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# Energy Efficiency and Renewable Energy Portfolios

## 2019 Annual Evaluation Report (Volume II – Program Guidance Document)

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**Prepared for:**

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# Table of Contents

Opinion Dynamics

# Table of Tables

# Table of Figures

# 1. Introduction

Volume II of the 2019 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, which is now a part of TRC Companies. In 2017, PSEG Long Island added the Home Energy Management program to the Energy Efficiency Portfolio, implemented by its subcontractor, Tendril, which is now part of Uplight. PSEG Long Island continues to implement the Renewable Energy Portfolio. This evaluation covers the period from January 1, 2019, to December 31, 2019.

Opinion Dynamics created this document for use by PSEG Long Island and TRC 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, ex post gross, and ex post net. 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 2019 program year (PY). 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 ex post savings.
- 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.
- Appendix C presents a Glossary of Terms used in this report.

## 1.1 Key Definitions

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

- Gross Impacts: The change in energy consumption or demand that results directly from program-related actions taken by participants, regardless of why they participated. These impacts include coincidence factors (CFs) for demand, waste-heat factors, and installation rates. Gross impacts presented in this report do not include line losses and, therefore, represent the energy and demand savings as would be measured at the customers' meters.
- Net Impacts: The change in energy consumption or demand that results directly from program-related actions taken by customers (both program participants and non-participants) that 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 impacts presented in this report also include line losses and, therefore, represent the energy and demand savings as would be measured at the generator.

- Net-to-Gross Ratio (Free-Ridership and Spillover): The factor that, when multiplied by the gross impacts, 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 Gross Savings: The energy and demand savings expected by the program as found in the program tracking database.
- Verified Ex Ante Gross 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.
- Ex Post Net Savings: The savings realized by the program after independent evaluation determines ex post gross savings and applies ex post NTGRs developed by the evaluation team. Ex post net savings also include line losses. 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 6.0% on energy consumption (resulting in a multiplier of 1.0638 = [1 ÷ (1 − 0.060)]) and of 8.5% on peak demand (resulting in a multiplier of 1.0929 = [1 ÷ (1 − 0.085)]) to estimate energy and demand savings at the power plant.
- kW (Demand or Capacity): The average level of power used for an hour. Peak demand is the average power used across a four-hour period when there is high use. For Long Island, peak demand may take place anytime from 2 pm to 6 pm, 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 4 pm and 5 pm 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 6.16% in the 2019 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 6.16% 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 6.16%. 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 ex post gross 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 gross energy and demand savings associated with PSEG Long Island's programs. The majority of our gross impacts come from engineering analyses using algorithms and inputs derived from the program tracking databases. We also performed consumption analyses[1] 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 2019 custom projects.

When conducting the 2019 impact evaluation, the evaluation team relied primarily upon the 2019 PSEG Long Island Technical Reference Manual (TRM),[2] as well as any relevant primary research that was available to both the implementation and evaluation teams before the start of the 2019 program year (e.g., *2018 PSEG Long Island Commercial and Residential Potential Study 2019–2038*). Additionally, to bolster gross savings calculations when primary data were unavailable, the evaluation team referenced several secondary sources,

[1] 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."

[2] The evaluation team also consulted the 2020 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 2020 Prospective TRM delivered in June 2019, is intended for use in 2020 program planning and ex ante savings calculations. Therefore, while we leveraged some assumptions from this document in the 2019 evaluation, we did not incorporate code or other changes in the 2019 evaluation that are specific to the future planning efforts.

such as the New York State TRM version 6 (NY TRMv6), and other regional TRMs and relevant studies, where applicable. Finally, the evaluation team leveraged 2019 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 2019 program.

Information made available to the evaluation team after the start of the 2019 program year will be used in future evaluations. This includes the Solar Output Study completed at the end of 2018. 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 2019 PSEG Long Island TRM.

The evaluation team's ex post gross impacts are used for the determination of annual demand and energy savings toward PSEG Long Island's annual goal attainment. In addition, these ex post gross savings are used to inform any needed adjustments to program planning and ex ante assumptions. Based on the specific requirements of each use, we developed the two separate gross savings estimates described below.

#### Verified Ex Ante Gross 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 gross 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 end of January. The memorandum is presented in Appendix B of this report.

#### Ex Post Gross Savings

The evaluation team calculates ex post gross savings using detailed measure-level tracking information and applying the best information and methods available at the time of the evaluation to determine ex post gross savings. PSEG Long Island uses the ex post gross savings to refine its savings estimates going forward and help inform its program planning and goal setting process for the next program year. The ex post gross savings and the realization rate of ex post savings compared to ex ante savings are the primary focus of this report. In 2019, PSEG Long Island's savings goals shifted from net savings at the generator to gross savings at the customer's meter to be in alignment with the targets established by the New Efficiency: New York December 2018 Order.[3] As such, PSEG Long Island began tracking its program savings in terms of gross energy and demand savings without line losses in 2019, and this evaluation applies the same metrics in establishing realization rates and when comparing ex post savings to ex ante and program goals.

### 1.2.2 Net Impact Methods

The evaluation team's net impacts are primarily used as inputs to the benefit/cost assessment of PSEG Long Island programs. Among other inputs, the benefit/cost and economic impact assessments require an estimate of net program savings at the generator. 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

[3] Case 18-M-0084, In the Matter of a Comprehensive Energy Efficiency Initiative, Order Adopting Accelerated Energy Efficiency Targets (issued December 13, 2018).

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 2019, we had no new primary data collection or activities with which to update previous NTGRs. The ex post NTGR values applied within the cost-effectiveness savings are presented in Appendix A.

## 1.3 Summary of Energy and Demand Gross Impacts

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

Table 1-1. Portfolio Evaluated Gross Impacts

| Program | Ex Ante Gross Savings | | Verified Ex Ante Gross Savings | | Ex-Post Gross Savings | | Realization Rate[a] | |
|---|---|---|---|---|---|---|---|---|
| | MWh | MW | MWh | MW | MWh | MW | MWh | MW |
| Energy Efficiency Portfolio | | | | | | | | |
| Commercial Efficiency Program | 98,720 | 17.59 | 97,743 | 17.81 | 94,983 | 17.65 | 96% | 100% |
| Residential Efficiency Programs | | | | | | | | |
| Energy Efficient Products | 159,804 | 42.95 | 159,809 | 42.95 | 172,583 | 42.05 | 108% | 98% |
| Home Comfort | 3,707 | 1.33 | 3,472 | 1.17 | 3,578 | 1.02 | 97% | 77% |
| Residential Energy Affordability Partnership | 1,475 | 0.41 | 1,472 | 0.36 | 1,219 | 0.29 | 83% | 70% |
| Home Performance | 2,298 | 1.65 | 2,300 | 1.65 | 2,743 | 0.96 | 119% | 58% |
| Home Energy Management | 61,313 | NA | 64,015 | N/A | 31,405 | NA | 51% | NA |
| Subtotal Residential | 228,598 | 46.34 | 231,068 | 46.13 | 211,528 | 44.32 | 93% | 96% |
| Total Energy Efficiency Portfolio (Commercial and Residential) | 327,318 | 63.93 | 328,811 | 63.94 | 306,511 | 61.96 | 94% | 97% |
| Renewable Energy Portfolio | 12,822 | 5.07 | 12,814 | 5.05 | 11,825 | 4.72 | 92% | 93% |
| Total Energy Efficiency and Renewable Energy Portfolios | 340,140 | 69.00 | 341,625 | 68.99 | 318,336 | 66.69 | 94% | 97% |

Note: Totals may not sum due to rounding.

[a] Realization rate compares ex post gross savings to ex ante gross 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. Opinion Dynamics 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-

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

electric (i.e., gas and fuel oil) energy savings where applicable, as well as non-energy benefits, resulting in different benefit totals than the UCT. Non-energy benefits (NEBs) are accounted for in the SCT through the application of a benefit "adder", which accounts for the societal benefits generated by energy efficiency programs beyond energy savings. The evaluation team applied this "adder" to 2019 evaluation results to be consistent with the methods used by PSEG Long Island in its 2019 program planning. NEB adders are commonly used in SCTs, but 2019 is the first year that we have applied it to the evaluation of PSEG Long Island's programs. A 15% adder was applied to the electric avoided costs generated by market rate programs and a 30% adder was applied for income-qualified programs (REAP)[5]. 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, that match 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 2.29 and 0.68 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 2.01 for the Energy Efficiency Portfolio and 6.48 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 2019: REAP, Home Performance, HEM, and Renewables (Solar PV). The cost-effectiveness of the REAP program increased from 0.32 in 2018 to 0.66 in 2019, with the addition of the NEB adder. Notably, cost-ineffectiveness is not unusual for low-income programs, which typically are not required to be cost-effective. The SCT ratio of the Home Performance program increased from 0.17 in 2018 to 0.54 in 2019 due to higher savings for this program in 2019, as well as the addition of the NEB adder. Conversely, The SCT ratio of the HEM program decreased from 1.5 in 2018 to 0.69 in 2019 due to lower savings for this program in 2019. 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 2018, the Home Comfort[6] program also had an SCT ratio of less than 1, however in 2019, the program achieved an SCT ratio of 1.09. This increase in cost effectiveness is primarily driven by the addition of the NEB adder to the SCT test.

The UCT was also less than 1 for Home Comfort, REAP, HEM, and Home Performance in 2019. The Renewable Energy Portfolio had a UCT ratio significantly greater than 1 in 2019, largely due to the low costs incurred by PSEG Long Island to implement this program.

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[5] An adder of 15% was applied to all measures to account for NEBs, except for in the residential low-income segment, where a 30% NEBs adder was applied. This is in line with levels in Vermont. See:
https://puc.nh.gov/EESE%20Board/Meetings/2017/021717EERSWorkshop2/OrderReCostEffectivenessScreeningofHeating.pdf

[6] Formerly called the Cool Homes Program

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 | $60,108,870 | $35,065,406 | 1.71 | $88,987,484 | $46,481,667 | 1.91 |
| Residential Efficiency Programs | | | | | | |
| Energy Efficient Products | $87,678,947 | $21,545,738 | 4.07 | $127,124,368 | $34,082,312 | 3.73 |
| Home Comfort | $3,613,581 | $4,171,394 | 0.87 | $5,174,271 | $4,754,416 | 1.09 |
| Residential Energy Affordability Partnership | $985,437 | $2,318,414 | 0.43 | $1,588,562 | $2,414,622 | 0.66 |
| Home Performance | $2,425,948 | $11,444,413 | 0.21 | $5,031,697 | $9,284,062 | 0.54 |
| Home Energy Management | $1,363,729 | $3,207,538 | 0.43 | $2,293,286 | $3,322,058 | 0.69 |
| Subtotal Residential | $96,067,642 | $42,687,497 | 2.25 | $141,212,185 | $53,857,471 | 2.62 |
| Total Energy Efficiency Portfolio (Commercial and Residential) | $156,176,512 | $77,752,903 | 2.01 | $230,199,668 | $100,339,138 | 2.29 |
| Renewable Energy Portfolio | $15,025,766 | $2,319,217 | 6.48 | $20,944,187 | $30,752,362 | 0.68 |
| Total Energy Efficiency and Renewable Energy Portfolios | $171,202,279 | $80,072,120 | 2.14 | $251,143,855 | $131,091,500 | 1.92 |

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

## 1.5 Summary of Economic Impacts

Opinion Dynamics estimated the expected changes to Long Island's overall economic output and employment resulting from PSEG Long Island's 2019 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 2019 and for the 10-year period of 2019 to 2028. 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 2019 investments in the Energy Efficiency Portfolio are expected to return $142.8 million in total economic benefits to the regional economy (in 2019 dollars), with an employment benefit of 1,056 new full-time equivalent employees (FTEs)[7] over that time period.

[7] 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 2019 Energy Efficiency Portfolio Investments

| 2019 Energy Efficiency Portfolio Investments | 2019 Economic Impact | 2019-2028 Economic Impact (NPV[a]) |
|---|---|---|
| **Economic Impact** | | |
| Total Economic Output (millions) | $75.6 | $142.8 |
| Direct Effect | $60.1 | $60.1 |
| Indirect & Induced Effects | $15.5 | $82.6 |
| Employment (FTE) | 523 | 1,056 |
| **Impact per $1M Investment** | | |
| 2019 Program Investment (millions) | $78.7 | $78.7 |
| Total Economic Output in M per $1M Investment | $0.96 | $1.8 |
| Employment (FTE) per $1M Investment | 6.7 | 13.4 |

[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 higher total economic output in 2019 ($75.6 million) than in 2018 ($73.0 million), reflecting an increase in program expenditures as well as adjustments to the composition of the Energy Efficiency Portfolio between the years.

Over 10 years, the 2019 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 $18.8 million in total economic benefits to the regional economy (in 2019 dollars), with an employment benefit of 116 new FTEs over that time period.

Table 1-4. Economic Impact of 2019 Renewable Energy Portfolio Investments

| 2019 Renewable Energy Portfolio Investments | 2019 Economic Impact | 2019-2028 Economic Impact (NPV[a]) |
|---|---|---|
| **Economic Impact** | | |
| Total Economic Output (millions) | $14.8 | $18.8 |
| Direct Effect | $17.4 | $17.4 |
| Indirect & Induced Effects | -$2.6 | $1.4 |
| Employment (FTE) | 84 | 116 |
| **Impact per $1M Investment** | | |
| 2019 Program Investment (millions) | $2.3 | $2.3 |
| Total Economic Output in M per $1M Investment | $6.3 | $8.0 |
| Employment (FTE) per $1M Investment | 35.8 | 49.4 |

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

Similar to recent results, 2019 spending on PSEG Long Island's Renewable Energy Portfolio resulted in greater benefits to the Long Island economy than in early program years. However economic impacts have declined since the peak in 2015, due to reduced funding availability through NYSERDA's NY-Sun program. The renewables portfolio still realized positive economic impacts in 2019; however, with very little NY-Sun funds available, this results in lower overall economic output compared to its peak.

# 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 and providing other types of support, such as energy audits and technical assistance studies. The CEP is delivered through several distinct program components, as noted below. In 2019, PSEG Long Island continued to optimize the CEP to best address current market conditions and customer and contractor needs. In 2019, the CEP included the following components:[8]

- Comprehensive Lighting: The Comprehensive Lighting component includes 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. In 2018, CEP administrators transitioned from a fixed incentive rate to a performance-based incentive measured in dollars per expected kilowatt-hour savings. In addition, program staff updated eligibility requirements to allow all commercial customer classes to apply for Comprehensive Lighting incentives. All projects continue to require preapproval and pre-inspection (except for new construction) and are subject to post-inspection.
- Fast Track Lighting: The Fast Track Lighting component previously limited its applicants to commercial small business customers (billed under rate codes 280 or 281), but now includes customers from all rate classes. The program participation process is streamlined and designed to address key barriers to participation (e.g., lack of time and resources) among small business customers. Fixed rebates are prescribed for each measure. The measures offered 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.
- Exterior Lighting: The Exterior Lighting component includes incentives for exterior lighting replacement and retrofit measures and accepts customers of all rate classes. Rebates are offered on a per-unit basis. All projects require preapproval and pre-inspection and are subject to post-inspection.
- Heating, Ventilation, and Air Conditioning (HVAC): The HVAC component includes high-efficiency air conditioners (ACs) and heat pumps, including ductless mini-split heat pumps, variable refrigerant flow heat pumps, and geothermal heat pumps.[9]
- Standard: All other prescriptive measure offerings fall under the Standard program component. This includes building envelope measures, compressed air, refrigeration, and variable frequency drives (VFDs).[10] Standard projects require preapproval and are subject to pre- and post-inspections.
- Custom/Whole Building Design: The Custom/Whole Building Design component 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 New York State building codes. Custom projects offer flexibility in equipment choices and incentive

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[8] CEP administrators also claimed savings achieved through the Online Marketplace component in 2019, although this channel represents a *de minimis* proportion of 2019 CEP energy and demand savings.
[9] CEP administrators launched a standalone geothermal heat pump 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.
[10] CEP administrators introduced a standalone refrigeration application in 2019, but rebates and savings are still included in the Standard component.

amounts, allowing PSEG Long Island to meet customer needs better 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.

In addition to the core components described above, PSEG Long Island's 2019 CEP portfolio included no-cost energy assessments, cost-shared technical assistance studies, building commissioning co-funding, Leadership in Energy and Environmental Design (LEED) certification incentives, Online Marketplace, and ENERGY STAR® Benchmarking certification. Only savings from the Online Marketplace were claimed in 2019.

### 2.1.1 Program Design and Implementation

CEP administrators take steps to adapt the program design and implementation process to suit the needs of their business customers better. Recent changes from 2018 and 2019 that played an important role in program performance are:

- Offering rebates for new prescriptive refrigeration measures within the Standard component,
- Offering performance-based lighting rebates through the Comprehensive Lighting program component for the entire program year, and
- Offering a landlord incentive for three months of the program year.

Each of the program additions are described in more detail below.

#### Refrigeration Rebates

PSEG Long Island introduced a standalone refrigeration application in 2019. The new application covered refrigerated case lighting and a variety of prescriptive refrigeration measures including ENERGY STAR refrigerators and freezers, electronically commutated fan motors, floating head pressure controls, evaporators, and refrigerator night covers. Program staff developed a standalone application for refrigeration projects after witnessing an increase in applications in 2018. Since then, program staff report a continued increase in refrigeration projects in the pipeline.

#### Performance Lighting Rebates

2019 marks the first full program year since PSEG Long Island began implementing performance-based incentives for Comprehensive Lighting. 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 to performance-based savings aligns rebates with the claimable savings and internal program budgets. According to program staff, this shift in incentive design-focused contractor efforts on high-value opportunities, such as replacing existing T12s and older T8s with LEDs, which generate higher per-unit savings and now deliver a commensurate incentive.

#### Landlord Incentives

PSEG Long Island offered limited-time landlord incentives from January through March 2019 to facilitate and encourage energy efficiency upgrades for customers who occupy multi-unit buildings. Landlords who participated in the CEP could have received an additional payment ranging from $500 to $10,000 depending on the dollar amount of their original rebate. Although program staff considered the landlord incentive to be effective at driving landlords and their tenants to participate, PSEG Long Island discontinued the incentive due to budgetary considerations.

### 2.1.2 Program Participation and Performance

PSEG Long Island's CEP performed well in 2019, with its verified ex ante gross savings achieving 102% of the energy savings goal and 90% of the peak demand goal. Table 2-1 presents 2019 CEP performance compared to goals.

