table 9-21. Billing Analysis Coefficients for the Base Model

Equation Term	Model Coefficients	Robust Standard Error
Post	2.5854344	0.0291105
Post x Treatment	-0.6737126	0.0328346

Table 9-22. Billing Analysis Coefficients for the Weather-Adjusted Base Model

Equation Term	Model Coefficients	Robust Standard Error
Post	2.0026098	0.0283792
CDD	6.2116030	0.0151476
HDD	0.1137794	0.0014653
Post x Treatment	-0.5397726	0.0319750

Table 9-23. Billing Analysis Coefficients for the LDV Model

Equation Term	Model Coefficients	Robust Standard Error
Treatment	-0.3213860	0.0306488
Pre-period usage	0.0023214	0.0000670
Pre-period summer usage	0.0005635	0.0001101
Pre-period winter usage	-0.0001078	0.0001447

Table 9-24 shows the summary of per-household savings for the two cohorts for the 2018 calendar year.

Table 9-24. 2018 HEM Unadjusted Per-Household Net Savings

Cohort	Number of Customers Treated in 2018[a]	Unadjusted Net Savings (% per household)	Unadjusted Net Energy Savings (kWh) (per household)[b]	Unadjusted Net Savings (MWh)[c]
Cohort 1	331,433	1.06%	113.6	37,661
Cohort 2	158,714	1.06%	115.3	18,301
Total	490,147	1.06%	114.2	55,962

[a] Refers to the number of customers whom PSEG LI selected to provide HERs to and who received at least one bill.
[b] Refers to the per-household per-day savings multiplied by the average number of days in the participating households that were in the HEM program in 2018.
[c] Prorated for participants whose accounts closed during 2018.

9.8.3 Joint Savings Analysis

The evaluation team conducted the joint savings analysis to answer the following research questions:

- Does the program treatment have an incremental effect on participation in other residential energy efficiency programs offered by PSEG Long Island?
- What portion of savings from the program treatment is double counted by other residential energy efficiency programs offered by PSEG Long Island?

The information provided in the HERs aims to induce additional program participation. If this messaging is effective, we would expect to see an uplift in participation in other PSEG Long Island residential energy efficiency programs among HEM treatment participants or a higher rate of participation among the treatment group compared to the control group. Increased participation in other PSEG Long Island energy efficiency programs by the treatment participants would mean that some portion of savings from other programs may be counted by both the HEM program (through the consumption analysis savings estimate) and other energy efficiency programs (through deemed savings in their tracking databases or in their impact evaluations). To avoid double counting these savings, the joint savings analysis first determined whether there was participation uplift. If so, then the double counted savings were deducted from the unadjusted ex post savings from the HEM program.

The evaluation team compared the participation rates and ex post net savings claimed between treatment and control groups by measuring differences in participation rates and average ex post net energy savings per participant. Using the post-only difference approach, as shown in the following equation, the evaluation team calculated the participation uplift and savings adjustments.

Post-only Difference Equation

$$POD\ Estimator = Y_{1t} - Y_{1c}$$

where Y represents either the participation rate or the energy savings per participant, t refers to the treatment group participants, and c refers to the control group participants.

Analytical Approach

To determine whether the HEM program treatment generated participation uplift in 2018 (e.g., an increase in participation in other energy efficiency programs in 2018 due to participation in the HEM program), we calculated whether more treatment than control group members participated in other PSEG Long Island residential energy efficiency initiatives after receiving HERs. We calculated uplift using a post-only difference estimator and tested the result for statistical significance. Any positive difference between the treatment and control population that is statistically significant is the net increase in cross-program participation (and associated savings) due to the HEM program.

The evaluation team cross-referenced the HEM program database—both treatment and control groups—with the databases of other residential energy efficiency programs in 2018. We included five residential programs in our analysis for 2018:

- Cool Homes
- Energy Efficient Products (EEP), including:
  - Appliance Recycling
  - Lighting (Online Store Only)
  - Rebates
- Home Performance Direct Install (HPDI)
- Home Performance with ENERGY STAR (HPwES)
- Residential Energy Affordability Partnership (REAP)

Through this effort, the team determined whether each customer (in either a treatment or control group) participated in any other PSEG Long Island residential energy efficiency program before and after the 2017 experiment start date. The team also referenced the PSEG Long Island TRM to pull average program level and measure level evaluated net savings to scale the participation uplift to a savings uplift.