Table 2-1. 2019 CEP Verified Ex Ante Gross Program Performance Against Goals

| Metric | MWh | MW |
|---|---|---|
| Goal | 95,953 | 20 |
| Verified Ex Ante Gross Savings | 97,743 | 18 |
| % of Goal | 102% | 90% |

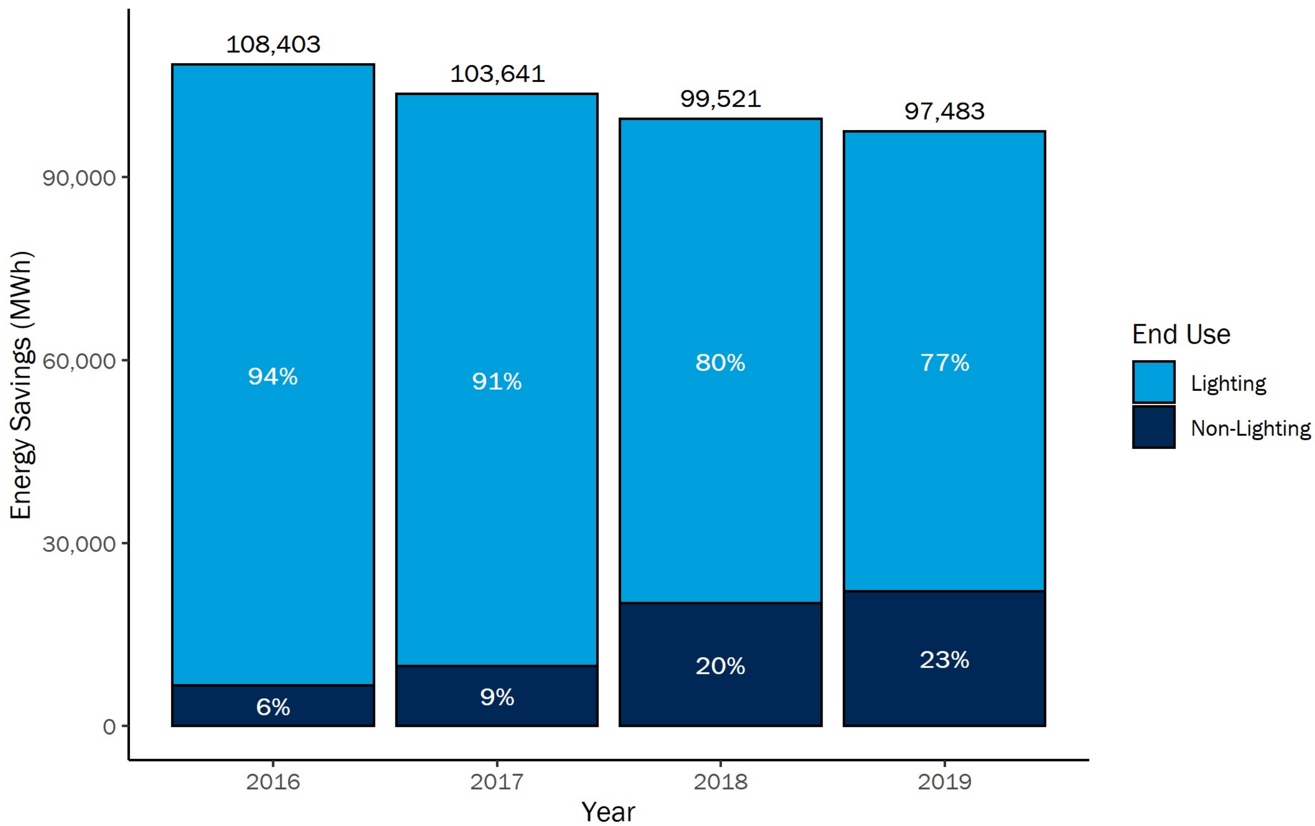
Comprehensive Lighting projects accounted for the largest share of CEP ex ante gross energy and demand savings in 2019. As shown in Table 2-2, Comprehensive Lighting projects accounted for 58% of ex ante gross energy savings and 78% of ex ante gross demand savings in 2019. Exterior Lighting accounted for 13% of ex ante gross energy savings but no demand savings in 2019.

Table 2-2. 2019 CEP Ex Ante Gross Savings by Program Component

| Program Component | Ex Ante Gross Savings | |
|---|---|---|
| | MWh% | MW% |
| Comprehensive Lighting | 58% | 78% |
| Exterior Lighting | 13% | 0% |
| Custom (CHP) | 9% | 6% |
| Standard | | |
| *Refrigeration* | 5% | 2% |
| *Motors & VFDs* | 2% | 1% |
| *Compressed Air* | 1% | <1% |
| *Building Envelope* | <1% | <1% |
| Standard Subtotal | 8% | 3% |
| Fast Track Lighting | 5% | 6% |
| Custom (non-lighting) | 5% | 2% |
| HVAC | 2% | 4% |
| Custom (lighting) | <1% | <1% |
| Online Marketplace | <1% | <1% |

While the CEP continues to rely 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 77% in 2019, as shown in Figure 2-1.

Figure 2-1. Historical Ex Ante Net Energy Savings by End Use




Note: This figure presents net savings as opposed to gross savings to facilitate comparisons with prior evaluations.

### 2.1.3 Program Marketing

Program marketing and outreach efforts in 2019 remained largely consistent with prior years. PSEG Long Island leveraged a range of marketing strategies and tactics to broaden customer and trade ally awareness of the CEP and its benefits. Marketing strategies in 2019 continued to be focused on leveraging trade allies and TRC energy consultants to educate customers about program offerings. Consistent with prior years, PSEG Long Island held a contractor breakfast informing trade allies about new commercial and residential offerings. PSEG Long Island, in addition, employed the use of pamphlets, flyers, calendars, and other branded materials to deliver program messaging.

PSEG Long Island continued to participate in a variety of events with community partners such as the U.S. Green Buildings Council. PSEG Long Island also hosted a conference in 2019, focused on CHP and refrigeration, which saw high attendance, according to program staff.

### 2.1.4 Anticipated Changes in 2020

To better align with New York State goals for greenhouse gas (GHG) reductions the program will begin targeting MMBtu reductions by introducing a variety of new non-lighting measures and rolling out further performance-based applications in 2020. Anticipated changes to CEP in 2020 include:

- Discontinuing incentives for fuel cells and CHP projects, because of site-level fossil fuel GHG impacts
- Introducing a performance-based HVAC application with incentives on a dollar-per-MMBtu basis
- Offering incentives focused on beneficial electrification, such as electric lawnmowers, battery-powered lawn tools, and small commercial electric vehicles, such as golf carts or forklifts
- Investigating green roofs, anaerobic digesters, and other non-traditional measures to help drive site-level fossil fuel reductions.

## 2.2 Commercial Efficiency Program Impacts

The following sections provide the results of the engineering analysis for the CEP. Section 2.2.1 presents ex post gross savings, and Section 2.2.2 presents ex post net savings. Ex post gross savings differ from ex post net savings in that ex post net savings are developed using ex post NTGRs and line loss factors for energy and demand, while ex post gross savings do not include those factors. For a detailed list of NTGRs see Appendix A.

### 2.2.1 Ex Post Gross Impacts

Table 2-3 compares ex post gross savings to ex ante gross savings and shows the associated realization rates by program component. The evaluation team calculated realization rates by dividing ex post gross savings values by ex ante gross savings values. Overall, the CEP achieved 96% of its ex ante gross energy and 100% of its ex ante gross demand savings. Ex post gross realization rates for energy savings ranged from 79% for the Fast Track Lighting program component to 143% for the Standard Refrigeration program component. Ex post gross realization rates for demand savings ranged from 80% for the Custom (lighting) program component to 243% for the Standard Compressed Air program component.

Table 2-3. 2019 CEP Ex Post Gross Impacts

| Program Component | Ex Ante Gross Savings | | Ex Post Gross Savings | | Realization Rate | |
|---|---|---|---|---|---|---|
| | kWh | kW | kWh | kW | kWh | kW |
| Comprehensive Lighting | 57,520,766 | 13,721 | 54,114,456 | 13,522 | 94% | 99% |
| Exterior Lighting | 12,961,696 | 0 | 13,025,274 | 0 | 100% | N/A |
| Custom (CHP) | 8,584,753 | 1,074 | 8,708,670 | 1,056 | 101% | 98% |
| Standard | | | | | | |
| *Refrigeration* | 4,492,735 | 296 | 4,399,943 | 436 | 98% | 147% |
| *Motors & VFDs* | 2,352,766 | 138 | 3,372,413 | 151 | 143% | 109% |
| *Compressed Air* | 819,123 | 60 | 766,007 | 149 | 94% | 248% |
| *Building Envelope* | 199,974 | 81 | 190,241 | 90 | 95% | 111% |
| Standard Subtotal | 7,864,597 | 576 | 8,728,604 | 825 | 111% | 143% |
| Fast Track Lighting | 5,330,565 | 1,081 | 4,191,456 | 1,096 | 79% | 101% |
| Custom (non-lighting) | 4,577,894 | 323 | 4,349,000 | 258 | 95% | 80% |

| Program Component | Ex Ante Gross Savings | | Ex Post Gross Savings | | Realization Rate | |
|---|---|---|---|---|---|---|
| | kWh | kW | kWh | kW | kWh | kW |
| HVAC | 1,589,946 | 775 | 1,588,687 | 857 | 99% | 111% |
| Custom (lighting) | 286,215 | 40 | 271,904 | 32 | 95% | 80% |
| Online Marketplace | 3,801 | 1 | 4,496 | 1 | 118% | 133% |
| CEP Total | 98,720,235 | 17,590 | 94,982,548 | 17,648 | 96% | 100% |

Note: Totals may not sum due to rounding.

The Comprehensive Lighting (58%), Exterior Lighting (13%), CHP (9%), and Standard (8%) program components together represent 88% of the overall CEP ex post gross 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.

## Combined Heat and Power Project Savings

The 2019 program year included three CHP projects. Overall, CHP ex ante gross savings, ex post gross savings, and realization rates are shown in Table 2-3 above, under "Custom (CHP)." The three projects consist of electricity generation through natural gas engines and waste heat recovery. Table 2-4 summarizes the electricity savings, additional gas consumption to produce the electricity, and gas savings through waste heat recovery.

Table 2-4. 2019 Combined Heat and Power Project Summary

| Project ID | Ex Ante Gross Savings | | Ex Post Gross Savings | | | | |
|---|---|---|---|---|---|---|---|
| | kWh | kW | kWh | kW | Additional Gas Consumption (therms) | Heat Recovery Savings (therms) | Total Facility Net Gas Impact (therms) |
| 2017-1725751 | 1,210,997 | 146 | 1,171,318 | 149 | (70,713) | 49,578 | (21,135) |
| 2017-1726948 | 2,067,310 | 251 | 2,089,031 | 251 | (144,402) | 73,283 | (71,119) |
| 2018-1736430 | 5,306,446 | 678 | 5,448,321 | 656 | (437,362) | 184,902 | (252,460) |
| CHP Total | 8,584,753 | 1,074 | 8,708,670 | 1,056 | (652,477) | 307,763 | (344,714) |

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.

### Comprehensive Lighting

The evaluation team utilized a mixed-methods approach following the program administrator's year-long effort to initiate robust tracking of measure-level information. For lighting replacement measures, the evaluation team conducted a population-level analysis of savings for the first time with this program, while lighting control measures lacking key information in the program tracking data underwent a desk review analysis of a representative sample with the expansion of results to the population.

- A small portion (3%) of incented measures do not include information on the installed lamp wattage in program tracking data extracted from Captures. While the information was available through the individual project workbooks, the evaluation team determined that averages from program tracking data for similar measures accurately estimated the connected kW for replacement equipment. This evaluation adjustment resulted in a 3% reduction in comprehensive lighting energy and demand savings because the program administrator assumed the efficient lighting energy use and demand was zero.

- For projects that included occupancy sensors, the program administrators assumed an energy savings factor (ESF) ranging between 13% and 50% depending on sensor type. The evaluation team applied a 30% ESF per the 2019 PSEG Long Island TRM, resulting in a slight decrease in ex post gross savings.
- Through the desk reviews, the evaluation team found that program tracking data did not include gross demand savings for 13% of the occupancy sensors sample. We observed a similar rate (17%) of missing demand savings in the population of occupancy sensor measures. The 255% realization rate for occupancy sensor demand savings calculated through the desk reviews is representative of the population, including those projects without gross demand savings recorded. The effect on the overall Comprehensive Lighting program component demand savings is an increase of approximately 1.7%.

### Standard

The Standard program component offers energy savings opportunities for Refrigeration, Compressed Air, Motors and VFDs, and Building Envelope measures.

- **Refrigeration** measures represent 57% of ex ante energy savings in the Standard component and 5% of overall CEP ex ante energy savings. The ex post gross energy and demand realization rates are 98% and 147%, respectively. Because program administrators do not track comprehensive project- and measure-specific information, inhibiting a population-level evaluation, the evaluation team performed desk reviews. We leveraged project documents to determine measure-specific parameters and derive energy and demand savings,[11] applying the methods specified by the 2019 PSEG Long Island TRM.[12] The program administrator used a mix of sources for savings assumptions, including the 2019 PSEG Long Island TRM, historic program data, and the 2010 LIPA Technical Manual. However, the evaluation team requested but did not receive specific input assumptions utilized by the program administrator, preventing the evaluation team from identifying specific input discrepancies.
- **Compressed Air** measures represent 10% of ex ante total energy savings within the Standard component. The evaluation team calculated similar realization rates for ex post gross energy (94%) and demand (248%) savings as in 2018. In general, the program administrator utilized the 2010 LIPA Technical Manual algorithms and assumptions, while the evaluation team followed the 2019 PSEG Long Island TRM, leading to differences in demand and energy savings. The following observations account for most of the difference in savings:
  - For variable displacement measures, the program administrator assumes a 0.0527 kW/hp savings factor, and the evaluation team used a 0.116 kW/hp savings factor--a 120% increase. Further, the program administrator applies a 502 kWh/hp savings factor in comparison to the 476 kWh/hp savings factor applied by the evaluation team; a 5% decrease.
  - For air dryer measures, the program administrator claims no demand savings following the 2010 LIPA Technical Manual. The evaluation team applied the 2019 PSEG Long Island TRM and

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

[12] Several measures (refrigerator and freezer walk-in strip curtains, floating head pressure controls, ENERGY STAR refrigerator or freezer, refrigerator and freezer night covers, refrigerator and freezer case door retrofit, and zero energy doors) were new in the 2019 program year and not included in the 2019 TRM. For these measures, the evaluation team used the 2020 PSEG Long Island TRM.

calculated demand savings associated with these measures, increasing the overall compressor demand realization rate.

- Motor and VFD measures represent 30% of ex ante total energy savings within the Standard component (an increase from 7% in 2018). The engineering analysis resulted in the ex post gross realization rate of 143% for energy savings and 109% for demand savings.
  - Program tracking data contained detailed information for each installation that enabled the evaluation team to conduct engineering analyses by facility and motor type. We used normalized savings values (i.e., kW/hp or kWh/hp) that the 2019 PSEG Long Island TRM recommends based on different building types and VFD applications.
  - The evaluation team believes that ex ante savings are based on the 2010 LIPA Technical Manual planning document for VFD savings factors, resulting in significant savings differences.
- Building Envelope measures represent 3% of ex ante total energy savings within the Standard component. The following discrepancies resulted in 95% and 111% realization rates for energy and demand savings, respectively:
  - The evaluation team used installation-specific building types, installed areas, and normalized savings values (kW/sf or kWh/sf) by building type as recommended by the 2019 PSEG Long Island TRM. Conversely, ex ante savings rely on the New York State Energy Efficiency Portfolio Standard for normalized savings values.

### Combined Heat and Power

The ex post gross realization rates are 101% and 98% for gross energy and demand savings, respectively, for three projects completed in 2019. The evaluation team received a combination of monthly reports and AMI metering data that provided the CHP systems' cumulative runtime, electricity generation, and waste heat output. For all three projects, the evaluation team received 15-minute facility AMI data for the post-installation period; the pre-installation period AMI data was available for two of the three projects.

To estimate the electric energy impacts for all three projects, the evaluation team first calculated typical power production, adjusting for seasonal demand variation when applicable. The average produced power (kW) was then multiplied by an estimated annual operating hours to account for system downtime and maintenance.

- The ex post gross demand savings are slightly lower than ex ante primarily due to differences in electrical production. For all three projects, actual performance data gleaned from AMI data, showed a slight decrease in electricity production. Estimated annual operating hours were slightly higher in two projects and lower in one project, with a cumulative offsetting effect on overall energy realization rates.
- Using manufacturer data and CHP modeling software, the evaluation team also quantified the required natural gas input as well as the estimated recovered thermal energy for each of the three projects, totaling 307,763 therms per year overall.

### Custom Program Component

For both the Custom (non-lighting) and Custom (lighting) measures, the evaluation team applied the Custom Component realization rates (95% for energy savings and 80% for demand savings) from the 2012 impact evaluation.[13]

### Fast Track Lighting

The evaluation team observed one discrepancy between claimed and evaluated savings relating to operating hours assumptions.

- The program administrators apply operating hours from the 2010 LIPA Technical Manual, referencing studies from 1994 and 1996. Conversely, the evaluation team adheres to the operating hours assumptions provided in the 2019 PSEG Long Island TRM, which pulls from the NY TRM v6.1.[14] This difference in hours assumptions accounts for all of the difference between claimed and evaluated energy and demand savings, resulting in the 79% gross energy realization rate and 101% demand realization rate.

### HVAC

Several factors led to discrepancies between ex ante and ex post gross savings, resulting in realization rates of 99% for energy and 111% for demand savings:

- The primary difference in energy savings for HVAC measures is the baseline heating seasonal performance factor (HSPF) for ground source heat pumps (GSHP). The evaluation team applied the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard 90.1 2013 baseline HSPF of 11.26 (COP of 3.3), while the program administrator assigned an HSPF of 7.7 (COP of 2.7), possibly coming from the ASHRAE 90.1 2010 manual. This difference had a minimal impact on HVAC program energy savings realization due to GSHP small share of program component savings.
- In 2018, the evaluation team updated the assumed CF from 0.72 to 0.80 to align with the 2018 PSEG Long Island TRM. This continues to be a difference in assumptions in 2019 and is the primary driver of the 111% demand realization rate.

### Exterior Lighting

The evaluation team did not find any issues that led to the realization rate discrepancies.

### Other Program Components

For the Other Program Components, which include the Building Operator Trainings (none completed in 2019) and the Online Marketplace, the evaluation team found one discrepancy for the Online Marketplace measures:

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13 Realization rates are based on post-installation measurement and verification of 67 sites for the 2012 impact evaluation; LIPA Efficiency Long Island and Renewable Energy Portfolio 2012 Program Guidance Document found at https://www.psegliny.com/aboutpseglongisland/legalandregulatory/-/media/7483A6F1EF7B45AD853DA36BE9A8334F.ashx

14 The New York State TRM v6.1 (effective January 31, 2019 through December 31, 2019) is available at http://www3.dps.ny.gov/W/PSCWeb.nsf/All/72C23DECFF52920A85257F1100671BDD

- The evaluation team found that savings tracked in TRC's Captures database do not account for cooling bonuses for either energy or demand savings for lighting measures. We include cooling bonuses in ex post gross savings, resulting in larger energy and demand impacts compared to ex ante savings.

### 2.2.2 Ex Post Net Impacts for Cost-Effectiveness

Table 2-5 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 84% for energy savings and 78% for demand savings. Ex post realization rates for energy savings ranged from 54% for the Fast Track Lighting program component to 97% for the CHP program component. Ex post realization rates for demand savings ranged from 60% for the Fast Track Lighting program component to 119% for the Standard program component.

Table 2-5. 2019 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 | 56,445,200 | 13,939 | 48,189,392 | 10,754 | 85% | 77% |
| Exterior Lighting | 12,756,480 | 0 | 9,914,451 | 0 | 78% | N/A |
| Custom (CHP) | 8,917,831 | 1,150 | 8,616,025 | 1,073 | 97% | 93% |
| Standard | | | | | | |
| *Refrigeration* | 4,452,047 | 302 | 3,349,105 | 342 | 75% | 113% |
| *Motors & VFDs* | 1,622,677 | 98 | 2,566,981 | 118 | 158% | 121% |
| *Compressed Air* | 810,748 | 61 | 583,061 | 117 | 72% | 191% |
| *Building Envelope* | 198,045 | 82 | 144,806 | 70 | 73% | 86% |
| Standard Subtotal | 7,083,518 | 543 | 6,643,953 | 649 | 94% | 119% |
| Fast Track Lighting | 5,910,323 | 1,438 | 3,190,411 | 861 | 54% | 60% |
| Custom (non-lighting) | 4,530,359 | 329 | 3,421,553 | 210 | 76% | 64% |
| HVAC | 1,539,239 | 769 | 1,209,261 | 673 | 79% | 88% |
| Custom (lighting) | 277,660 | 40 | 209,703 | 25 | 76% | 64% |
| Online Marketplace | 4,218 | 1 | 3,437 | 1 | 81% | 96% |
| CEP Total | 97,464,827 | 18,209 | 81,398,186 | 14,247 | **84%** | **78%** |

Note: Totals may not sum due to rounding.

## 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: The CEP has continued to make progress in expanding its non-lighting program offerings in 2019, with lighting savings representing 77% of ex ante gross energy and 84% of ex ante gross demand (down from 80% and 88%, respectively, in 2018).
  - 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 continue to adjust and/or cap 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 the continued exploration of high-efficiency commercial kitchen equipment as well as the 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 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 administrators should continue incorporation of measure- and project-specific data to tracking systems, most notably for the following data in Captures:
    - Occupancy sensor watts controlled (Comprehensive Lighting program component)
    - Building type (Comprehensive Lighting program component)
    - Voltage and amperage ratings for anti-sweat door heater control and electronically commutated motor refrigeration measures (Standard program component)
- Key Finding #3: Program savings algorithms and input assumptions continue to reference the 2010 LIPA Technical Manual for some CEP components.
  - Recommendation: At the end of the 2018 program year, 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 PSEG Long Island TRM and NY TRM moving forward. We believe the PSEG Long Island TRM is the more accurate source of assumptions, because of the Long Island specific research that has supported its development. Further, the application of the PSEG Long Island TRM fosters synergy across other PSEG Long Island efficiency programs. We recommend continuing to align with the PSEG Long Island TRM, and we will continue to work to develop agreed-upon algorithms and inputs with the implementation team in conjunction with the annual evaluation.
- Key Finding #4: In 2018, the evaluation team recommended "the program revise eligibility requirements to require all applicants to provide 15-minute interval data" on CHP performance. In 2019, the recommended information was available for all three projects that were incented in the program year.
  - Recommendation: To maintain the success of the CHP program component, the evaluation team recommends continued tracking and provision of 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
- Absorption chiller cooling energy, in tons (if applicable)

To appropriately account for seasonal variation and equipment persistence, we recommend that the data be trended for three years, as these sophisticated systems may experience equipment degradation, operational failures, unexpected maintenance downtime, and control system overrides beyond the first year. 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 continually.

- Key Finding #5: Program tracking data extracted from Captures contains minor data gaps in the utility gross demand and energy fields, most notably in Comprehensive Lighting occupancy sensor measures.
  - Recommendation: As part of the New Efficiency: New York goal setting, energy efficiency programs are required to report gross savings, in contrast to the historical emphasis on net savings. To ensure complete and accurate accounting, we recommend the program administrator update tracking systems to include utility gross savings (i.e., savings not including line loss factors) for all measures, in addition to net savings, which are necessary for cost-effectiveness testing.
- Key Finding #6: The Custom program component, excluding CHP projects, continues to use research that is several years old, and accounts for 5% of total ex ante energy savings.
  - Recommendation: The evaluation team recommends updating research during the next evaluation period to inform new realization rates for Custom measures.

# 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 lighting, appliances, and other products among PSEG Long Island residential customers. In 2019, the EEP program provided rebates on a range of products, including LED lighting, ENERGY STAR appliances, advanced power strips, and efficient HVAC and water heating equipment. The program also rebated recycled appliances, such as refrigerators, freezers, dehumidifiers, and room air conditioners.

Prior to the start of the program year, PSEG Long Island updated the list of qualifying products to reflect ENERGY STAR's standards and market trends. The EEP program retained a mix of both lighting and non-lighting measures from the previous program year. However, in anticipation of the upcoming Energy Independence and Security Act (EISA) Tier 2 lighting standards, program implementers worked with vendors in 2019 to freeze the pipeline of standard LED bulbs. In 2019, PSEG Long Island added ENERGY STAR "Most Efficient" bathroom ventilation fans, ENERGY STAR freezers, and connected "smart" lighting to the program.

In 2019, PSEG Long Island transitioned rebate processing from a third-party vendor to in-house. As a part of the transition, program staff worked to develop new workflows and oversee data migration efforts, both of which proved a significant challenge. Upon overcoming these hurdles, however, program staff report they saw significant gains in efficiency and flexibility when working with program participants. Specifically, staff were able to quickly prioritize and address participant issues as they arose. Greater control over invoicing also allowed staff to offer participants bill credits if they preferred not to wait for a rebate check.

The next section provides a summary of program performance. Following that, we provide a detailed examination of notable trends in program participation for several EEP measures. We then provide an overview of verified ex ante gross and net savings and descriptions of key drivers of gross savings realization rates. We conclude with key findings and recommendations for 2020.

### 3.1.1 Program Participation and Performance

Overall, 2019 was a successful year for the EEP program. According to program staff, the program exceeded its internal goals of achieving energy savings within budget and outperformed participation expectations. Program staff reported that the ability to process appliance rebates in-house contributed to the program's success in 2019.

Opinion Dynamics' evaluation confirmed that the program performed well in 2019, with verified ex ante savings reaching 122% of the energy savings goal and 126% of the peak demand goal. Table 3-1 presents 2019 EEP program performance compared to goals.

Table 3-1. 2019 EEP Program Verified Ex Ante Gross Program Performance Against Goals

| Metric | MWh | MW |
|---|---|---|
| Goal | 130,599 | 34 |
| Verified Ex Ante Gross Savings | 159,809 | 43 |
| % of Goal | 122% | 126% |

In 2019, the EEP program rebated or provided more than 4.5 million energy-efficient products to PSEG Long Island residential customers. As with previous years, standard and specialty lighting rebates represented the majority of measures; specifically, standard and specialty lighting represented 99% of all measures. ENERGY STAR dehumidifiers and advanced power strips were the next most common measures. Despite only a limited promotional window when rebates were available (see the Marketing section, 3.1.2), smart thermostats were the next most common measure, highlighting their continued popularity with consumers.

Table 3-2 below summarizes participation for each program measure compared to the planning goal. The EEP program exceeded most of its measure-level participation goals, with an especially strong performance in the lighting category.

Table 3-2. 2019 EEP Program Participation Compared to Goals, by Measure

| Measure | Number of Units Sold or Provided | Planned Units (Goal) | Percentage of Goal Achieved |
|---|---|---|---|
| Lighting | | | |
| LED Standard | 2,066,907 | 1,000,000[a] | 207% |
| LED Specialty | 2,424,034 | 2,250,640[a] | 108% |
| National Theater for Children (NTC) School Kits | 19,000 | 14,250 | 133% |
| Connected Lighting | 15,143 | 2,000 | 757% |
| Connected Lighting Kits | 1,527 | 500 | 305% |
| Appliances | | | |
| Dehumidifier – ENERGY STAR | 4,900 | 3,000 | 163% |
| Pool Pump - Variable Speed | 2,888 | 2,750 | 105% |
| Pool Pump - Two Speed | 3 | 300 | 1% |
| Clothes Washers – Most Efficient | 2,658 | 2,000 | 133% |
| Clothes Dryers – ENERGY STAR | 2,577 | 2,000 | 129% |
| Clothes Dryers - Most Efficient | 28 | 50 | 56% |
| Refrigerator –Most Efficient | 774 | 2,000 | 39% |
| Room Air Purifier – ENERGY STAR | 664 | 600 | 111% |
| Freezer – ENERGY STAR | 309 | 250 | 124% |
| Dishwasher –Most Efficient | 256 | 750 | 34% |
| Advanced Power Strips | | | |
| Advanced Power Strip Tier 1 | 4,385 | 2,000 | 219% |
| Advanced Power Strip Tier 2 | 49 | 500 | 10% |
| HVAC and Water Heating | | | |
| Smart Thermostats | 2,921 | NR | NR |
| Bathroom Exhaust Fans – ENERGY STAR | 277 | 250 | 111% |
| Bathroom Exhaust Fans – Most Efficient | 20 | 150 | 13% |
| Heat Pump Water Heater - Small | 122 | 150 | 81% |
| Heat Pump Water Heater - Large | 67 | 50 | 134% |

| Measure | Number of Units Sold or Provided | Planned Units (Goal) | Percentage of Goal Achieved |
|---|---|---|---|
| Appliance Recycling | | | |
| Refrigerator Recycle – Post-2001 & Pre-2010 | 1,887 | 2,000 | 94% |
| Refrigerator Recycle – Pre-2001 | 1,147 | 800 | 143% |
| Room Air Conditioner Recycle | 387 | 400 | 97% |
| Dehumidifier Recycle | 112 | 150 | 75% |

Source: Program tracking data, program planning spreadsheet, and PSEG Long Island KPI scorecard.

[a] Standard and specialty lighting goals include planned units for Techniart LEDs.

NR: PSEG Long Island did not report a smart thermostat goal in the KPI scorecard. The program did not rebate smart thermostats for most of the year, except for an Earth Day sale in April 2019, though thermostats were available in the Online Store year-round.

Table 3-3 shows the distribution of ex ante gross energy and demand savings across EEP program measures. Lighting accounted for 91% of ex ante gross energy savings and 86% of ex ante gross demand savings in 2019. Pool pumps and appliance recycling contributed the next highest shares of savings.

Table 3-3. 2019 EEP Program Ex Ante Gross Savings by Program Component

| Measure | Ex Ante Gross Savings | |
|---|---|---|
| | MWh% | MW% |
| Lighting | 91% | 86% |
| Pool Pumps | 4% | 9% |
| Appliance Recycling | 2% | <1% |
| NTC School Kits | 1% | 1% |
| Dehumidifiers – ENERGY STAR | <1% | 2% |
| Smart Thermostats | <1% | <1% |
| Heat Pump Water Heaters | <1% | <1% |
| Room Air Purifiers | <1% | <1% |
| Advanced Power Strips | <1% | <1% |
| Clothes Washers | <1% | <1% |
| Clothes Dryers | <1% | <1% |
| Refrigerators | <1% | <1% |
| Dishwashers | <1% | <1% |
| Freezers | <1% | <1% |
| Bathroom Exhaust Fans | <1% | <1% |

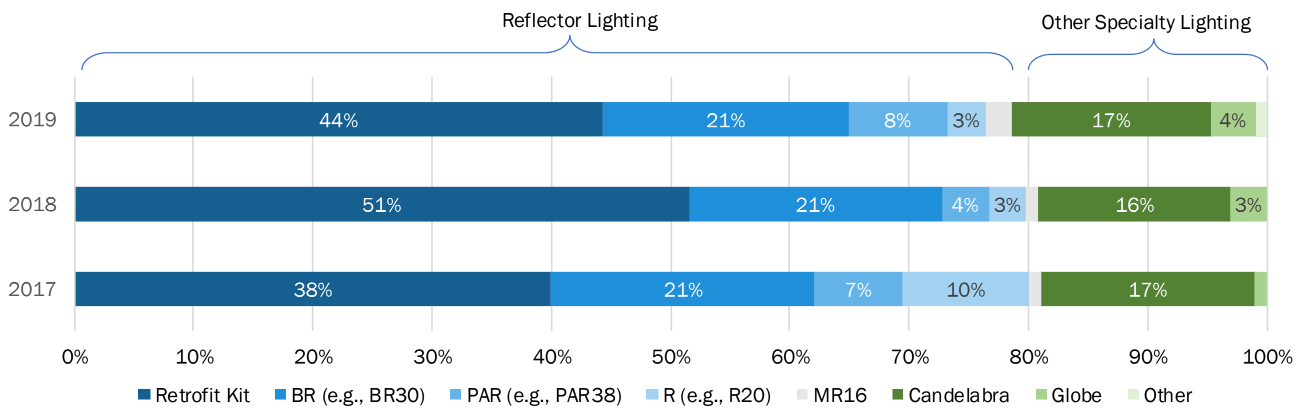
In the remainder of this section, we provide more detailed analyses of notable trends for a selection of program measures. Our analysis focused on measures with a significant difference between 2018 and 2019, that were new measures in 2019, or that will undergo programmatic changes in 2020.

## Lighting

Consistent with prior years, lighting remained a foundational component of the EEP program in 2019, contributing 91% of the program's ex ante gross energy savings and 86% of its ex ante gross demand savings. All lighting measure types exceeded their goals, with standard and connected lighting vastly exceeding their goals; PSEG Long Island achieved double its standard lighting, and nearly eight times its connected lighting goals. Key trends for lighting measures are described below.

- **Lighting type mix**: The program marked down approximately 4.5 million bulbs in 2019; similar to the volume of 2018 (4.7 million). As in past years, the EEP program marked down a fairly even mixture of specialty and standard lighting (54% and 46% of markdowns, respectively). Connected lighting, new to 2019, represented less than 1% of markdowns. As in previous years, reflector lighting continued to dominate specialty lamp markdowns (76% of specialty markdowns). The most common types of reflectors were retrofit kits (i.e., for can lights) and BR30 bulbs (Figure 3-1).

Figure 3-1. Share of EEP Program Specialty LED Markdowns by Lighting Type, 2017-2019




Source: EEP upstream rebate program-tracking data, 2017–2019.

Notes: Percentages less than 3% are not shown. The 2019 most common "other" shapes were specialty A-lines, strip lighting, and other decorative LEDs.

- **Pack size:** Consistent with the last few years, customer purchases continued to shift away from larger pack sizes and concentrated on mid-size packs (i.e., 3-packs and 4-packs); 97% of specialty LED and 96% of standard LED purchases were in 4-packs or smaller. 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.
- **Connected Lighting**: Connected (or “smart”) lighting had a promising start as a new measure in 2019. The program achieved approximately 7.5 times the markdown goal; the program marked down over 15,000 connected light bulbs compared to a goal of 2,000. The connected lighting offering included either single bulbs or a kit with two bulbs and a smart lighting WI-FI hub.
- **School kits:** The program also had a significant influx of standard LEDs through a partnership with the NTC. NTC is a touring company that writes and performs original shows designed to educate students in K-12 schools on a variety of topics. Throughout the year, NTC performed shows aimed at promoting energy efficiency to the public, private, and charter schools in the PSEG Long Island service territory. Following these performances, students received vouchers for free kits of four LEDs that they could redeem online. According to the program, tracking data, the program distributed 19,000 kits containing 76,000 standard LEDs through this partnership with NTC.
- **Impacts of EISA**: PSEG Long Island has, in recent years, assumed that its current level of lighting savings would 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, residential lighting would be practically eliminated as a source of savings after 2021.[15] 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) and then executed this plan in December 2019. As a result, many program administrators in New York and throughout the U.S. continue to invest in standard LED lighting rebates in 2020 and plan to do so in 2021. PSEG Long Island is considering when to discontinue standard LED markdowns and may reinstate standard LED markdowns in 2020 and 2021.

### Appliances

Appliance rebates contributed 6% of the EEP program's ex ante gross energy savings and 12% of its ex ante gross demand savings. This category includes pool pumps, dehumidifiers, room air purifiers, clothes washers and dryers, dishwashers, refrigerators, and freezers. Pool pumps were the largest contributor to savings amongst appliances (4% of ex ante gross energy savings), followed by ENERGY STAR dehumidifiers (0.66% of ex ante gross energy savings).

Appliance rebates performed well overall in 2019; many measures exceeded their participation goal. Program staff attributed much of the success of appliances to the growing popularity of rebates amongst customers. Staff noted that, based on receipts, many customers returned inefficient appliances when they learned of rebates and purchased program-eligible appliances instead. A few appliances fell short of the goal, including refrigerators, dishwashers, two-speed pool pumps, and ENERGY STAR Most Efficient clothes dryers. Key trends for appliances are below.

- Overall: 2019 rebate volumes for appliances were similar to 2018; appliances were generally within 5% to 15% of the 2018 volume. Clothes dryers, room air purifiers, and dishwashers grew in volume while pool pumps, clothes washers, and refrigerators shrunk in volume.
- Pool pumps: More than 99% of rebated pool pumps (N=2,891) were variable speed; only three were two-speed pumps. Variable speed pumps are typically much more expensive options compared to two-speed pumps and, accordingly, rebate volumes for these measures were significantly different. However, there are also many more types of ENERGY STAR-rated variable speed pool pumps available in the market compared to two-speed pumps.[16] The dominance of variable speed pumps in the program may be due to a combination of the larger rebate amount and product availability.
- Freezers: ENERGY STAR freezers were a new measure in 2019 and achieved 124% of their participation goal. This suggests that the program has set an appropriate rebate level for the volume it seeks to achieve moving forward.
- Dishwashers: PSEG Long Island added ENERGY STAR "Most Efficient" dishwashers to the program in 2018. The EEP program saw 19% more dishwasher rebates in 2019 than the prior year but reached only 34% of its goal with 256 units rebated. Program staff commented on two significant barriers to purchasing this product: 1) "Most Efficient" dishwashers are more than double the price of ENERGY STAR dishwashers, and 2) retailers do not typically stock or showcase "Most Efficient" products due to limited floor space. Opinion Dynamics' reviewed the ENERGY STAR product finder website and confirmed that "Most Efficient"-certified dishwashers are significantly more expensive than a typical ENERGY STAR dishwasher; most were more than $1,200 dollars and ranged up to $2,800 dollars.[17]

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[15] Opinion Dynamics (December 2018). PSEG Long Island Commercial and Residential Potential Study 2019–2038. Volume 1: Methodology and Results (FINAL DRAFT).
[16] The ENERGY STAR product finder website lists 141 variable speed pumps versus five two-speed pumps. https://www.energystar.gov/productfinder/product/certified-pool-pumps/results: Last accessed 3/10/2020.
[17] https://www.energystar.gov/most-efficient/me-certified-dishwashers. Last accessed 3/10/2020.

As such, the EEP program's rebate may not be enough to convince customers to pay more than they would for a typical ENERGY STAR dishwasher. However, there does seem to be a considerable number of "Most Efficient" dishwasher models available in 2020,[18] which may help the program moving forward if retailers begin to stock them more often.

- Refrigerators: Rebates for refrigerators also did not meet program planning expectations in 2019. The EEP program rebated 774 refrigerators, which is 39% of the 2019 goal and a 43% reduction from the previous year's volume. Given the poor performance of refrigerator rebates, along with their high cost per BTU saved,[19] PSEG Long Island will be discontinuing refrigerator rebates in 2020.

### Appliance Recycling

Appliance recycling contributed 2% of the EEP program's ex ante gross energy savings and less than 1% of its ex ante gross demand savings. The program offered rebates for 3,533 recycled appliances, which is about 500 fewer appliances compared to 2018 (4,006 appliances). The program did not meet its goals for most recycling measure categories (between 75% and 97% of goal), but strong performance in the pre-2001 refrigerators category (143% of goal) enabled the program to exceed appliance recycling goals overall (105% of goal).

### Advanced Power Strips

Advanced power strips contributed less than 1% of the EEP program's ex ante gross energy and demand savings. In 2019, the EEP program rebated 4,434 advanced power strips; more than double the 2019 goal, and more than five times the number of rebates from the previous year. Nearly 99% (4,385) of these rebates were Tier 1 strips, while Tier 2 strips made up 1% (49 rebates). Despite exceeding the 2019 goal, PSEG Long Island will discontinue Tier 1 rebates in 2020. As with refrigerators, program staff cite the high cost per BTU saved with Tier 1 power strips as the main reason for their removal from the EEP program. Program staff plan to monitor sales of Tier 2 strips as the program enters 2020 to inform future offerings better.

### HVAC and Water Heating

HVAC and water heating measures altogether contributed less than 1% of the EEP program's ex ante gross energy and demand savings. This category includes smart thermostats, bathroom exhaust fans, and heat pump water heaters.

- Smart thermostats: The program did not rebate smart thermostats for most of the year, except for an Earth Day sale in April 2019, though thermostats were available in the Online Store year-round. The program sold 61% fewer smart thermostats compared to 2018.
- Heat pump water heaters: The EEP program provided rebates for 189 heat pump water heaters. This represents a 29% increase compared to 2018 (147 rebates), and 95% of the 2019 unit goal. Moving forward, continuing to incentivize efficient heat pump water heaters enables PSEG Long Island to tap into savings opportunities for the 15% of residential customers using electric water heaters and moreover capitalize on a market in which very few customers (<1%) are adopting this emerging technology on their own.[20] In the short term, the market for heat pump water heaters is likely to remain nascent; according to a recent set of Long Island market actor interviews we completed, manufacturers and distributors are generally not promoting or selling heat pump water heaters.

[18] *Ibid.* The ENERGY STAR product finder website lists 78 "Most Efficient" dishwashers". Last accessed 3/10/2020.
[19] Dollars per BTU is a metric PSEG Long Island uses to assess the cost-effectiveness of measures.
[20] Opinion Dynamics (August 2018). *PSEG Long Island Commercial and Residential Potential Study 2019–2038. Volume 2: Market Baseline Data Collection Details.*

Barriers they mentioned include a lack of new construction (i.e., what would otherwise be a potentially good market), the large size of heat pump water heaters, and concerns about the durability and longevity of the technology. Over the long term, however, this measure is poised to offer broader savings opportunities across PSEG Long Island's service territory as policymakers and utilities ramp up beneficial electrification efforts to meet New York State's aggressive clean energy goals.