The evaluation team defined the pre- and post-period based on Cohort 1 treatment customers' experiment start date of September 8, 2017. Consistent with the consumption analysis, the joint savings analysis used treatment customers in Cohort 1.

Joint Savings Analysis Results

The evaluation team calculated participation rates and ex post net savings claimed between treatment and control groups. Table 9-25 presents the participation uplift rate by program, and Table 9-26 shows the per-participant savings due to uplift. The savings value for the post-only difference of 0.612 kWh is multiplied by the number of participants in 2018 (490,147) to arrive at a total savings value of 300 MWh.

Table 9-25. Participation Uplift Rate by Program

Program	Post-Treatment	Post-Control	Post-Only Difference
HPwES	0.135%	0.151%	-0.016%
HPD	0.035%	0.033%	0.002%
Cool Homes	0.594%	0.593%	0.000%
REAP	0.143%	0.116%	0.027%
EEP	2.284%	1.999%	0.284%
Total	3.137%	2.825%	0.311%

Note: Totals may not sum due to rounding.

Table 9-26. Per-Participant Savings (kWh) from Participation Uplift

Program	Post-Treatment	Post-Control	Post-Only Difference
HPwES	0.027	0.030	-0.003
HPD	0.500	0.477	0.023
Cool Homes	4.235	4.232	0.003
REAP	1.234	1.002	0.232
EEP	8.600	8.243	0.357
Total	14.595	13.984	0.612

9.9 Solar Photovoltaic Program

The evaluation team conducted an in-depth interview with the Solar Photovoltaic program manager, reviewed program materials, and reviewed program tracking data for the 2018 Solar Photovoltaic program evaluation.

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

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

Program	Measure	Ex Post – Ex Ante NTGR Differences	Ex Post Values			Ex Ante – Calculated Program Values (all values calculated from gross and net values provided by the program)		
			FR	SO	NTGR	FR	SO	NTGR
Cool Homes	Traditional Split CAC Equipment (kW)	-38%	48%	0%	52%	10%	0%	90%
Cool Homes	Traditional Split CAC Equipment (kWh)	-38%	48%	0%	52%	10%	0%	90%
Cool Homes	Traditional Split CAC – QI (kW)	59%	0%	49%	149%	10%	0%	90%
Cool Homes	Traditional Split CAC – QI (kWh)	51%	0%	41%	141%	10%	0%	90%
Cool Homes	Traditional Split CAC – Total (kW)	-6%	*	*	84%	10%	0%	90%
Cool Homes	Traditional Split CAC – Total (kWh)	-25%	*	*	65%	10%	0%	90%
Cool Homes	GSHP (kW)	0%	0%	0%	100%	0%	0%	100%
Cool Homes	GSHP (kWh)	0%	0%	0%	100%	0%	0%	100%
Cool Homes	ASHP – Equipment (kW)	0%	10%	0%	90%	10%	0%	90%
Cool Homes	ASHP – Equipment (kWh)	0%	10%	0%	90%	10%	0%	90%
Cool Homes	ASHP – Quality Installation	0%	10%	0%	90%	10%	0%	90%
Cool Homes	Ductless Mini-Split (kW)	0%	10%	0%	90%	10%	0%	90%
Cool Homes	Ductless Mini-Split (kWh)	0%	10%	0%	90%	10%	0%	90%
HPDI	All Measures (kW)	-88%	*	*	41%**	0%	0%	100%
HPDI	All Measures (kWh)	-60%	*	*	31%**	0%	0%	100%
HPwES	All Measures (kW)	-88%	*	*	11%**	0%	0%	100%
HPwES	All Measures (kWh)	-12%	*	*	42%**	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 AC	0%	30%	25%	95%	30%	25%	95%
EEP	Solid State Lighting	0%	*	*	55%	45%	0%	55%
EEP	Refrigerator Recycle	-9%	52%	0%	48%	43%	0%	57%
EEP	Pool Pumps	0%	20%	10%	90%	20%	10%	90%
EEP	Smart Power Strips	0%	0%	0%	100%	0%	0%	100%