- Bathroom exhaust fans: The program tested the feasibility of rebates for two types of ENERGY STAR ventilation fans in 2019. The program ultimately exceeded its standard high-efficiency fans goal (277 units, 111% of goal) but fell short of its "Most Efficient" fans goal (20 units, 13% of goal). PSEG Long Island will be discontinuing rebates on all ventilation fan models in 2020 due to the high cost per BTU saved associated with this measure.

### Anticipated Changes in 2020

PSEG Long Island's plan for 2020 assumed the EISA lighting standards requiring all standard A19 lamps sold in the U.S. be efficient (i.e., LED or CFL technology) would, in fact, go into effect on January 1st, 2020. A19 lamps were, therefore, discontinued from the EEP program beginning in 2020. Action taken by the DOE in December of 2019 rolled back the EISA standards, prompting many program administrators in New York and throughout the U.S. to continue to invest in standard LED lighting rebates in 2020 and beyond. As such, PSEG Long Island will need to determine if it wishes to reintroduce the A19 lighting measure for 2020 and 2021.

PSEG Long Island continues to identify new measures for the EEP program. Chargeable lawn equipment and heat pump pool heaters were added in 2020. In addition, PSEG Long Island discontinued several measures in 2020, including Tier 1 power strips, refrigerators, bathroom exhaust fans, and the NTC school kits.

## 3.1.2 Program Marketing

The program generally reduced marketing efforts compared to 2018. PSEG Long Island did not promote the program through corporate events, food bank partnerships, community events, or trade shows, as it did in 2018. The 2019 marketing efforts included in-store signage, a bill insert for ENERGY STAR "Most Efficient" appliances early in 2019, targeted promotional efforts for smart thermostats, and dealer partnerships for pool pumps and pool heaters.

### Smart Thermostat Promotions

PSEG Long Island conducted two promotional campaigns for smart thermostats in 2019.

- The first campaign was an Earth Day sale that offered customers a $50 discount in the Online Marketplace for 22 days during April 2019. The campaign discounted five specific models: two Nest models, two Ecobee models, and one Lux model. Program staff said the promotion went well; the program sold more than half of its 2019 volume (1,724 out of the 2,921 thermostats) during that campaign. Note, the Earth Day sale was the only time in 2019 that the program offered its own discount for smart thermostats.
- The second campaign promoted manufacturers' Black Friday sales from November 29 through December 3rd (note, the program did not offer an additional discount). Nest, Ecobee, and Emerson were offering between $30 and $70 discounts on their thermostats. PSEG Long Island used two email blasts, web banners, and social media posts to promote these offers. Program staff said the second campaign was less successful than the first; the program sold less than 100 thermostats during that time.

### Pool Pump and Pool Heater Dealer Partnerships

The program partnered with local pool dealers to promote pool pumps and pool pump water heaters. The program required dealer staff to take training from local manufacturers to receive certification for installing pool pumps and pool heaters. In return, the program allowed the dealers to use PSEG Long Island signage to promote high-efficiency pool pump and pool heater rebates to customers.

## 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 ex post gross savings, and Section 3.2.2 presents the ex post net savings for cost-effectiveness. Ex post gross savings differ from ex post net savings in that ex post net savings are developed using ex post NTGRs and include line losses. For a list of NTGRs used in this evaluation, see Appendix A.

### 3.2.1 Ex Post Gross Impacts

Table 3-4 shows ex ante gross savings, ex post gross savings, and realization rates by measure category for the 2019 EEP program. The overall EEP program realization rates, calculated as the ratio of ex post gross savings to ex ante gross savings, were strong; 108% for gross energy savings and 98% for gross demand savings. However, almost all measures (except advanced power strips) had gross energy and demand realization rates that were different from 100%. Our analysis revealed systematic discrepancies between ex post and ex ante, which we describe further in the next section.

Table 3-4. 2019 EEP Program Ex Post Gross Impacts

| Measure | N | Ex Ante Gross Savings | | Ex Post Gross Savings | | Realization Rate | |
|---|---|---|---|---|---|---|---|
| | | kWh | kW | kWh | kW | kWh | kW |
| Lighting | 4,507,611 | 145,222,349 | 36,842 | 160,228,427 | 39,382 | 110% | 107% |
| Pool Pumps | 2,891 | 7,043,301 | 4,067 | 6,849,246 | 1,694 | 97% | 42% |
| Appliance Recycling | 3,533 | 2,652,211 | 428 | 1,310,992 | 201 | 49% | 47% |
| NTC School Kits | 19,000 | 1,856,946 | 470 | 1,088,755 | 345 | 59% | 73% |
| ENERGY STAR Dehumidifiers | 4,900 | 1,052,665 | 1,007 | 1,002,649 | 179 | 95% | 18% |
| Room Air Purifiers | 664 | 424,780 | 47 | 523,999 | 60 | 123% | 128% |
| Clothes Washers - Most Efficient | 2,658 | 416,574 | 0.4 | 369,958 | 36 | 89% | 8,851% [a] |
| Heat Pump Water Heaters | 189 | 387,695 | 32 | 352,504 | 32 | 91% | 101% |
| Smart Thermostats | 2,921 | 303,965 | 0.0 | 419,424 | 66 | 138% | N/A |
| Advanced Power Strips | 4,434 | 271,325 | 29 | 271,351 | 30 | 100% | 100% |
| Clothes Dryers | 2,605 | 88,466 | 13 | 95,276 | 14 | 108% | 108% |
| Refrigerators | 774 | 41,454 | 5.0 | 36,364 | 4.4 | 88% | 87% |
| Freezers | 309 | 18,577 | 2.3 | 12,317 | 1.5 | 66% | 66% |
| Dishwashers | 256 | 15,290 | 1.6 | 12,648 | 1.3 | 83% | 83% |
| Bathroom Exhaust Fans | 297 | 8,889 | 1.1 | 8,725 | 1.1 | 98% | 98% |
| Totals | 4,553,042 | 159,804,486 | 42,946 | 172,582,637 | 42,046 | 108% | 98% |

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

[a] The large demand realization rate for clothes washers is driven by program administrator applying CF 100 times lower than specified in 2019 PSEG Long Island TRM. Additional details provided below.

## Reasons for Differences in Impacts

In this section, we provide reasons for the difference between ex ante and ex post savings for each measure with gross realization rates different from 100%. Most often, the difference between ex post and ex ante savings estimates is that ex ante estimates apply 2019 PSEG Long Island TRM default assumptions, based on 2017 participant data, while the ex post estimates use actual values in the 2019 program tracking data. Note, we ordered the findings below in descending order of the measure's contribution to ex ante gross kWh savings.

- Lighting: Gross realization rates for lighting measures altogether were 110% for energy savings and 107% for demand savings. The differences between ex ante and ex post gross are due differences in assumptions for the measures as described below.
  - Standard and Specialty Bulbs: The gross realization rates for standard LEDs were 110% for energy savings and 110% for demand savings. The gross realization rates for specialty LEDs were 103% for energy savings and 103% for demand savings. Program administrators applied 2019 PSEG Long Island default assumptions for existing and installed wattage values to calculate ex ante savings. In contrast, the evaluation team used tracked wattages from the 2019 program tracking data. Compared to the default assumptions, the 2019 tracking data had higher baseline wattages for both standard and specialty bulbs and lower installed wattage for specialty bulbs, increasing ex post savings compared to ex ante.
  - Connected Lighting Bulbs: The gross realization rates for this measure were 89% for energy savings and 85% for demand savings. Realization rates are driven by a difference in the energy-saving factor (ESF) to account for hours of use (HOU) reductions. The program administrators applied a 15% ESF based on the commercial networked lighting measure in New York (NY) TRM v.6.1.[21] This ESF represents commercial buildings, which have different operational characteristics than residential and utilize lighting types different than A19 bulbs. Until further research results are available to inform ESF factors for connected lighting, the evaluation team does not recommend the use of ESF to reduce HOU.[22] The evaluation team applied an ESF of 0%, which reduces ex post savings compared to ex ante.
  - Connected Lighting Kits: Gross realization rates for this measure were 21% for gross energy savings and 23% for gross demand savings. These realization rates primarily reflect an error in the calculation of ex ante gross savings. Program staff applied "per kit" savings assumptions (where each kit contains four bulbs) to "per bulb" quantities. The evaluation team corrected this error and, also, removed the ESF as described above for connected lighting bulbs, reducing ex post savings compared to ex ante.
  - LED In Storage: Gross realization rates for previously rebated bulbs coming into service from storage were 171% for energy savings and 123% for demand savings. The evaluation team applied a third-year carryover in-service rate (ISR) of 3% to 2017 incentivized LEDs and a second-year carryover ISR of 5% to 2018 incentivized LEDs. Specifically, we applied these values to 2017 and 2018 ex-post gross savings for LEDs to determine carryover savings. The program administrator applied the second- and third-year carryover ISRs to 2018 and 2018 EEP LED evaluated net savings, which incorporates a net-to-gross ratio of 0.55.

[21] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs. Version 6.1. Effective January 31, 2019.

[22] The evaluation team reviewed connected lighting measure entries in the Illinois TRM v.8.0 and Mid-Atlantic TRM v.8.0. Both resources drew upon two separate studies that produced diverging results. This contributed to the evaluation team's judgment for the need of additional research to support the reduction of operational hours for residential connected lighting.

- **Pool Pumps:** Gross realization rates for this measure were 97% for energy savings and 42% for demand savings. Program administrators applied 2019 PSEG Long Island TRM default assumptions for savings per unit. However, the PSEG Long Island TRM updates for 2019 occurred in 2018, prior to new guidance from ENERGY STAR on pool pumps; effective January 2, 2019, ENERGY STAR requires that all pool pumps be rated according to weighted energy factors (WEF). As such, ex ante assumptions did not capture this change in requirement. The evaluation team applied an approach specified in the NY TRM v.6.1. That incorporates the new requirements to include WEF, reducing ex post savings compared to ex ante.
- **Appliance Recycling:** The realization rates for appliance recycling measures altogether were 49% and 47% for gross energy and demand savings, respectively. The differences between ex ante and ex post gross are due to differences in assumptions for the measures as described below.
  - **Refrigerator Recycling:** The gross realization rates for this measure was 50% for energy savings and demand savings. Program administrators applied assumptions that did not account for replacing the recycled refrigerator with a new unit. As specified in the 2019 PSEG Long Island TRM, the evaluation team subtracted the kWh usage of a federal standard refrigerator, based on replaced refrigerator type, from the kWh consumption of the recycled unit (i.e., to represent the replacement placed back onto the grid), reducing ex post savings compared to ex ante.
  - **Room Air Conditioner Recycling:** The gross realization rates for this measure were 20% for energy savings and 20% for demand savings. The program administrators applied 2019 PSEG Long Island TRM default assumptions of 132 kWh annual savings per recycled unit, based on ENERGY STAR guidelines.[23] The evaluation team used an approach from the NY TRM v.6. This approach uses TRM specified Combined Energy Efficiency Ratio (CEER) values of the recycled units based on collected recycled unit capacities and references federal standards for current baseline unit CEER values. Savings are then calculated using a difference in unit efficiency between the recycled units and the federal standard baseline unit. This approach offers increased accuracy in savings but resulted in lower average savings per unit, reducing ex post savings compared to ex ante.
  - **Dehumidifier Recycling**: The gross realization rates for this measure were 40% for energy savings and 20% for demand savings. Program administrators applied default, deemed assumptions, dating back to the 2015 PSEG Long Island TRM, of 0.28 kW and 471 kWh annual savings per unit. The evaluation team calculated ex post annual savings per unit of 0.033 kW and 187 kWh, using actual capacity and vintage data from the 2019 program tracking data and current federal standard efficiencies, reducing ex post savings compared to ex ante.
- **NTC School Kits**: Gross realization rates for this measure were 59% for energy savings and 73% for demand savings. The NTC school kits contain four standard LED lightbulbs. The program administrators used an ISR of 0.85, while the evaluation team used 0.50 based on evaluation results of a similar "kits" program offered by Con Edison.[24] The ISR value of 0.85 is not specific to ISR research for other NTC school kit programs, nor is there PSEG Long Island-specific research for this offering. As such, the evaluation team determined that the Con Edison value of 0.50 is more appropriate. Additionally, similar to other lighting measures, the evaluation team used actual lighting wattage values from the 2019 program tracking database as opposed to default TRM values. Adjusting wattages increased savings but adjusting ISRs downward had a larger impact on savings overall, reducing ex post savings compared to ex ante.
- **ENERGY STAR Dehumidifiers**: Gross realization rates for this measure were 95% for energy savings and 18% for demand savings. The program administrators applied 2019 PSEG Long Island TRM

[23] https://www.energystar.gov/sites/default/files/asset/document/RoomAirConditionerTurn-InAndRecyclingPrograms.pdf
[24] http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7B8A5823A1-BF93-492B-A18D-D8913C4AF425%7D

default assumptions for annual operating hours. Specifically, the default assumption was 313 operating hours, based on 68 operating days per year multiplied by 4.6 operating hours per day. The evaluation team found that the 4.6 hours per day assumption, from ENERGY STAR, is based on 365 operating days, which would result in 1,679 operating hours per year. Additionally, program administrators applied 2019 PSEG Long Island TRM default assumptions for unit energy consumption and efficiency while the evaluation team used actual values from the 2019 program tracking data. The evaluation team applied the corrected (i.e., larger) operating hours assumption, however, the actual units rebated were 11% larger and 1% less efficient compared to assumptions, reducing ex post savings compared to ex ante.

- Room Air Purifiers: Gross realization rates for this measure were 123% for energy savings and 128% for demand savings. The program administrators applied 2019 PSEG Long Island TRM default assumptions for efficiency, standby power, and clean air delivery. The evaluation team used actual values from the 2019 program tracking database, increasing ex post savings values compared to ex ante.
- Clothes Washers: Gross realization rates for this measure were 89% for energy savings and 8,851% for demand savings. For energy savings, program administrators used 2019 PSEG Long Island TRM default assumptions for several inputs (i.e., washer energy savings, electric drying energy savings, and electric water heater energy savings) while the evaluation team used actual values for from the 2019 program tracking database, reducing ex post savings compared to ex ante. For demand savings, the evaluation team found an incorrectly applied CF (0.029% instead of 2.9%), increasing ex post demand savings by nearly two orders of magnitude compared to ex ante.
- Heat Pump Water Heaters: Gross realization rates for this measure were 91% for energy savings and 101% for demand savings. The program administrator applied NY TRM v6.1 assumptions and algorithms, as recommended by the 2019 PSEG Long Island TRM, with two notable inconsistencies: (1) the program planning algorithm incorrectly multiplied by the derating factor, rather than dividing; and (2) the program algorithm did not include the air conditioning factor. The evaluation team corrected these issues, reducing ex post energy savings compared to ex ante. There was also a small misapplication of savings per unit (i.e., a possible data entry error) in ex ante demand savings. The evaluation team corrected this issue, increasing ex post demand savings compared to ex ante.
- Smart Thermostats: Gross realization rates for this measure were 138% for energy savings. The program did not claim ex ante demand savings for this measure. Program administrators applied deemed energy savings assumptions from the NY TRM v6 appropriate for non-learning Wi-Fi thermostats to all measures. The evaluation team identified smart thermostat measures in the 2019 program tracking database with and without learning capabilities. For smart thermostat units with learning capabilities, the evaluation team applied NY TRM v6 algorithms and assumptions for learning thermostats. For all other measures, the evaluation team applied NY TRM v6.1 algorithms and assumptions for Wi-Fi thermostats. Additionally, for units with learning capabilities, as defined in the Thermostats - Learning section of the NYS TRM v6, the evaluation team applied central cooling factor and electric heating values from the 2018 PSEG Long Island Commercial and Residential Potential Study[25]. These adjustments resulted in larger savings values for learning thermostats, increasing ex post energy savings compared to ex ante. Additionally, the evaluation team estimated ex post gross demand savings of 0.23 kW per non-learning thermostat, whereas the program administrators did not claim demand savings. Note, the NY TRM does not specify demand savings for learning thermostats.
- Clothes Dryers: Gross realization rates for this measure were 108% for energy and demand savings. The program administrators applied 2019 PSEG Long Island TRM default assumptions for efficient

[25] PSEG Long Island Commercial and Residential Potential Study 2019–2038. Volume 1: Methodology and Results.

unit combined energy factors, while the evaluation team used actual values from the 2019 program tracking data. The average installed unit was more efficient than assumed in ex ante for Electric Resistance Clothes Dryers, which represent 99% of 2019 dryer measures, increasing ex post savings compared to ex ante.

- Refrigerators: Gross realization rates for this measure were 88% for energy savings and 87% for demand savings. Program administrators used 2019 PSEG Long Island TRM default values for baseline and efficient unit energy consumption. The evaluation team used actual values from the 2019 program tracking database. These actual consumption values reflect smaller existing and installed units, on average, than assumed in program planning, reducing ex post savings compared to ex ante.
- Freezers: Gross realization rates for this measure were 66% for energy and demand savings. Since freezers are a new offering for 2019, program administrators applied default assumptions and algorithms from the ENERGY STAR Qualified Product List (QPL) and the NY TRM v6. The evaluation team also applied NY TRM v6 algorithms. Still, it used actual values for average adjusted volume, baseline unit energy consumption, and efficient unit energy consumption from the 2019 program tracking database. We found that both baseline and efficient unit energy consumption values assumed by the program administrator were greater than actuals from the 2019 program tracking database, on average, reducing ex post savings compared to ex ante.
- Dishwashers: Gross realization rates for this measure were 83% for energy and demand savings. Program administrators used 2019 PSEG Long Island TRM default assumptions for efficient unit consumption. The evaluation team applied actual values from the 2019 program tracking database. These actual efficient unit consumption values are higher, on average, than 2019 PSEG Long Island TRM specified values, reducing ex post savings compared to ex ante.
- Bathroom Exhaust Fans: Gross realization rates for this measure were 98% for energy and demand savings. Since bathroom exhaust fans are a new offering for 2019, program administrators applied assumptions and algorithms from the Illinois TRM v7.0.[26] The evaluation team also applied Illinois TRM v7.0 algorithms but used actual values for fan flow rate, baseline fan efficiency, and fan efficiency from the 2019 program tracking database. The main driver of reduced ex post savings compared to ex ante is a lower fan efficiency in the actual program tracking data, on average, reducing ex post savings compared to ex ante.

### 3.2.2 Impacts for Cost-Effectiveness

Table 3-5 provides a program-level comparison of ex post net savings to ex ante net 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 represent the ratio of ex post net savings to ex ante net savings. Overall, the EEP program achieved an ex post net realization rate of 106% for energy savings and 93% for demand savings.

[26] 2019 Illinois Statewide Technical Reference Manual for Energy Efficiency. Version 7.0. Volume 3: Residential Measures. Effective January 1, 2019.