Program	Measure	Ex Post – Ex Ante NTGR Differences	Ex Post Values			Ex Ante – Calculated Program Values (all values calculated from gross and net values provided by the program)		
			FR	SO	NTGR	FR	SO	NTGR
EEP	Room AC Recycle	-9%	52%	0%	48%	43%	0%	57%
EEP	Dehumidifier Recycle	-9%	52%	0%	48%	43%	0%	57%
EEP	Super-Efficient Dryer	0%	20%	10%	90%	20%	10%	90%
EEP	ENERGY STAR Room Air Purifiers	0%	30%	15%	85%	30%	15%	85%
EEP	Clothes Washers - Most Efficient	0%	20%	10%	90%	20%	10%	90%
EEP	Heat Pump Water Heaters	0%	0%	0%	100%	0%	0%	100%
EEP	Dishwasher	0%	20%	10%	90%	20%	10%	90%
EEP	Smart Thermostat	0%	10%	0%	77%	10%	0%	77%
CEP - Lighting	Comprehensive Lighting (kW)	-20.13%	30%	1.87%	71.87%	*	*	92%
CEP - Lighting	Comprehensive Lighting (kWh)	-20.45%	30%	1.55%	71.55%	*	*	92%
CEP - Lighting	Fast Track Lighting (kW)	-20.13%	30%	1.87%	71.87%	*	*	92%
CEP - Lighting	Fast Track Lighting (kWh)	-20.45%	30%	1.55%	71.55%	*	*	92%
CEP - Lighting	Prescriptive Lighting (kW)	-20.13%	30%	1.87%	71.87%	*	*	92%
CEP - Lighting	Prescriptive Lighting (kWh)	-20.45%	30%	1.55%	71.55%	*	*	92%
CEP - Non-Lighting	HVAC (kW)	-18.13%	30%	1.87%	71.87%	*	*	90%
CEP - Non-Lighting	HVAC (kWh)	-18.45%	30%	1.55%	71.55%	*	*	90%
CEP - Non-Lighting	Compressed Air (kW)	-19%	30%	1.87%	71.87%	*	*	91%
CEP - Non-Lighting	Compressed Air (kWh)	-19%	30%	1.55%	71.55%	*	*	91%
CEP - Non-Lighting	Refrigeration (kW)	-28%	30%	1.87%	71.87%	*	*	100%
CEP - Non-Lighting	Refrigeration (kWh)	-28%	30%	1.55%	71.55%	*	*	100%
CEP - Non-Lighting	Refrigeration (vending) (kW)	-27%	30%	1.87%	71.87%	*	*	99%
CEP - Non-Lighting	Refrigeration (vending) (kWh)	-27%	30%	1.55%	71.55%	*	*	99%
CEP - Non-Lighting	Motors and VFDs (kW)	8%	30%	1.87%	71.87%	*	*	64%
CEP - Non-Lighting	Motors and VFDs (kWh)	8%	30%	1.55%	71.55%	*	*	64%
CEP - Non-Lighting	Building Envelope (kW)	-28%	30%	1.87%	71.87%	*	*	100%
CEP - Non-Lighting	Building Envelope (kWh)	-28%	30%	1.55%	71.55%	*	*	100%
CEP - Non-Lighting	Thermal Energy Storage (kW)	0%	*	*	100%	*	*	100%
CEP - Non-Lighting	Thermal Energy Storage (kWh)	0%	*	*	100%	*	*	100%

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 - Custom	All Measures (kW)	-18.13%	30%	1.87%	71.87%	*	*	90%
CEP - Custom	All Measures (kWh)	-18.45%	30%	1.55%	71.55%	*	*	90%
CEP – CHP	All Measures (kW and kWh)	0%	*	*	93%	*	*	93%
REAP	All Measures (kW)	-60%	*	*	40%**	0%	0%	100%
REAP	All Measures (kWh)	-51%	*	*	49%**	0%	0%	100%
Renewables	Solar Photovoltaic (kW)	0%	*	*	100%	*	*	100%
Renewables	Solar Photovoltaic (kWh)	0%	*	*	100%	*	*	100%
HEM	All Measures (kWh)	16%	*	*	116%**	*	*	100%

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

** These numbers are realization rates calculated through combined consumption analysis and engineering analysis.

Appendix B. 2018 Verified Ex Ante Savings

Background

PSEG Long Island has requested that the Opinion Dynamics evaluation team provide "verified ex ante" energy and demand savings as part of its evaluation of PSEG Long Island's 2018 energy efficiency and renewable energy programs. This memo defines "verified ex ante" savings and presents the 2018 verified ex ante savings for each program.

Definition of Verified Ex Ante

Beginning with program year 2015, PSEG Long Island has requested annually that the Opinion Dynamics evaluation team develop a verified ex ante savings metric as a comparison to the established annual savings goals. To allow for direct comparison, the methods and assumptions used to develop the verified ex ante savings values are consistent with the methods and assumptions used by PSEG Long Island to develop their annual plan for program savings, which are the basis of the annual savings goals. In other words, for each program measure documented in PSEG Long Island's tracking data in 2018, the evaluation team estimated the associated savings using the same methods and assumptions used by PSEG Long Island in its program planning and goal setting process for the 2018 program year.

It should be noted that the *verified ex ante* savings presented below are not equivalent to the *evaluated net savings* and *ex post net savings* developed each year as part of the evaluation team's annual impact evaluation of the PSEG Long Island's efficiency and renewable energy programs, which we will be delivering by June 1st. The evaluation team's efforts to develop 2018 *evaluated* and *ex post* savings estimates for the 2018 program year are ongoing. The reported verified ex ante savings result from the evaluation team's efforts to verify that the ex ante savings claimed by each program are developed using methods (i.e., calculations, assumptions, and NTGRs) that are consistent with those used in the planning and goal setting process.

Table B1 summarizes the 2018 verified ex ante savings.

Summary of 2018 Verified Ex Ante Savings and Goals

Table B1. Summary of 2018 Verified Ex Ante Savings Goals

Program	2018 Net Savings Goals		Ex Ante Net Savings		Verified Ex Ante Savings		Verified Ex Ante Realization Rate	
	MWh	MW	MWh	MW	MWh	MW	MWh	MW
Total Commercial[1]	**97,802**	**24.9**	**99,521**	**21.0**	**99,108**	**20.9**	**100%**	**99%**
Energy Efficient Products[2]	112,363	24.68	135,527	29.70	136,036	27.94	100%	94%
Cool Homes[3]	3,234	2.42	3,425	2.34	3,528	2.39	103%	102%
Residential Energy Affordability Partnership[4]	1,920	0.49	2,001	0.49	1,907	0.48	95%	97%
Home Performance[5]	3,682	2.72	3,473	2.18	3,458	2.17	100%	100%
Home Energy Management[6]	40,000	N/A	47,810	N/A	47,845	N/A	100%	N/A
Total Residential	**161,198**	**30.3**	**192,237**	**34.7**	**192,774**	**33.0**	**100%**	**95%**
Energy Efficiency Total	**259,000**	**55.3**	**291,758**	**55.7**	**291,882**	**53.8**	**100%**	**97%**
Renewable Total	**9,948**	**4.0**	**14,663**	**6.0**	**14,663**	**6.0**	**100%**	**100%**
Total Portfolio	**268,948**	**59.3**	**306,421**	**61.7**	**306,545**	**59.8**	**100%**	**97%**