Table 3-5. 2019 Energy Efficient Products Ex Post Net Impacts for Cost Effectiveness

| Measure | N | Ex Ante Net Savings | | Ex Post Net Savings | | Realization Rate | |
|---|---|---|---|---|---|---|---|
| | | kWh | kW | kWh | kW | kWh | kW |
| Lighting | 4,507,611 | 85,222,012 | 22,237 | 93,750,675 | 23,672 | 110% | 106% |
| Pool Pumps | 2,891 | 6,743,398 | 4,005 | 6,557,788 | 1,666 | 97% | 42% |
| NTC School Kits | 19,000 | 1,580,380 | 411 | 637,038 | 207 | 40% | 50% |
| Appliance Recycling | 3,533 | 1,472,704 | 246 | 669,443 | 105 | 45% | 43% |
| ENERGY STAR Dehumidifiers | 4,900 | 951,873 | 938 | 351,994 | 65 | 37% | 7% |
| Heat Pump Water Heaters | 189 | 416,330 | 35 | 375,005 | 35 | 90% | 101% |
| Clothes Washers - Most Efficient | 2,658 | 399,337 | 2.9 | 393,572 | 40 | 99% | 1386% |
| Room Air Purifiers | 664 | 383,526 | 45 | 473,828 | 56 | 124% | 124% |
| Advanced Power Strips | 4,434 | 288,643 | 32 | 288,671 | 32 | 100% | 100% |
| Smart Thermostats | 2,921 | 248,989 | 0 | 343,571 | 56 | 138% | N/A |
| Clothes Dryers | 2,605 | 84,847 | 13 | 91,222 | 14 | 108% | 106% |
| Refrigerators | 774 | 39,748 | 4.8 | 34,817 | 4.3 | 88% | 89% |
| Freezers | 309 | 17,787 | 2.2 | 11,793 | 1.5 | 66% | 67% |
| Dishwashers | 256 | 14,698 | 1.6 | 12,110 | 1.3 | 82% | 82% |
| Bathroom Exhaust Fans | 297 | 8,523 | 1.4 | 8,354 | 1.1 | 98% | 78% |
| Totals | 4,553,042 | 97,872,794 | 27,974 | 103,999, 881 | 25,955 | 106% | 93% |

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

## 3.3 Conclusions and Recommendations

The evaluation team offers the following findings and recommendations for the EEP program moving forward:

- Key Finding #1: Program administrators derive planning assumptions and ex ante calculations from previous years' program tracking data. For example, program administrators based 2019 planning assumptions on 2017 program tracking data. Ex post savings estimates use actual values from the current year's program tracking data, when available. As such, there is a systematic discrepancy between ex ante and ex post savings for many measures. In 2018, the Captures database began tracking measure-level data, which provides the opportunity for ex ante savings estimates to use actual values from the current year's program tracking data, similar to the Home Comfort program ex ante method.
  - Recommendation: Program administrators should use the measure-level data available in Captures to estimate ex ante savings. The use of actual installed parameters, such as LED wattages, water heater energy factors, and clothes washer capacities, will reduce discrepancies with ex post savings.
- Key Finding #2: Savings from smart thermostat measures vary based on whether the thermostat has learning capabilities, but the tracking database does not have information to determine whether

rebated units are learning or non-learning. The evaluation team made determinations this year based on the model name and SKU numbers in the dataset.

- Recommendation: For smart thermostat measures, track whether a smart thermostat measure possesses learning capabilities based on NYS TRM v7 learning thermostat classification criteria.[27] This will support the identification of thermostats with learning capabilities, allowing the program to claim savings for these units more accurately. These five NYS TRM v7 criteria learning thermostats must meet at minimum include:
  - Working as a basic thermostat in absence of connectivity to the service provider;
  - Giving residents some form of feedback about the energy consequences of their settings;
  - Providing information about HVAC energy use, such as monthly run time;
  - Providing the ability to set a schedule; and
  - Providing the ability to work with utility programs to prevent brownouts and blackouts, while preserving consumers' ability to override those grid requests.

- Key Finding #3: The gross realization rates for recycled refrigerators was 50% for energy savings and demand savings. Program administrators applied assumptions that did not account for replacing the recycled refrigerator with a new unit while ex-post included an assumption that the refrigerator is replaced as specified in the 2019 PSEG Long Island TRM. Conversations with the program administrators revealed that there is some level of secondary refrigerator recycling; savings calculations should not apply a replacement assumption in these cases.
  - Recommendation: We recommend tracking primary versus secondary status of recycled refrigerators to allow for a more accurate application of replaced refrigerator assumptions.

[27] Learning thermostat criteria provided in Measure Description of the "Thermostat – Learning" section in the NYS TRM v6.

# 4. Home Comfort Program

## 4.1 Home Comfort Program Description

PSEG Long Island designed the Home Comfort program (formerly referred to as the Cool Homes program) to improve the energy efficiency of residential heating and cooling systems throughout Long Island. Customers are eligible to receive rebates for the installation of a variety of high-efficiency heating and cooling systems, including split central air conditioners (traditional CACs), geothermal heat pumps (also known as ground source heat pumps or GSHPs), air-source heat pumps (ASHPs), and ductless mini-split systems (heat pumps and ACs). Program administrators also maintain a pool of participating contractors that are certified to perform Quality Installations (QI) of HVAC equipment, which they promote on the program website. These participating contractors perform Manual J calculations to install appropriately sized energy-efficient units and ensure the refrigerant charge and airflow are checked using prescribed tests. Participating contractors receive incentives for each eligible installation they complete.

### 4.1.1 Program Design and Implementation

Home Comfort program administrators prioritized the installation of ASHPs in 2019 and introduced rebates for cold climate heat pumps as the program continued the transition away from focusing largely on cooling measures to those that improve both heating and cooling efficiency. While customer rebates remained largely unchanged for the measures that remained consistent between 2018 and 2019, PSEG Long Island increased the QI contractor rebate for both Tier 1 and Tier 2 ASHPs, as shown in Table 4-1. Similar to 2018, the Home Comfort program administrators offered QI trainings to participating contractors, and reimbursement of up to 75% of program-related tools.

Table 4-1. Changes to Customer Rebates and Contractor Incentives From 2018 to 2019

| Measure | Tier | Customer Rebate | | Contractor Incentive | |
|---|---|---|---|---|---|
| | | 2018 | 2019 | 2018 | 2019 |
| ASHP | 1 | $350/system | No change | $100/first system, $50 each additional | $125/first system, $50 each additional |
| | 2 | $450/system | $400/system | | $150/first system, $50 each additional |
| ASHP (Cold Climate) | 3 | N/A | $450/system | N/A | $200/first system, $50 each additional |
| Ductless Mini Split Heat Pump (Cold Climate) | N/A | N/A | $350/system | N/A | N/A |
| Packaged Terminal Heat Pumps | N/A | N/A | $100/system | N/A | N/A |
| Split CAC | 1 | $150/system | $175/system | $100/first system, $50 each additional | $75/first system, $50 each additional |
| | 2 | $250/system | No change | | |
| | 3 | $350/system | No change | | |

In addition to the rebate changes, PSEG Long Island made updates to the efficiency requirements for GSHPs and packaged terminal heat pumps, as shown in Table 4-2.

Table 4-2. Changes to Equipment Efficiency Requirements From 2018 to 2019

| Measure | Tier | Efficiency Requirements | |
|---|---|---|---|
| | | 2018 | 2019 |
| ASHP (Cold Climate) | 3 | N/A | Northeast Energy Efficiency Partnerships Cold Climate Air Source Heat Pump Specification Product Listing, SEER ≥ 17 and HSPF ≥ 10 |
| Ductless Mini Split Heat Pump (Cold Climate) | N/A | N/A | Northeast Energy Efficiency Partnerships Cold Climate Air Source Heat Pump Specification Product Listing, SEER ≥ 18 and HSPF ≥ 10 |
| GSHP | 1 | Water to Air Closed: EER ≥ 17.1 and EER < 20, and COP ≥ 3.6<br>Water to Air Open: EER ≥ 21.1 and EER < 25, and COP ≥ 4.1<br>Water to Water Closed: EER ≥ 16.1 and EER < 17.5, and COP ≥ 3.1<br>Water to Water Open: EER ≥ 20.1 and EER < 23, and COP ≥ 3.5<br>DGX: EER ≥ 16 and EER < 21, and COP ≥ 3.6 | Water to Air Closed: EER ≥ 17.1 and COP ≥ 3.6<br>Water to Air Open: EER ≥ 21.1 and COP ≥ 4.1<br>Water to Water Closed: EER ≥ 16.1 and COP ≥ 3.1<br>Water to Water Open: EER ≥ 20.1 and COP ≥ 3.5<br>Direct Geoexchange: EER ≥ 16.0 and COP ≥ 3.6 |
| Packaged Terminal Heat Pumps | N/A | N/A | EER ≥ 11.4 and COP ≥ 3.3 |

### 4.1.2 Program Participation and Performance

PSEG Long Island's Home Comfort program performed well in terms of energy savings in 2019. Verified ex ante savings reached 127% of the energy savings goal and 65% of the peak demand goal. Table 4-3 presents the performance of the 2019 Home Comfort program compared to goals.

Table 4-3. 2019 Home Comfort Program Verified Ex Ante Gross Program Performance Against Goals

| Metric | MWh | MW |
|---|---|---|
| Goal | 2,728 | 1.81 |
| Verified Ex Ante Gross Savings | 3,472 | 1.17 |
| % of Goal | 127% | 65% |

Split CACs continued to account for the largest individual share of Home Comfort gross demand savings in 2019 (78%). However, ductless mini splits surpassed split CAC installations as the primary driver of program energy savings. Ductless mini-split installations accounted for 47% of ex ante gross energy savings, compared to 25% generated by split CAC instillations. Table 4-4 shows the distribution of ex ante gross energy and demand savings by Home Comfort program measure.

Table 4-4. 2019 Home Comfort Program Ex Ante Gross Savings by Program Component

| Program Component | Ex Ante Gross Savings | |
|---|---|---|
| | MWh (%) | MW (%) |
| Ductless Mini Split | 47% | <1% |
| Split CAC | 25% | 78% |
| ASHP | 17% | 6% |
| GSHP | 11% | 16% |
| Smart Thermostat | <1% | 0% |

PSEG Long Island rebated 5,049 measures through the Home Comfort program. Split CACs and ductless mini split systems accounted for the largest shares of installations with 46% and 41% of installations, as shown in Table 4-5.

Table 4-5. Count of 2019 Home Comfort Program Rebated Systems by Measure

| Measure | Quantity | Percent |
|---|---|---|
| Split CAC | 2,315 | 46% |
| Ductless Mini Split | 2,045 | 41% |
| ASHP | 385 | 8% |
| Smart Thermostat | 162 | 3% |
| GSHP | 142 | 3% |
| Total | 5,049 | 100% |

Overall, PSEG Long Island rebated 15% fewer systems in 2019 than in 2018; a decrease driven largely by rebating 32% fewer Split CAC systems in 2019 (Table 4-6). Though the share of Split CAC installations out of total installations has fallen steadily over the previous four years, the larger reduction from 2018 to 2019 represents PSEG Long Islands shift towards offering more heating and cooling measures.

Table 4-6. Difference in Number of Home Comfort Program Measures Installed, 2015–2019

| Measure | 2015 | 2016 | 2017 | 2018 | 2019 | Percent Difference 2018 to 2019 |
|---|---|---|---|---|---|---|
| Split CAC | 5,114 | 4,362 | 3,630 | 3,415 | 2,315 | -32% |
| Ductless Mini Split | 894 | 814 | 1,200 | 1,884 | 2,045 | 9% |
| ASHP | 249 | 90 | 181 | 346 | 385 | 11% |
| GSHP | 166 | 125 | 187 | 151 | 142 | -6% |
| **Subtotal** | **6,423** | **5,391** | **5,198** | **5,796** | **4,887** | **-16%** |
| Smart Thermostat | | | | 155 | 162 | 5% |
| Total | 6,423 | 5,391 | 5,198 | 5,951 | 5,049 | -15% |

Source: Home Comfort program-tracking data, 2015, 2016, 2017, 2018, 2019.

### 4.1.3 Program Marketing

In 2019, PSEG Long Island officially re-branded the Home Comfort program (previously referred to as the Cool Homes program) to reflect the transition from cooling focused measures to broader heating and cooling measures. As such, the program team updated marketing collateral, including brochures and conference materials. Specifically, the program team updated materials to include more information related to ASHPs and cold climate heat pumps. Program administrators continued to leverage similar marketing channels as in previous years, including attending industry trade meetings to promote the program and educate contractors, engineers, and architects about the benefits of becoming qualified contractors. Program administrators also marketed the program through radio and direct mail campaigns.

In addition to these broad marketing strategies, program administrators implemented targeted campaigns aimed at specific customers. Similar to 2018, program administrators continued a targeted outreach campaign aimed at promoting GSHPs to communities on the North and South forks of Long Island. Additionally, program administrators organized events to promote the Home Comfort program, specifically heat pump offerings, in communities with a higher penetration of electric resistance heating. These targeted campaigns provided customers with information about the benefits of heat pumps, the range of program rebates, and the pool of preferred contractors. Notably, program administrators identified that lack of customer knowledge about heat pumps as a potential challenge for future years. They cited effective marketing campaigns as a critical strategy for addressing this barrier.

### 4.1.4 Anticipated Changes for Future Years

In 2020, split CAC systems and ductless mini-split ACs will no longer be eligible for rebates through the Home Comfort program.[28] In addition, program administrators will only provide rebates for installations completed by a participating Home Comfort contractor. Program administrators reported that contractors are aware this transition is occurring and seem to be embracing the new emphasis on heat pumps.

Also, in 2020, program administrators will begin shifting the focus of the program toward the replacement of electric resistance and fossil fuel heating systems. Accordingly, program savings will become increasingly dominated by MMBtu savings. This transition will be accompanied by a new rebate structure where customer rebate levels vary based on the system being replaced.

#### Air Source Heat Pump Pilots

In preparation for the changes to the program's design, PSEG Long Island launched three pilot offerings in 2019 that mirror the future of the Home Comfort program. These pilots focused on: (1) electric resistance heating replacements (launched in Q2), (2) whole house new construction installations (launched in Q3), and (3) whole house non-electric heating system replacements (launched in Q4). The whole house offerings required the installation of a NEEP listed cold climate heat pump that could meet 100% of the home's heating load. Customers could keep fossil fuel systems as supplemental heating sources but were required to install integrated controls to ensure the additional system only operates when outdoor temperatures drop below a set temperature. PSEG Long Island designed the whole house pilots as fuel switching offerings to produce MMBtu savings in addition to kWh savings. Accordingly, PSEG Long Island expanded program tracking systems to independently track savings from improved efficiencies (kWh) and from the displacement of fossil fuel consumption (MMBtu) to capture the savings achieved through fuel switching installations fully. These offerings will become critical program components as PSEG Long Island moves toward portfolio-wide MMBtu goals.

PSEG Long Island offered substantial rebates through these pilots. Contractors received an incentive of $500 per project for each pilot installation. To verify the eligibility of the proposed installations, program

[28] Rebates for split CACs and mini-split air conditioners will be paid in 2020 due to a backlog of 2019 applications. Thus, these measures will count as 2020 program activity. However, no new applications will be accepted in 2020.

administrators required contractors to obtain pre-approval prior to installing these systems. Customer rebates ranged from $600 per ton to $1,500 per ton depending on the replacement type and income level (Table 4-7).

Table 4-7. 2019 Customer Rebates, Contractor Incentives, and Efficiency Requirements for Pilot Offerings

| Equipment Type | Efficiency Requirements | Customer Rebate | Customer Rebate (Low-Moderate Income) | Contractor Incentive |
|---|---|---|---|---|
| Electric Resistance Replacements | | | | |
| ASHP | SEER ≥ 16 and HSPF ≥ 8.5 | $800/ton | $1,200/ton | $500/project |
| | SEER ≥ 17 and HSPF ≥ 10 | $1,000/ton | $1,500/ton | |
| ASHP (Cold Climate) | SEER ≥ 17 and HSPF ≥ 10 | $1,000/ton | $1,500/ton | $500/project |
| Ductless Mini Split Heat Pump | SEER ≥ 18 and HSPF ≥ 8.5 | $800/ton | $1,200/ton | $500/project |
| | SEER ≥ 18 and HSPF ≥ 10 | $1,000/ton | $1,500/ton | |
| Ductless Mini Split Heat Pump (Cold Climate) | SEER ≥ 18 and HSPF ≥ 10 | $1,000/ton | $1,500/ton | $500/project |
| Whole House Projects | | | | |
| ASHP (Cold Climate) | SEER ≥ 17 and HSPF ≥ 10 | $1,000/ton (New Construction)<br>$800/ton (Existing Oil & No CAC)<br>$600/ton (All Other) | $1,500/ton (New Construction)<br>$1,200/ton (Existing Oil & No CAC)<br>$900/ton (All Other) | $500/project |
| Ductless Mini Split Heat Pump (Cold Climate) | SEER ≥ 18 and HSPF ≥ 10 | $1,000/ton (New Construction)<br>$800/ton (Existing Oil & No CAC)<br>$600/ton (All Other) | $1,500/ton (New Construction)<br>$1,200/ton (Existing Oil & No CAC)<br>$900/ton (All Other) | $500/project |
| Integrated Controls | N/A | $500/project | $500/project | N/A |

## 4.2 Home Comfort Impacts

### 4.2.1 Ex Post Gross Impacts

Table 4-8 provides a program-level comparison of ex post gross savings to ex ante gross savings by measure category.

Table 4-8. 2019 Home Comfort Program Ex Post Gross Impacts

| Category | Unit Installs | Ex Ante Gross Savings | | Ex Post Gross Savings | | Realization Rate | |
|---|---|---|---|---|---|---|---|
| | | kWh | kW | kWh | kW | kWh | kW |
| Ductless Mini Split Heat Pump | 2,002 | 1,733,892 | -6.0 | 1,562,272 | -5.7 | 90% | 95% |
| Split CAC | 2,315 | 928,267 | 1,038 | 925,134 | 802 | 100% | 77% |
| ASHP | 385 | 614,525 | 75 | 413,078 | 57 | 67% | 76% |
| GSHP | 142 | 393,355 | 213 | 634,865 | 159 | 161% | 74% |

| Category | Unit Installs | Ex Ante Gross Savings | | Ex Post Gross Savings | | Realization Rate | |
|---|---|---|---|---|---|---|---|
| | | kWh | kW | kWh | kW | kWh | kW |
| Smart Thermostat | 162 | 23,742 | 0 | 30,696 | 0 | 129% | N/A |
| Ductless Mini Split AC | 43 | 12,416 | 7.2 | 11,424 | 5.4 | 92% | 75% |
| Totals[a] | 5,049 | 3,707,016 | 1,328 | 3,578,288 | 1,018 | 97% | 77% |

Note: Totals may not sum due to rounding

[a] Four project adjustments of 819 kWh and 0 kW is included in ex ante and ex post total gross savings and overall realization rates, but not shown as a separate line item in this table.

### Reasons for Differences in Gross Impacts

To estimate ex post gross energy and demand savings, the evaluation team used installed sizes and efficiencies of rebated equipment, as determined through examination of the 2019 program tracking data. The evaluation team relied on the 2019 PSEG Long Island TRM, which references the 2015 International Energy Conservation Code (IECC) and NY TRMv6.1, for baseline efficiencies. The evaluation team also conducted a measure-level savings approach to calculate the total ex post gross savings for CACs, ASHPs, Ductless Mini-splits, and Smart Thermostats. To verify gross savings for GSHP measures, we reviewed a sample of projects and extrapolated the results to the population. Most measure-specific discrepancies between ex ante and ex post gross savings are due to differences in program and evaluation assumptions, including, but not limited to, baseline efficiencies and full load operating hours of equipment.

Below we describe the evaluation team's measure-specific savings calculations and reasons for discrepancies between gross ex ante savings and ex post savings for each measure.

- Ductless Mini-split Systems: Program administrators completed two types of ductless mini-split installations in 2019: "Cooling Only" (i.e., ductless mini-split AC) and "Heating & Cooling" (i.e., ductless mini-split HP) installations. The evaluation team applied air conditioning baseline efficiency and equivalent full load hours to AC installations and applied heat pump baseline values to heat pump installations.
  - Ductless Mini-split Heat Pumps: The evaluation team calculated realization rates of 90% for gross energy savings and 95% for gross demand savings. We removed 98 records from the analysis that included ex ante savings, but also indicated zero quantities installed, resulting in the lower realization rates.
    - Negative ex post demand savings are primarily the result of 488 (24% of total ductless mini-split heat pump installations) installations with EER values (ranging between 8.2 and 11.6)[29] that are less than code baseline (11.76). These measures effectively negate the demand savings generated from the other 1,515 ductless mini-split heat pump installations. Additionally, the evaluation team identified differences in the CF values used by the program (0.8) and the evaluation team (0.65), which also lowered realization rates.
  - Ductless Mini split AC: The evaluation team calculated realization rates of 92% for gross energy savings and 75% for gross demand savings. Discrepancies between ex ante and ex post demand savings are primarily driven by differences in the CF values used in the calculations. Consistent with values specified in the 2019 PSEG Long Island TRM, the evaluation team applied a CF of 0.65, while the program applied a CF of 0.8. Additionally, program administrators claimed savings

[29] The evaluation team verified the accuracy of installed EER values by manually checking AHRI certificates available in the Captures tracking system against the AHRI database at https://www.ahridirectory.org/Search/SearchHome?ReturnUrl=%2f.

for projects that listed zero units installed in the program tracking data, which the evaluation excluded from the analysis, resulting in lowered energy and demand savings realization rates.