Note: numbers may not sum due to rounding

1) **Commercial Efficiency program (CEP):** The evaluation team performed desk reviews for a sample of CEP lighting projects and found minor discrepancies with prescriptive deemed savings values in LM Captures that incorrectly included waste heat factors twice. This portion of the CEP lighting program is being phased out and was not significant enough to contribute to changes in overall CEP realization rates. Additionally, during the database review for the HVAC component, we found a small number of projects (ten projects) with inconsistent EER values tracked in LM Captures Database compared with the EER values used in the worksheet calculations. We also found that the net-to-gross ratio of HVAC measures for 2016 project applications (projects completed in 2018) in LM Captures database (92%) was higher than the CEP planning net-to-gross ratio (90%) used in other projects. We note that the net-to-gross issue was limited to 2016 project applications and has since been corrected in all 2017 and 2018 project applications. The evaluation team did not perform any verification of 2018 custom projects. Verified ex ante savings for custom projects utilize a realization rate from desk reviews of a sample of custom projects developed for the 2014 evaluation (86% for demand and 96% for energy savings). The 99% demand realization rate for CEP is largely due to the realization rate applied to custom projects.
2) **Energy Efficient Products (EEP):** The only verified ex ante discrepancy identified in the EEP program is the result of rounding at the measure level. Program year 2018 was the first year that EEP data was tracked within LM Captures. The per-unit savings values were rounded to 3 decimal places in LM Captures, whereas planning assumptions are based on formulas and therefore result in more precise values. Because the per-unit savings values were rounded, then applied to 4.77 million products, this has significant effects on the program's realization rate. This issue affects all measures for both demand and energy savings but is most apparent in the LED demand savings.
3) **Cool Homes:** The evaluation team performed a desk review and verified the appropriate application of the program's planning assumptions. For a considerable number of CAC and ASHP installations, the ex ante gross impacts (demand and energy) did not consider savings from quality installations (QI) for measure names that did not appear to have an equipment-only classification in the LM Captures database. This adjustment resulted in a higher than 100% verified ex ante realization rate. We also found differences in baseline efficiency values specified by the planning document and the actual values in LM Captures for ASHP, split CAC, GSHP, and ductless mini-split units. A significant number of projects used less stringent baseline EER, SEER, and HSPF values than specified by the planning document to estimate ex ante savings, and also used different values for equivalent full load heating and cooling hours than those provided in planning assumptions.
4) **Residential Energy Affordability Partnership (REAP):** The lower verified ex ante MWh savings is due to a difference in the application of installed efficiency values. For measures where pre or post efficiency values were used in the planning assumptions and available in LM Captures, the evaluation team applied the actual values, whereas the tracking data applied planning values. This methodology is consistent with how the evaluation team has calculated verified ex ante for this program in the past and based on discussions with PSEG Long Island. The slightly lower verified ex ante MW savings for the REAP

program is due to rounding at the measure level. The per-unit savings were rounded to three decimal places in LM Captures, whereas planning assumptions were based on formulas and therefore result in more precise values.

5) Home Performance Programs: The evaluation team was unable to perform a comprehensive verification of ex ante savings for Home Performance with ENERGY STAR projects due to limited visibility into the program contractors' building energy modelling software-based savings estimates. Instead, the evaluation team reviewed the per-project and per-measure savings to ensure they were reasonable. The evaluation team also verified the count of thank you kits, and appropriate application of the program's planning assumptions for LED and advanced power strips (APS) gross savings to estimate the verified ex ante savings. The ex ante savings were appropriately calculated, but were rounded based on planning values, which is the cause of the slight discrepancy with verified ex ante MW savings. The evaluation team also calculated a slightly lower verified ex ante MW savings for the HPD program due to rounding at the measure level. The per-unit savings were rounded to 3 decimal places in LM Captures, whereas planning assumptions were based on formulas and therefore result in more precise values.
6) Home Energy Management: The evaluation team used the deemed savings planning assumption of 25.15 kWh per mailed home energy report and applied this to the total number of HEM reports mailed in 2018. Some HEM program participants began to be treated as Super Saver customers beginning in May of 2018. Reports mailed to these customers prior to when the Super Saver home energy reports began to be mailed are treated as HEM reports and included in the savings shown here. This analysis resulted in 1,902,418 reports attributed to the HEM for the VEA, compared to 1,901,042 claimed (ex ante) reports.

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