- Split Central Air Conditioners: The evaluation team calculated realization rates of 100% for gross energy savings and 77% for gross demand savings for the installation of CACs. Discrepancies between ex ante and ex post demand savings are primarily driven by differences in the CF values used in the calculations. Consistent with values specified in the 2019 PSEG Long Island TRM, the evaluation team applied a CF of 0.65, while ex ante calculations assumed a CF of 0.8. Additionally, ex ante calculations assumed a kW QI factor of 0.096, in contrast, the 2019 PSEG Long Island TRM specified a QI factor of 0.05. Lastly, program administrators claimed savings for 12 records in the program tracking data that listed zero units installed.
- Air Source Heat Pumps: The evaluation team calculated realization rates of 67% for gross energy savings and 76% for gross demand savings for the installation of ASHPs. The evaluation team's adjustments to projects where ASHPs replace electric resistance heating units drove the lower energy realization rate (described below). Differences in CF values drove the lower demand savings realization rate. Similar to demand discrepancies in the split CAC analysis, program administrators assumed a CF of 0.8 and a QI factor of 0.096, while the evaluation team applied a CF of 0.65 and a QI factor of 0.5 from the 2019 PSEG Long Island TRM. Finally, we removed savings claimed from 21 records that listed zero units installed.
- Electric Resistance Unit Replacements: With the shift towards more comprehensive heating and cooling offerings (see Section 4.1.4), the Home Comfort program team promoted ASHPs specifically to customers with electric resistance heating units. In 2019, the program completed 64 of these projects. In estimating ex post savings for these projects, the evaluation team assumed the new ASHP units met the full heating needs of the homes and applied effective full load hours of 327 for cooling and 1,538 for heating, as recommended in the New Efficiency: New York Residential Heat Pump Analysis May 2019 update.[30] The evaluation team calculated cooling savings based on code baseline equipment and efficiencies (SEER 14 and EER 11.76) and applied a baseline HSPF of 3.41 for heating calculations to reflect the efficiency of the preexisting electric resistance heating system. In contrast, ex ante calculations assumed SEER values ranging from 8 to 13 and EER values from 6 to 12, resulting in lower realization rates.
- Geothermal Heat Pumps (GSHP): The evaluation team calculated realization rates of 161% for gross energy savings and 74% for gross demand savings for the installation of GSHPs. To estimate ex post savings for a sample of 26 projects (representing 51% of ex ante savings), the evaluation team applied savings algorithms and assumptions from the 2019 PSEG Long Island TRM, in coordination with Manual J heating and cooling loads, rated heating and cooling capacities (in tons), and efficiencies (EERs and COPs) available in the program tracking data. Differences in equipment capacities and AHRI-rated efficiencies from project documentation compared to values listed in the program tracking database (on average, 13%, 14%, and 11% greater for heating capacity, heating efficiency, and cooling efficiency, respectively) increased ex post gross savings versus ex ante. Additionally, the ex post gross demand savings are lower than the ex ante savings because the evaluation team applied a CF of 0.69 specified in the 2019 PSEG Long Island TRM. In contrast, the ex ante calculations assume a CF of 0.8.
- Smart Thermostats: The evaluation team calculated a realization rate of 129% for smart thermostat gross energy savings. Ex post energy savings exceed ex ante savings because the evaluation team applied updated deemed savings values for smart thermostat installations based controlled by the

[30] New Efficiency: New York. Analysis of Residential Heat Pump Potential and Economics. Update May 2019. New York State Energy Research and Development Authority (NYSERDA).

thermostat. Per a 2017 memorandum[31] developed by the evaluation team, we applied energy savings values of 174 kWh/year to homes with central cooling and 402 kWh/year for homes with a heat pump. Ex ante calculations assumed a deemed savings value of 174 kWh/year to all installations without accounting for heat pumps.

### 4.2.2 Ex Post Net Impacts for Cost-Effectiveness

Table 4-9 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 Home Comfort program achieved an ex post net realization rate of 114% for energy savings and 94% for demand savings. Ex post realization rates for energy savings ranged from 79% for the ASHP installations to 167% for GSHP. Ex post realization rates for demand savings ranged from 75% for the ASHP and GSHP installations to 100% for split CAC.

Table 4-9. 2019 Home Comfort Program 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 |
| Ductless Mini Split Heat Pump | 2,002 | 1,587,471 | -6.3 | 1,718,671 | -5.66 | 108% | 90% |
| Split CAC | 2,315 | 885,785 | 1,021 | 1,068,267 | 1,025 | 121% | 100% |
| ASHP | 385 | 573,530 | 75 | 454,431 | 56.50 | 79% | 75% |
| GSHP | 142 | 418,579 | 233 | 698,422 | 174 | 167% | 75% |
| Smart Thermostat | 162 | 22,239 | 0 | 26,002 | 0 | 117% | N/A |
| Ductless Mini Split AC | 43 | 10,938 | 6.5 | 12,567 | 5.4 | 115% | 82% |
| **Totals[a]** | **5,049** | **3,499,013** | **1,330** | **3,978,830** | **1,256** | **114%** | **94%** |

Note: Totals may not sum due to rounding.

[a] Four project adjustments of 471 kWh and 0.2 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.

## 4.3 Conclusions and Recommendations

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

- Key Finding #1: Current program tracking systems do not differentiate between split CAC and single package units. Therefore, the evaluation team assumed all 2019 CAC installations were split systems with baseline efficiencies of 11.18 EER and 13 SEER when calculating ex post savings.
  - Recommendation: Collect information on base case and installed unit configuration (i.e., split or packaged) to improve the accuracy of ex ante energy savings calculations.

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

- Key Finding #2: The evaluation team identified ASHP and CAC records with no baseline EER or EFLH Cooling values entered in the program tracking data.
  - Recommendation: Consistently track all baseline information in the program tracking data to support greater transparency in future evaluations.
- Key Finding #3: The evaluation team identified ductless mini-split records with installed EERs below code baseline and installed SEERs greater than code baseline. The low EER values resulted in negative ex ante and ex post demand savings for these records, and minimal demand savings for the ductless mini-split offering, as a whole.
  - Recommendation: Only incentivize units with an EER above the federal baseline of 11.76.
- Key Finding #4: Program administrators applied a deemed savings value for smart thermostats that accounted for cooling savings only.
  - Recommendation: Adopt deemed savings values specific to the HVAC equipment controlled by the thermostat, as outlined in the 2020 PSEG Long Island TRM.
- Key Finding #5: The program tracking database did not specify whether Manual J values accompanying GSHP installations corresponded to heating or cooling loads.
  - Recommendation: Track Manual J values for both heating and cooling loads in the tracking data as separate fields for all GSHP measures.
- Key Finding #6: Project documentation on AHRI equipment capacities and efficiencies for GSHP installations do not match values listed in the program tracking database (which are used in ex ante savings calculations).
  - Recommendation: Consider aligning tracked values for equipment capacity and efficiencies with those listed on unit specifications and AHRI certificates for all GSHP installation

# 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. 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 April 2019, the income eligibility guidelines changed from 70% of the 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 and free installation of energy-saving measures. Program measures included LED light bulbs, domestic hot water (DHW) measures, thermostatic valves, exterior lighting, Tier 1 smart power strips, room air conditioners (RACs), dehumidifiers, and refrigerators. In 2019, the program administrators added LED candelabras, night lights, and 50-pint dehumidifiers to generate additional savings for program participants. During the home energy audit, auditors provide power strips to customers with instructions on how to use the new equipment, but auditors do not install the equipment.

In addition to providing program participants with energy-saving measures, the program includes a strong educational component. During the audit, the auditor works with participating customers to determine additional energy-saving actions and behavior changes that customers will commit to. These additional steps help the customers generate savings beyond those realized by the measures installed during the home audit. By educating the 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 auditors also inspect the customers' heating and hot water systems for safety.

### 5.1.2 Program Participation and Performance

In terms of verified ex ante gross savings, the REAP program performed well in 2019, reaching 100% of the energy savings goal and 112% of the peak demand goal. However, as presented in Section 5.2.1, ex post gross savings for 2019 were lower than the verified ex ante savings for the program. Table 5-1 presents verified ex ante gross savings compared to goals for the 2019 REAP program.

Table 5-1. 2019 REAP Program Verified Ex Ante Gross Program Performance Against Goals

| Metric | MWh | MW |
|---|---|---|
| Goal | 1,472 | 0.32 |
| Verified Ex Ante Gross Savings | 1,472 | 0.36 |
| % of Goal | 100% | 112% |

Table 5-2 shows the distribution of savings by program component. Interior lighting continues to account for the largest share of REAP program gross energy and demand savings accounting for 46% of ex ante gross energy savings and 52% of ex ante gross demand savings in 2019.

Table 5-2. 2019 REAP Program Ex Ante Gross Savings by Program Component

| Program Component | Ex Ante Utility Gross Savings | |
|---|---|---|
| | MWh% | MW% |
| Interior Lighting | 46% | 52% |
| Domestic Hot Water | 14% | 0% |
| Power Strips | 9% | 4% |
| Exterior Lighting | 5% | 0% |
| Refrigerator | 3% | 1% |
| Room AC | 3% | 25% |
| Dehumidifier | 2% | 2% |
| LED Candelabra[a] | 13% | 15% |
| 50-Pint Dehumidifier[a] | 2% | 0% |
| LED Nightlight[a] | 2% | 1% |

[a] These measures were not included in the 2018 program.

The REAP program treated 2,155 unique participants in 2019 compared to 2,106 customers in 2018 for an increase of 2%. Of the participants, nearly all received lighting and power strips as shown in Table 5-3.

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

| Measure Category | Percent Receiving[a] |
|---|---|
| Interior Lighting | 94% |
| Domestic Hot Water | 16% |
| Power Strips | 100% |
| Exterior Lighting | 22% |
| Refrigerator | 8% |
| Room AC | 29% |
| Dehumidifier | 8% |
| LED Nightlight | 51% |
| LED Candelabra | 33% |
| 50-Pint Dehumidifier | 6% |

[a] Of the 2,155 unique REAP program participants in 2019.

### 5.1.3 Program Marketing

The REAP program maintained the same marketing approach in 2019 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 REAP program outreach events across the PSEG Long Island service territory during 2019 to reach customers that may be best served by the program. In 2019, PSEG Long Island participated in the Long Island regional event of the Low-Income Forum on Energy. This event was part of a series of regional events across New York aimed at fostering education and awareness of initiatives targeting low-income energy customers. At the Long Island event, advocacy groups from across Long Island come together with PSEG Long Island staff to learn about the programs offered by PSEG Long Island, including the REAP program. In addition, PSEG Long Island hosts the annual Energy Forum for Advocates typically held in the fall, prior to the start of the heating season which has over 300 advocacy attendees. The Energy Forum for Advocates is a full day event where presentations are given on assistance programs offered by PSEG Long Island including REAP, Household Assistance Rebate program and Financial Assistance, as well as non-PSEG Long Island assistance programs, such as HEAP, CDC Long Island and United Way's Project Warmth. In addition to these efforts, the REAP program introduced the following new marketing efforts in 2019:

- PSEG Long Island REAP Program Management coordinated with the Red Cross by including the Red Cross flyers in the REAP Customer Education Folders that detail the offering in addition to the installation of smoke detectors free of charge for customers. The PSEG Long Island REAP Program field technicians determine whether smoke detectors are working properly or not working at all and refers the REAP customer to the American Red Cross accordingly.
- PSEG Long Island marketing staff sent email "blasts" to low- and moderate-income customers informing them of the benefits of the REAP program.
- In September 2019, PSEG Long Island began highlighting new energy-efficient appliances and strategies for low-income customers in the home energy report offered through their HEM program.

### 5.1.4 Anticipated Changes in 2020

In 2020, PSEG Long Island plans to continue to implement the program consistent with past years; however, program managers report that they will be adjusting their savings for some measures (e.g., DHW measures with oil baselines) as part of the move towards MMBtu savings goals.

## 5.2 REAP Program Impacts

### 5.2.1 Ex Post Gross Impacts

As in previous years, the evaluation team used both engineering and consumption analysis to estimate savings for the REAP program in 2019.[32] The combined consumption and engineering analyses found that the REAP program generated approximately 1,219 MWh in gross energy savings in 2019, or about 83% of the ex ante gross energy savings. The program achieved ex post gross demand savings of 288 kW, as presented in Table 5-4.

Table 5-4. 2019 REAP Program Ex Post Gross Impacts

| Category | N[a] | Ex Ante Gross Savings | | Ex Post Gross Savings | | Realization Rate | |
|---|---|---|---|---|---|---|---|
| | | kWh | kW | kWh | kW | kWh | kW |
| Interior Lighting | 2,015 | 683,460 | 213 | 572,450 | 181 | 84% | 85% |
| Domestic Hot Water | 346 | 201,649 | 1 | 168,897 | 1 | 84% | 73% |
| Power Strips | 2,153 | 131,779 | 18 | 110,375 | 12 | 84% | 67% |
| Exterior Lighting | 481 | 76,910 | 0 | 64,418 | 0 | 84% | NA |
| Refrigerator | 182 | 50,621 | 6 | 42,399 | 5 | 84% | 88% |
| Room AC | 631 | 46,945 | 103 | 39,320 | 32 | 84% | 31% |
| Dehumidifier | 168 | 33,189 | 7 | 27,798 | 5 | 84% | 84% |

[32] To calculate ex post gross savings, we applied the consumption analysis realization rate (84%) to the ex ante gross savings. For measures new to the 2019 program year, we used an engineering approach to estimate savings. This resulted in a combined realization rate of 83%. All gross impacts exclude line-losses. To calculate demand, we use a kW/kWh ratio from the engineering analysis.

| Category | N[a] | Ex Ante Gross Savings | | Ex Post Gross Savings | | Realization Rate | |
|---|---|---|---|---|---|---|---|
| | | kWh | kW | kWh | kW | kWh | kW |
| LED Candelabra[b] | 707 | 190,072 | 60 | 135,235 | 43 | 71% | 71% |
| LED Nightlight[b] | 1,093 | 34,657 | 0 | 10,975 | 0 | 32% | NA |
| 50-Pint Dehumidifier[b] | 124 | 25,645 | 5 | 47,427 | 8 | 185% | 185% |
| **Total[c]** | **2,155** | **1,474,926** | **412** | **1,219,292** | **288** | **83%** | **70%** |

[a] Number of REAP program participants with measures in 2019.

[b] These measures were not a part of the 2018 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 program total participants counts, net savings, and realization rates.

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

### 5.2.2 Ex Post Net Impacts for Cost-Effectiveness

To estimate ex post net impacts for cost-effectiveness purposes, the evaluation team used a similar approach to calculating gross savings, except for using net values that incorporate line losses.[33] This results in ex post net savings of 1,298 MWh and 315 MW. Notably, the ex ante net savings are higher than the ex ante gross savings displayed in Table 5-5. This is due to the application of line losses that increase those ex ante gross savings proportionally by the line loss factor.

Table 5-5. 2019 REAP Program Ex Post Net Impacts for Cost-Effectiveness

| Category | N[a] | Ex Ante Net Savings | | Ex Post Net Savings | |
|---|---|---|---|---|---|
| | | kWh | kW | kWh | kW |
| Interior Lighting | 2,015 | 727,992 | 222 | 609,749 | 198 |
| Domestic Hot Water | 346 | 214,557 | 2 | 179,708 | 1 |
| Power Strips | 2,153 | 140,137 | 20 | 117,376 | 13 |
| Exterior Lighting | 481 | 81,629 | 0 | 68,370 | 0 |
| Refrigerator | 182 | 53,879 | 6 | 45,128 | 6 |
| Room AC | 631 | 49,969 | 112 | 41,853 | 35 |
| Dehumidifier | 168 | 35,309 | 8 | 29,574 | 5 |
| LED Candelabra[b] | 707 | 202,294 | 64 | 143,867 | 47 |
| LED Nightlight[b] | 1,093 | 36,774 | 0 | 11,675 | 0 |
| 50-Pint Dehumidifier[b] | 124 | 27,280 | 5 | 50,454 | 9 |
| **Total[c]** | **2,155** | **1,569,820** | **439** | **1,297,754** | **315** |

[a] Number of REAP program participants with measures in 2019.

[b] These measures were not a part of the 2018 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 program total participants counts, net savings, and realization rates.

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

[33] To calculate ex post net savings, we applied the consumption analysis realization rate (84%) to the ex ante net savings. For measures new to the 2019 program year, we used an engineering approach to estimate savings. This resulted in a combined realization rate of 83%. All net impacts include line-losses. To calculate demand, we use a kW/kWh ratio from the engineering analysis.

### 5.2.3 Analysis Approach and Detailed Results

As in previous years, the evaluation team used both engineering and consumption analysis to estimate savings for the REAP program in 2019. Consumption analyses, which use actual customer electric usage to estimate savings and account for the interactive effects of multiple measures, typically provide a more robust assessment of energy savings than engineering estimates. For this reason, the evaluation team primarily based the program energy savings on the results of the consumption analysis. We used the engineering analysis to calculate a demand to energy ratio, which allows us to estimate 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 analysis uses 2018 participants as the treatment group. It uses the pre-participation period of the 2019 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 (2018 participants) in their post-installation period. With LED candelabras, 50-pint dehumidifiers, and night lights added at the start of 2019, however, the consumption analysis does not capture any savings from these new measures. For the participants who had these new measures installed in 2019, the measure-level savings calculated in the engineering analysis are added to the savings shown by the consumption analysis.

Using future participants as a comparison group assures us that the treatment and comparison groups are equivalent, at least as it relates to self-selection of program participation. The criteria and process for program selection are similar between early and later participants. However, there can be differences in the groups from one year to the next, so we performed analyses to check that both groups of participants are similar in other ways. 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 similar in consumption and weather experienced during the same calendar period, 2017, 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 in terms of electricity usage. The 2019 cohort's pre-treatment usage was slightly lower than that of the 2018 cohort. The difference was largely limited to the first quarter of 2017 when the billing records for a substantial portion of comparison group customers was missing. Later in the year, the consumption patterns converged between the two groups, indicating that they are similar when all data are comparable. We show these comparisons in Section 9.5.

The consumption analysis model uses monthly billing data to quantify post-installation 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 ex post demand and energy savings for each measure. Next, we applied this ratio to the energy savings estimates derived from the consumption analysis to generate ex post demand savings.

#### Engineering Analysis

The evaluation team used program tracking data and engineering analysis to estimate gross energy and demand savings achieved by each measure installed through the 2019 REAP program. As described above, the results of the engineering impacts analysis provide us with the demand to energy ratio needed to develop demand savings from the energy consumption analysis and an understanding of the relative contribution of the measures offered by the program. In other words, we conduct this analysis to provide insights into the individual measure savings compared to ex ante to enhance per-unit assumptions, as well as to understand variations between consumption analysis results and planning assumptions.

Table 5-6 shows the ex post gross savings as determined by the engineering analysis for each measure category. The sum of measure-level savings in the engineering analysis, or the total Engineering Analysis Gross Savings in Table 5-6, exceed the total gross ex post savings determined through the combined consumption and engineering analysis (see Table 5-4). This is a common result when comparing results from engineering and consumption analyses and is likely due to a combination of factors, including overstated measure-level savings and interaction among measures (e.g., improved lighting efficiency may also increase heating load).

Table 5-6. 2019 REAP Program Measure-Specific Gross Impacts: Engineering Analysis

| Category | N[a] | Ex Ante Gross Savings | | Engineering Analysis Gross Savings | | Engineering Analysis Realization Rate | |
|---|---|---|---|---|---|---|---|
| | | kWh | kW | kWh | kW | kWh | kW |
| Interior Lighting | 2,015 | 683,460 | 213 | 987,904 | 313 | 145% | 147% |
| Domestic Hot Water | 2,153 | 201,649 | 1 | 237,220 | 1 | 118% | 103% |
| Power Strips | 124 | 131,779 | 18 | 129,528 | 14 | 98% | 79% |
| Exterior Lighting | 346 | 76,910 | 0 | 97,764 | 0 | 127% | 0% |
| Refrigerator | 707 | 50,621 | 6 | 46,014 | 6 | 91% | 95% |
| Room AC | 1,093 | 46,945 | 103 | 41,036 | 34 | 87% | 33% |
| Dehumidifier | 481 | 33,189 | 7 | 55,774 | 10 | 168% | 145% |
| LED Candelabra | 631 | 190,072 | 60 | 135,235 | 43 | 71% | 71% |
| LED Nightlight | 168 | 34,657 | 0 | 10,975 | 0 | 32% | - |
| 50-Pint Dehumidifier | 182 | 25,645 | 5 | 47,427 | 8 | 185% | 185% |
| **Total[b]** | **2,155** | **1,474,926** | **412** | **1,788,877[c]** | **429** | **121%** | **104%** |

[a] Number of REAP program participants with measures in 2019.

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

[c] Total savings reflect the results of the Engineering Analysis and are not the final program Ex Post Gross Savings. See Table 5-4 for the final program Ex Post Gross Savings.

## Reasons for Differences in Engineering Impacts

As shown in Table 5-6, the engineering analysis found that the sum of the measure-level savings estimates exceeded both of ex ante gross energy savings and ex ante gross demand savings. Below we describe the measure-specific engineering savings calculations and reasons for discrepancies between the ex ante assumptions and measure-level engineering results:

- Lighting: Interior and exterior lighting, including LED Candelabra and LED Nightlight measures, accounted for 69% and 83% of ex post gross energy and demand savings, respectively. The evaluation team calculated a combined realization rate for interior and exterior lighting of 125% for energy savings and 136% for demand. The Engineering Analysis Gross Savings are higher than the Ex Ante Gross Savings due to the following:
  - Delta Watts: The evaluation team calculated a difference in lighting wattages from 2019 tracking data for each individual bulb type. Of the 12 different LED lighting types provided by the REAP program, ten have a higher value for delta watts compared to those used by the program. Using

actual wattage values from program tracking data resulted in higher average delta watts for all LED lighting types in comparison to ex ante values and an increase in the overall lighting realization rate for both energy and demand.

- LED Nightlight Measure Wattage: Planning assumptions were unavailable for nightlights, so the evaluation team is unable to pinpoint differences between ex-ante and evaluation assumptions that led to a low realization rate for this measure.

- Domestic Hot Water: DHW measures include showerheads, faucet aerators, pipe insulation, turndown of hot water heater temperature, and thermostatic restrictor valves. Based on the engineering analysis, DHW measures account for 13% of gross energy savings. Below is a discussion of the differences between program assumptions and the evaluation findings.
  - Low-Flow Showerhead: The evaluation team incorporated actual delta flow rate (gallons per minute, GPM) values from the 2019 program tracking database, which are 7% greater than the 2017 values applied by the program administrator in ex ante savings. Based on the engineering analysis, these differences accounted for the Engineering Analysis Gross Savings realization rate of 107%.
  - Faucet Aerators and Flip Swivel Aerators: The evaluation team found that ex ante savings for 3 out of 80 faucet aerators and 8 out of 327 flip swivel aerators used planning assumptions from 2018, which were three times higher than 2019 planning assumptions, leading to a decrease in the energy realization rate. Additionally, the evaluation team incorporated actual delta flow rate values from the 2019 program tracking database, which are 1% lower than the value from 2017 program data applied by the program.
  - Temperature Turndown: The program administrator applied hot water temperature values from the 2019 PSEG Long Island TRM. The evaluation team calculated ex post savings using actual pre- and post-intervention hot water temperatures from the 2019 program tracking data. The resulting temperature change calculated from the 2019 program tracking data is 18% higher than the temperature reduction assumed in ex ante calculations. This resulted in gross realization rates of 118% for both energy and demand savings.
  - Thermostatic Restrictor Valves: The program administrator and evaluation team both applied the algorithm recommended in the 2019 PSEG Long Island TRM. However, the evaluation team calculated savings using installed showerhead GPM values from the program tracking data, whereas the program administrator applied the value recommended in the 2019 PSEG Long Island TRM. The installed GPM determined from the 2019 program tracking data was 62% greater than planning assumptions, resulting in a 62% engineering analysis gross realization rate.
- Refrigerator: The program administrator and evaluation team applied the same algorithms for refrigerator savings calculations. A discrepancy in savings arose because the evaluation team estimated the efficient unit annual energy consumption using the ENERGY STAR Appliance Calculator[34] and federal energy standard algorithms,[35] whereas the program administrator applied the manufacturer-specified annual energy consumption. The program tracking data does not include installed model numbers or annual energy consumption values, so the evaluation team could not verify the manufacturer's rated energy consumption. We, therefore, estimated annual consumption based on unit class and capacity. Based on the engineering analysis, the Engineering Analysis Gross Savings realization rates for refrigerators are 91% for energy and 95% for demand.

[34] 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

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

- Dehumidifier: The evaluation team found that the replaced dehumidifier energy factors were 6% lower, and the efficient dehumidifier energy factors were 13% higher than program assumptions. Additionally, the evaluation team noted that some of the reported efficiencies for existing systems were off by a value of one; upon reviewing individual contractor information and comparing it to program data, the problematic values were manually corrected to reflect the proper values. These changes resulted in an Engineering Analysis Gross Savings realization rates of 181% and 159% for energy and demand, respectively.
- Room Air Conditioners: The program administrator and evaluation team applied the same savings algorithms. The evaluation team applied a CF value of 0.30, specified in the 2019 PSEG Long Island TRM, whereas the program administrator applied a CF value of 0.80, specified in the 2018 PSEG Long Island TRM. This difference resulted in an engineering analysis demand savings realization rate of 33%. Additionally, the evaluation team applied actual removed and installed unit efficiencies from the 2019 planning assumptions, resulting in an increase of baseline and efficient unit efficiencies compared to planning assumptions. This difference led to a room air conditioner measure energy savings realization rate of 87%.
- Power Strips: The program administrator and evaluation team applied the same savings algorithms. However, the ex ante demand savings algorithm used a CF of 1.0, whereas the evaluation team applied a CF of 0.8 as specified in the 2019 PSEG Long Island TRM. This difference reduced engineering analysis savings compared to ex ante and resulted in 98% and 79% power strip measure realization rates for energy and demand, respectively.

### 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), calendar month, 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 any differences between the groups that could be seasonal. We did not include terms for specific measures or end-uses.

The evaluation team 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 measures installed in most households, it is impossible to estimate individual measure effects accurately. As such, the 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 5-7 presents the overall net program savings for 2019 REAP program participants based on the consumption analysis of 2018 participants. Because our regression model includes a comparison group of future participants, the results reflect net impacts. As shown below, the consumption analysis produced an 84% realization rate. When combined with the engineering analysis 2019 REAP program realized 83% of its expected savings. These results reflect savings attributable to the program and the types of measures installed during 2019.

Table 5-7. 2019 REAP Program Consumption Analysis Net Savings Compared to Ex Ante Net Savings

| N (2019 Participants)[a] | Observed Net Savings[b] | | Adjusted Program Planning Net Savings[c] | | Realization Rate |
|---|---|---|---|---|---|
| | Household Daily Savings (kWh) | Household Annual Savings (kWh) | Household Daily Savings (kWh) | Household Annual Savings (kWh) | |
| 2,155 | 1.67 | 610 | 2.00 | 728 | 84% |

[a] Number of REAP program participants with measures in 2019.
[b] Observed savings derived from consumption analysis do not include LED Candelabras, LED Nightlights and 50-pint dehumidifier as these measures were added to the program in 2019.
[c] Results include line loss factors as they represent net savings.

### Reasons for Differences Between Consumption Analysis and Ex Ante Savings

The 2019 combined consumption and engineering analysis resulted in slightly lower overall ex post gross savings than ex ante gross savings, as shown by the 84% realization rate for the 2018 measure categories. Note that with the application of the LED candelabra, LED nightlight and 50-pint dehumidifier ex post energy savings calculated using an engineering analysis, the overall realization rate is 83%. This realization rate for the 2019 program is an improvement compared to previous years. In 2018, the program realization rate was 45%.

The improved realization rate in 2019 is largely due to: 1) higher savings observed in the billing analysis, and 2) improvements in the program planning assumptions for measure-level savings. For example, the 2019 ex ante savings for multiple LED measures (10-watt A-lamp LEDs, 14-watt three-way LEDs, 5-watt globe LEDs, and R30 and R40 reflector bulbs) were about 30% lower than in 2018. These LED products accounted for a large percentage of ex ante savings in 2019 (44%) and an even higher percent of savings in 2018 (63%). The reduced per-bulb ex ante savings better aligned with the consumption analysis results. Similarly, the 2019 REAP program reduced ex ante savings for power strips by 41% compared to 2018 and for aerators by 70% compared to 2018. Combined, aerators and power strips accounted for 20% of total savings in 2019.

## 5.3 Conclusions and Recommendations

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

- Key Finding #1: The evaluation team consumption analysis results fell more in line with planning assumptions than in prior evaluations. This is primarily due to PSEG Long Island's revised lighting per-unit savings assumption that reflect increased saturation of efficient lighting in households. However, the program administrator's delta watts assumptions in lighting measure calculations do not correspond to the existing and installed wattage values reported in the program tracking database.
  - Recommendation: We recommend aligning existing and installed wattage values used in calculations with those reported in the program tracking database. This will support continued accuracy in lighting assumptions applied by the program administrators.
- Key Finding #2: 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: Track the refrigerator model configuration and icemaker characteristics in Captures to allow for more accurate savings estimates. While this information is available in project workbooks, incorporation to the program tracking data system supports evaluation

activities by eliminating need for desk review activities and historically leads to improved savings estimates and program performance.

- Key Finding #3: Savings from DHW measures, which include aerators, showerheads, pipe insulation, thermostatic valves, and turndown of water heater temperature, depend on key water heater characteristics that are not currently being tracked in Captures.
  - Recommendation: Begin tracking water heater type and capacity to support increased accuracy of savings calculations for the portfolio of DHW measures. While this information is available in project workbooks, incorporation to the program tracking data system supports evaluation activities by eliminating need for desk review activities and historically leads to improved savings estimates and program performance.

# 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, provision of a Home Energy Score, and possible free or rebated efficient equipment. The Home Performance Programs' design and implementation did not change significantly in 2019 compared to 2018.

## 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 an electric heat source. 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 2018 to 2019. Similar to 2018, program staff recorded all program tracking data in the TRM Captures database. The program administrators made several minor changes to measures available in 2019. The program added night/outdoor lighting, Tier 2 smart strips, and pipe insulation as new measures. Additionally, the program changed the composition of the "Thank You" Kits mailed to home energy assessment recipients. The Thank You Kits contain four LED bulbs, down from six that were included in 2018. Additionally, the kits no longer include a Tier 2 smart strip.

#### Home Performance with ENERGY STAR

Similar to HPDI, the HPwES program leverages a home audit conducted 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 the home's heating and cooling equipment and an assessment of insulation levels and air leakage to address building envelope efficiency. 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 participants seeking deeper retrofit opportunities may opt to also 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 natural gas 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 2019 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 83% of the energy savings goal and 76% of the peak demand goal in 2019. Table 6-1 presents 2019 Home Performance programs verified ex ante savings compared to goals.

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

| Metric | MWh | MW |
|---|---|---|
| Goal | 2,761 | 2.19 |
| Verified Ex Ante Net Savings | 2,300 | 1.65 |
| % of Goal | 83% | 76% |

In 2019, the HPDI program completed projects with 338 customers, while the HPwES program treated 1,578 customers. A total of 104 customers participated in both programs. Overall, 1,812 unique customers were treated by the Home Performance programs in 2019.[36]

### 6.1.3 Program Marketing

In 2019, the HPwES and HPDI programs continued with similar marketing approaches as in 2018. HPDI relies primarily on postcard mailings to generate interest and participation in the program. As noted by the program staff, they have a list of about 40,000 customers to whom they send postcards, specifically those who 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.

Additionally, program staff noted that they maintain partnerships with other organizations, such as National Grid and the American Red Cross, to help customers receive equipment to improve home energy efficiency and safety. National Grid offers a program to address heating so when HPwES assessors visit an income-qualified customer with gas heat, they make a referral. In addition, program staff make customer referrals to the American Red Cross when they find customers who do not have smoke detectors or ones that are not working properly.

### 6.1.4 Anticipated Changes in 2020

In 2020, the implementation team plans to continue the program consistent with past years; however, they expect to use a new audit tool. Their plan is roll out the new tool in January 2020. Program staff noted they were also considering offering air purifiers and a possible new financing partner for the 2020 program year.

[36] These numbers include 138 HPwES customers who installed 139 beneficial electrification measures.

## 6.2 Home Performance Programs Impacts

### 6.2.1 Ex Post Gross Impacts

As in previous years, the evaluation team used both engineering and a consumption analysis to estimate savings for the Home Performance programs in 2019.[37] The combined consumption and engineering analyses found that the programs generated approximately 2,743 MWh in gross energy savings in 2019, or about 119% of the ex ante gross energy savings. The program achieved ex post gross demand savings of 964 kW, as presented in Table 6-2.

Table 6-2. 2019 HPDI and HPwES Ex Post Gross Impacts

| Category | N[a] | Ex Ante Gross Savings[b] | | Ex Post Gross Savings | | Realization Rate | |
|---|---|---|---|---|---|---|---|
| | | kWh | kW | kWh | kW | kWh | kW |
| **HPDI** | | | | | | | |
| LED Bulbs | 5,753 | 157,797 | 44 | 220,746 | 62 | 140% | 141% |
| Domestic Hot Water (DHW) | 581 | 131,306 | 0.8 | 183,686 | 0.9 | 140% | 105% |
| Duct Sealing | 215 | 121,301 | 45 | 169,690 | 119 | 140% | 262% |
| Advanced Power Strips | 364 | 50,825 | 6.4 | 71,100 | 7.1 | 140% | 111% |
| Thermostatic Valve | 63 | 12,897 | 0.0 | 18,043 | 0.0 | 140% | N/A |
| **HPDI Subtotal** | **6,976** | **474,126** | **97** | **663,264** | **189** | **140%** | **196%** |
| **HPwES** | | | | | | | |
| Envelope | 1,847 | 603,262 | 857 | 843,914 | 169 | 140% | 20% |
| Air Sealing | 1,381 | 259,111 | 357 | 362,475 | 47 | 140% | 13% |
| Lighting | 116 | 67,523 | 0 | 94,459 | 30 | 140% | N/A |
| DHW[c] | 409 | 262,058 | 127 | 366,598 | 177.5 | 140% | 140% |
| HVAC[c] | 1,034 | 218,211 | 205 | 305,260 | 702 | 140% | 342% |
| Thank You Kits | 5,755 | 574,031 | 145 | 803,023 | 203 | 140% | 140% |
| Project Adjustment[d] | 5 | 0 | 0 | 0 | 0 | N/A | N/A |
| **HPwES Subtotal** | **10,547** | **1,984,197** | **1,691** | **2,775,729** | **1,328** | **140%** | **79%** |
| **Measure-Level Total[e]** | **17,523** | **2,458,323** | **1,788** | **3,438,993** | **1,518** | **140%** | **85%** |
| **Project-Level Total[f]** | **17,523** | **2,298,133** | **1,654** | **2,742,985** | **964** | **119%** | **58%** |

Note: Totals may not sum due to rounding.
[a] Count of measures installed through the HPDI or HPwES program.
[b] Reported ex ante gross savings includes measure-level electricity savings and interactive electricity impacts from incentivized measures but excludes beneficial electrification impacts from fuel-switching measures.
[c] DHW and HVAC measures do not include gross beneficial electrification, -135,554 kWh and -560,454 kWh, respectively, in ex ante values.
[d] The project adjustment includes five projects that were "zeroed out" in the program tracking database due to overall negative savings at the project level.
[e] Measure-level savings are obtained through contractor reports and are used in evaluating measure category ex ante savings to illustrate measure performance. These are not the official savings claimed by the program administrators.
[f] Project-level savings are obtained through the year-end closeout December 2019 Monthly KPI scorecard and are the official savings claimed by the program administrators. To be consistent with ex ante claimed savings approach, project-level ex post savings total includes beneficial electrification (from engineering analysis).

[37] To calculate ex post gross energy savings, we applied the consumption analysis realization rate (140%) to the ex ante gross savings. To calculate ex post gross demand, we use a kW/kWh ratio developed from the engineering analysis and apply to the ex post gross energy savings. All gross impacts exclude line-losses.

Presented in Table 6-2 are two realization rates for total measure-level and project-level claimed savings. The difference between measure-level and project-level ex ante savings is the exclusion of beneficial electrification savings from HPwES DHW and HVAC measure categories in measure-level savings, and inclusion in the project-level savings. Beneficial electrification measures offset fossil fuel consumption by converting systems to electricity-operated equipment, resulting in negative electric energy savings (i.e., increased electricity consumption). Overall, beneficial electrification projects have positive energy savings once fossil fuel reductions are accounted for. The evaluation team uses both the measure- and project-level savings to evaluate program performance.

Measure-level ex ante savings are reported through a contractor report, which includes details on beneficial electrification savings (i.e., negative electric savings). This detail allows us to develop measure-level realization rates. The evaluation team removes negative beneficial electrification savings from the contractor measure-level report before applying results from the consumption analysis, resulting in measure-level ex post savings. This step is necessary because the consumption analysis removes beneficial electrification projects from the analysis as fossil fuel savings are not captured in electricity billing data. All results in Table 6-2, with the exception of the project-level total, are measure-level and exclude beneficial electrification savings.

The project-level savings are the ex ante gross energy and demand savings claimed by PSEG Long Island. Project-level savings do not include the majority of beneficial electrification projects, because program administrator's zero out projects with overall negative savings (i.e., increased electricity consumption from beneficial electrification that outweighs electricity savings from a project's other measures (16% of 2019 HPwES projects). The evaluation team added beneficial electrification into ex post measure-level savings to create a comparable ex post energy and demand savings total for reporting final program realization rates.

### 6.2.2 Ex Post Net Impacts for Cost Effectiveness

To estimate ex post net impacts for cost-effectiveness purposes, the evaluation team used a similar approach to calculating gross savings, with the exception of using net values that incorporate line losses.[38] This results in ex post net savings of 2,509 MWh and 902 kW.

Table 6-3. Home Performance Programs Ex Post Net Impacts for Cost-Effectiveness

| Category | N[a] | Ex Ante Net Savings[b] | | Ex Post Net Savings | | Realization Rate | |
|---|---|---|---|---|---|---|---|
| | | kWh | kW | kWh | kW | kWh | kW |
| **HPDI** | | | | | | | |
| LED Bulbs | 5,753 | 167,983 | 46 | 234,995 | 63 | 140% | 138% |
| Domestic Hot Water | 581 | 139,692 | 0.9 | 195,418 | 0.9 | 140% | 107% |
| Duct Sealing | 215 | 129,043 | 50 | 180,521 | 125 | 140% | 252% |
| Advanced Power Strips | 364 | 54,054 | 7.1 | 75,617 | 7.5 | 140% | 106% |
| Thermostatic Valve | 63 | 13,721 | 0.0 | 19,195 | 0.0 | 140% | N/A |
| **HPDI Subtotal** | 6,976 | 504,494 | 104 | 705,745 | 197 | 140% | 190% |
| **HPwES** | | | | | | | |
| Envelope | 1,847 | 642,799 | 939 | 899,223 | 180 | 140% | 19% |
| Air Sealing | 1,381 | 276,123 | 391 | 386,273 | 50 | 140% | 13% |
| Lighting | 116 | 71,999 | 0 | 100,721 | 32 | 140% | N/A |

[38] To calculate ex post net savings, we applied the consumption analysis realization rate (140%) to the ex ante net savings. All net impacts include line-losses. To calculate demand, we use a kW/kWh ratio from the engineering analysis.

| Category | N[a] | Ex Ante Net Savings[b] | | Ex Post Net Savings | | Realization Rate | |
|---|---|---|---|---|---|---|---|
| | | kWh | kW | kWh | kW | kWh | kW |
| DHW[c] | 409 | 279,185 | 139 | 390,558 | 189.1 | 140% | 136% |
| HVAC[c] | 1,034 | 232,708 | 225 | 325,540 | 748 | 140% | 333% |
| Thank You Kits | 5,755 | 315,717 | 80 | 441,663 | 112 | 140% | 140% |
| Project Adjustment[d] | 5 | 0 | 0 | 0 | 0 | N/A | N/A |
| HPwES Subtotal | 10,547 | 1,818,531 | 1,774 | 2,543,977 | 1,311 | 140% | 74% |
| Measure-Level Total[e] | 17,523 | 2,323,025 | 1,877 | 3,249,722 | 1,508 | 140% | 80% |
| Project-Level Total[f] | 17,523 | 2,152,428 | 1,730 | 2,508,509 | 902 | 117% | 52% |

Notes: Totals may not sum due to rounding.
[a] Count of measures installed through the HPDI or HPwES program.
[b] Reported ex ante gross savings includes measure-level electricity savings and interactive electricity impacts from incentivized measures but excludes beneficial electrification impacts from fuel-switching measures.
[c] DHW and HVAC measures do not include net beneficial electrification, -144,340 kWh and -596,873 kWh, respectively, in ex ante values.
[d] The project adjustment includes five projects that were “zeroed out” in the program tracking database due to overall negative savings at the project level.
[e] Measure-level savings are obtained through contractor reports and are used in evaluating measure category ex ante savings to elucidate measure performance. These are not the official savings claimed by the program administrators.
[f] Project-level savings are obtained through the year-end closeout December 2019 Monthly KPI scorecard and are the official savings claimed by the program administrators. To be consistent with ex ante claimed savings approach, project-level ex post savings total includes beneficial electrification (from engineering analysis).

### 6.2.3 Analysis Approach and Detailed Results

As in previous years, the evaluation team used both engineering and consumption analysis to estimate savings for the Home Performance programs in 2019. Consumption analyses, which use actual customer electric usage to estimate savings and account for the interactive effects of multiple measures, typically provide a more robust assessment of energy savings than engineering estimates. For this reason, the evaluation team primarily based the program energy savings on the results of the consumption analysis. We used the engineering analysis to calculate a demand to energy ratio, which allows us to estimate 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 programs. 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, the analysis uses 2018 participants as the treatment group and uses the pre-participation period of the 2019 participants as the comparison group. The energy use of the comparison group prior to their program participation acts as the counterfactual or point of comparison for the treatment group (2018 participants) in their post-installation period. This is consistent with prior evaluations.

Using future participants as a comparison group makes it likely 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 analyses to confirm that both groups of participants are similar in other ways so that we can be confident in using 2019 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 9.6.

This model framework means that the consumption analysis does not capture the effect of any changes related to which measures are included in the program (e.g. the 2019 program added thermostatic valves, and the removed smart power strips and two light bulbs from the 'thank you' kit). We accounted for this discrepancy when calculating the realization rate by calibrating the 2019 ex ante gross savings estimates to include only those measures that were also included in the 2018 program. This "true-up", which was used only for the purposes of calculating the realization rate, ensured that our application of estimated 2018 savings to 2019 participants was an "apples-to-apples" comparison. In addition, our consumption analysis removed any beneficial electrification customers from the modeling.

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 ex post 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 ex post demand savings.

### Engineering Analysis: HPDI

The evaluation team used program tracking data and engineering analysis to estimate gross energy and demand savings achieved by each measure installed through the 2019 HPDI program. As described above, the results of the engineering impacts analysis provide us with the demand to energy ratio needed to develop demand savings from the energy consumption analysis and an understanding of relative contribution of the measures offered by the program. This analysis is conducted to provide insights into the individual measure savings compared to ex ante to enhance per-unit assumptions, as well as understand variations between consumption analysis results and planning assumptions.

Table 6-4 shows the engineering analysis gross savings for each measure category. The engineering analysis results differ from the ex post gross impacts where the consumption analysis (described in greater detail below) is applied to the overall ex post impacts. The total gross ex post savings determined through the combined consumption and engineering analysis presented in Table 6-2 exceeds the sum of the measure-level savings in the engineering analysis (see Table 6-4). This is likely due to the consumption analysis accounting for the savings that arise from the interaction among measures (e.g., improved lighting efficiency may also reduce cooling load).

Table 6-4. 2019 HPDI Engineering Analysis Gross Impacts

| Category | N[a] | Ex Ante Gross Savings[b] | | Engineering Analysis Gross Savings | | Engineering Analysis Realization Rate | |
|---|---|---|---|---|---|---|---|
| | | kWh | kW | kWh | kW | kWh | kW |
| LED Bulbs | 5,753 | 157,797 | 44 | 218,292 | 62 | 138% | 140% |
| Domestic Hot Water | 581 | 131,306 | 0.8 | 150,108 | 0.7 | 114% | 86% |
| Duct Sealing | 215 | 121,301 | 45 | 69,708 | 49 | 57% | 107% |
| Advanced Power Strips | 364 | 50,825 | 6.4 | 50,825 | 5.1 | 100% | 79% |
| Thermostatic Valve | 63 | 12,897 | 0 | 11,129 | 0 | 86% | N/A |
| **Measure-Level Total[c]** | **6,976** | **474,126** | **97** | **500,062** | **116** | **105%** | **120%** |
| **Project-Level Total[d]** | **6,976** | **474,126** | **97** | **500,062** | **116** | **105%** | **120%** |

[a] Count of measures installed through the HPDI program.
[b] Reported ex ante gross savings includes measure-level electricity savings and interactive electricity impacts from incentivized measures.
[c] Measure-level savings are obtained through contractor reports and are used in evaluating measure category ex ante savings to elucidate measure performance. These are not the official savings claimed by the program administrators.
[d] Project-level savings are obtained through the year-end closeout December 2019 Monthly KPI scorecard and are the official savings claimed by the program administrators. There are no beneficial electrification savings claimed in the HPDI program; therefore, measure-level and project-level savings match.

## Reasons for Differences in Engineering Impacts: HPDI

As shown in Table 6-4, the engineering analysis found that the sum of the ex post gross measure-level savings estimates exceeded both the ex ante gross energy savings and ex ante gross demand savings. Below we describe the measure-specific engineering savings calculations and reasons for discrepancies between the ex ante assumptions and measure-level engineering analysis gross results:

- **LED Bulbs:** LED bulbs account for approximately 44% of HPDI's engineering analysis gross energy savings and 53% of engineering analysis gross demand savings. The evaluation team calculated LED bulb realization rates of 138% for energy and 140% for demand savings. The engineering analysis gross savings are higher than the ex ante gross savings due to the following:
  - **Delta Watts:** The evaluation team calculated delta watts from 2019 tracking data for each individual bulb type offered through the program. The HPDI program offers 10 different LED lighting measures (for example, 10 watt A-Lamps), which are associated with different assumptions for replaced lamp wattage (i.e., a 10 watt A-Lamp is assumed by program administrators to replace a 43 watt lamp, on average). Of these 10 different LED lighting types, eight have a higher delta watts value compared to ex ante. Using actual wattage values for the removed and incented lamps from program tracking data resulted in higher average delta watts for all LED lighting measures in comparison to ex ante values and an increase in the overall lighting realization rates for both energy and demand.
- **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 30% of gross energy savings, but less than 1% of demand. Below is a detailed discussion of differences in ex ante and the ex post savings assumptions.
  - **Low-Flow Showerheads:** The evaluation team incorporated actual delta flow rate (gallons per minute, GPM) values from the 2019 program tracking database, which are 12% greater than the 2017 values (sourced from the 2017 REAP evaluation average baseline) applied by the program

administrator in ex ante savings. These differences accounted for the gross engineering analysis energy realization rate of 112%.

- Aerators: The program administrator applied baseline and installed flow rate assumptions from REAP aerator measures, instead of HPDI assumptions, in the 2019 PSEG Long Island TRM, but it is not clear why. The evaluation team used actual baseline and installed flow rate values from the 2019 program tracking database to calculate savings. Baseline and installed faucet flow rates from the program tracking database were observed to be less than those assumed by the program administrator, on average. Therefore, the delta flow rate developed from 2019 program tracking data values is 61% higher than the 2019 PSEG Long Island TRM REAP assumptions used in ex ante calculations and 1% higher than the 2019 PSEG Long Island TRM HPDI assumptions. The resulting gross engineering analysis energy realization rate is 161%. There are no demand savings associated with this measure.
- Temperature Turndown: The program administrator applied hot water temperature values from the 2019 PSEG Long Island TRM. The evaluation team used 2019 program tracking data on actual pre- and post-intervention hot water heater temperatures for calculating savings. The resulting temperature change calculated from the 2019 program tracking data is 17% lower than the temperature reduction assumed in ex ante calculations, resulting in a gross engineering analysis realization rate of 83% for both energy and demand savings.
- Thermostatic Restrictor Valves: The program administrator used 2019 PSEG Long Island baseline and installed flow rate assumptions from the REAP program instead of the HPDI program, but it is not clear why. The evaluation team incorporated actual installed showerhead flow rate values from 2019 program tracking data, which were 14% more efficient (i.e., lower flow rate in terms of water per minute) than the 2019 PSEG Long Island TRM REAP assumptions used in ex ante calculations and equal to the 2019 PSEG Long Island TRM HPDI assumptions. The resulting gross engineering analysis energy realization rate is 86%. There are no demand savings associated with this measure.

- Duct Sealing: Both the program administrator and the evaluation team both used the algorithm recommended in the 2019 PSEG Long Island TRM to quantify savings. The evaluation team found that the average duct leakage reduction from 2019 program tracking data is 7% greater than program assumptions. This resulted in 7% higher engineering analysis gross demand savings than ex ante. To estimate the ex ante energy savings per cubic feet per minute (CFM) reduction from heating, the program administrator assumed heat pump heating system types for all duct sealing installations. Since the HPDI program tracking database lacked heating system information, the evaluation team used a weighted heating kWh savings per CFM value based on actual heating system types consisting of electric resistance, electric forced air and heat pumps from 2019 HPwES participant data. The resulting gross engineering analysis energy realization rate of 57% is driven by adjustments to both duct leakage reduction values and energy savings per CFM reduction from heating.
- Power Strips: The program administrator and evaluation team applied the same savings algorithms. However, the ex ante demand savings algorithm used a CF of 1.0, whereas the evaluation team applied a CF of 0.8 as specified in the 2019 PSEG Long Island TRM. This difference reduced gross engineering analysis demand savings compared to ex ante with a resulting gross engineering analysis demand realization rate of 79%. The gross engineering analysis energy realization rate is 100%.

### Engineering Analysis: HPwES

For the HPwES program, the evaluation team performed the engineering analysis for the same purpose as detailed in the HPDI engineering analysis above. Table 6-5 provides a program-level comparison of gross engineering analysis savings to ex ante gross savings by measure category for the HPwES program as determined by the engineering analysis.

Table 6-5. 2019 HPwES Engineering Analysis Gross Impacts

| Category | N[a] | Ex Ante Gross Savings[b] | | Engineering Analysis Gross Savings | | Engineering Analysis Realization Rate | |
|---|---|---|---|---|---|---|---|
| | | kWh | kW | kWh | kW | kWh | kW |
| Building Envelope | 1,847 | 603,262 | 857 | 614,074 | 123 | 102% | 14% |
| Air Sealing | 1,381 | 259,111 | 357 | 368,045 | 47 | 142% | 13% |
| Lighting | 116 | 67,523 | 0 | 33,803 | 11 | 50% | N/A |
| DHW[c] | 409 | 262,058 | 127 | 11,443 | 6 | 4% | 4% |
| HVAC[c] | 1,034 | 218,211 | 205 | 173,598 | 399 | 80% | 195% |
| Thank You Kits | 5,755 | 574,031 | 145 | 635,278 | 161 | 111% | 111% |
| Project Adjustment[d] | 5 | 0 | 0 | 0 | 0 | N/A | N/A |
| **Measure-Level Total[e]** | **10,547** | **1,984,197** | **1,691** | **1,836,242** | **747** | **93%** | **44%** |
| Project-Level Total[f] | 10,547 | 1,824,007 | 1,557 | 1,385,961 | 747 | 76% | 48% |

Note: Totals may not sum due to rounding.
[a] Count of measures installed through the HPwES program.
[b] Reported ex ante gross savings includes measure-level electricity savings and interactive electricity impacts from incentivized measures but excludes beneficial electrification impacts from fuel-switching measures.
[c] The negative ex ante gross savings and realization rate for HVAC measures is due to beneficial electrification.
[d] The project adjustment includes the five projects that were "zeroed out" in the program tracking database due to overall negative savings at the project level.
[e] Measure-level savings are obtained through contractor reports and are used in evaluating measure category ex ante savings to elucidate measure performance. These are not the official savings claimed by the program administrators.
[f] Project-level savings are obtained through the year-end closeout December 2019 Monthly KPI scorecard and are the official savings claimed by the program administrators. To be consistent with ex ante claimed savings approach, project-level ex post savings total includes beneficial electrification (from engineering analysis).

### Reasons for Differences in Engineering Impacts: HPwES

The evaluation team received access to the EnergySavvy database that stored all HPwES tracking data in 2019. EnergySavvy's system aggregates results from different residential building energy modeling software, specifically, TREAT, OptiMiser, and Snugg Pro.

Using the detailed program tracking data, the evaluation team built customized reports to fit the needs of the evaluation analyses and to calculate ex post savings using the algorithms and methods outlined in the 2019 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 ex post and ex ante savings.

Below, we provide details behind the evaluation team's energy and demand savings calculations. 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 gross savings for building envelope measures within the EnergySavvy projects were in line with engineering-based energy savings, but significantly higher for peak demand savings. Overall, the gross engineering analysis realization rates for building envelope measures are 102% and 14% for energy and demand, respectively. Below is a review of methods applied by the evaluation team for insulation and other measures.

- Insulation: We evaluated insulation measures, including attic, roof, floor, wall, and foundation wall insulation, by following the algorithms defined in the 2019 PSEG Long Island TRM. We 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 efficiencies. The combined gross engineering analysis realization rates for insulation measures are 102% and 14% for energy and demand, respectively.
- Other Measures: Doors, windows, rim joist insulation, pipe insulation, and ventilation fan measures contributed to less than 0.1% of total project savings. Therefore, these measures were assigned 100% engineering-based realization rates by the evaluation team.

- Air Sealing: We calculated ex post gross savings using the 2019 PSEG Long Island TRM. The EnergySavvy systems report contained sufficient data on pre- and post-project air flow rates in CFM, HVAC system types, and HVAC efficiencies to calculate the gross engineering analysis savings for each project. Gross engineering analysis realization rates are 142% for energy and 13% for demand savings.
- Lighting: We calculated gross engineering analysis savings using the 2019 PSEG Long Island TRM. We applied CFs and operating hours for installed bulbs at the measure level to differentiate by location based on the 2018 PSEG Long Island Commercial and Residential Baseline Study.[39] Many projects had incomplete pre-installation tracking data, skewing the results from evaluated savings. To increase the accuracy of the lighting analysis, the evaluation team applied post-installation quantities when pre-installation quantities were unavailable, assuming one-for-one lamp replacement when not specified in tracking data.[40] When pre-installation wattages were unavailable, the average pre-installation wattage was applied. Pre-installation wattages were derived from projects with complete pre- and post-installation records, excluding LEDs reported as pre-installation lamps. We found a gross engineering analysis realization rate equal to 50% for energy but could not calculate a rate for demand since ex ante gross 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 applied the 2019 PSEG Long Island TRM and NY TRM v6 to calculate the gross engineering analysis 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. Gross engineering analysis realization rates are 4% for both energy and demand.
- HVAC Measures: Overall, HVAC measures achieved gross engineering analysis realization rates of 80% for energy and 195% for demand savings. Below, we discuss differences between ex ante and ex post savings for each measure type.
  - HVAC Duct Sealing and Insulation: The measure tracking data did not differentiate between duct sealing and duct insulation in all instances. The evaluation team determined if a measure is duct sealing or duct insulation by analyzing pre- and post-installation energy model characteristics. The evaluation team used the 2018 Connecticut Program Savings Document's algorithms to calculate savings from duct sealing measures and algorithms in the NY TRM v6.1 to calculate the savings from duct insulation measures.

[39] 2018 PSEG Long Island Commercial and Residential Baseline Study, Opinion Dynamics.

[40] The evaluation team observed the issue of zero reported pre-installation quantities arising for all contractors, suggesting that the data entry errors were not due to a specific contractor(s). The evaluation team also observed blank pre-installation lighting records, which did not correlate to the overall lighting project distribution, suggesting that the data for these measures was not entered properly in the modeling software.

- **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 applied the algorithms recommended in the 2019 PSEG Long Island TRM to calculate savings for HVAC equipment. The tracking data provided adequate information regarding system type, capacity, load fraction, and equipment efficiency to quantify ex post savings.
  - An estimated 91% of heat pump measures were installed by participants who switched from fossil fuel-based heating systems. Due to this prevalence of beneficial electrification interventions, the evaluation team 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 nearly all instances where new heat pumps were installed, the participating home did not previously have a cooling system. We categorized these measures as new construction and referenced a baseline of an equivalent heat pump reflecting code efficiency per 2015 International Energy Conservation Code (IECC) requirements.[41] This baseline efficiency was compared with the tracked installed efficiency to estimate the energy efficiency savings associated with the new heat pump installation.
- **Programmable Thermostats:** The evaluation team calculated savings using the 2019 PSEG Long Island TRM algorithm, resulting in a gross engineering analysis energy realization rate of 31%. There are no demand savings associated with this measure.

- **Thank You Kits:** For each HPwES audit completed by PSEG Long Island in 2019, a Thank You Kit was sent to the customer, containing four LED bulbs. The program administrator applied the planning assumptions for EEP standard LED bulbs. Evaluators applied 2019 PSEG Long Island TRM assumptions and algorithms for EEP standard LED to calculate ex post savings, resulting in a gross engineering analysis realization rate of 111% for both energy and demand. The higher realization rates are due to higher baseline wattages than assumed in planning. Evaluators used baseline wattages from 2019 EEP tracking data for standard LEDs and applied the PSEG Long Island 2018 Baseline Study HOU values.

### Beneficial Electrification Impacts

In 2019, the HPwES program completed 139[42] beneficial electrification projects that resulted in negative electric savings. These projects resulted from the customer's switching their primary space or water heating system from fossil fuels 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 quantified these beneficial electrification impacts separately through engineering analysis, as shown in Table 6-6. The energy savings of the removed fuel after electrification, and positive and negative impacts associated with energy efficiency measures, are expressed in MMBtu. Any ancillary savings indirectly associated with electrification measures have not been evaluated. Additionally, any fuel savings associated with non-electric measures, which are primarily NYSERDA-incented measures, have not been evaluated.

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[41] International Code Council (2014). 2015 IECC - International Energy Conservation Code. Retrieved from: https://codes.iccsafe.org/

[42] There may have been more projects that involved fuel switching, but this value represents only those that resulted in negative overall project savings.

Table 6-6. 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 | -297,763 | -1,016 | 258 | 4,114 | 84 | 60 | 3,502 |
| DHW | -152,518 | -520 | 1.9 | 782 | 0.0 | 348 | 612 |
| Total | -450,282 | -1,536 | 260 | 4,897 | 84 | 409 | 4,114 |

## Consumption Analysis Model Specification Results

The consumption analysis model is a one-way Linear Fixed Effects Regression model. A fixed effects 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), month, and weather. The treatment effect is the difference in energy use that is associated with participating in the program. We also include a term for each of the 12 months to provide 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.

We use a combined Home Performance programs model to estimate savings for 2018 participants attributable to the programs. We then apply those per-participant savings to the number of 2019 participants. These results reflect savings attributable to the programs and the types of measures installed during 2018. As described above, savings adjusted for the revised measure mix in 2019 are incorporated based on engineering estimates (this process is discussed further in Section 9.6.

Table 6-7 presents the overall net program savings for 2018 program participants. Because our regression model includes a comparison group of future participants, the results reflect net impacts. As shown below, the 2019 combined Home Performance programs realized 140% of their expected net savings at the participant level.

Table 6-7. 2019 Combined Home Performance Programs Consumption Analysis Net Savings Compared to Ex Ante Net Savings

| N[a] | Observed Net Savings | | Adjusted Program Planning Net Savings [b] | | Realization Rate |
|---|---|---|---|---|---|
| | Household Daily Savings (kWh) | Household Annual Savings (kWh) | Household Daily Savings (kWh) | Household Annual Savings (kWh) | |
| 1,782 | 2.3 | 824 | 1.61 | 589 | 140% |

[a] The total customer count is different than reported elsewhere in this chapter due to how program year assignment occurred in the consumption analysis. The consumption analysis assigned customers to a program year based on the date their first measure was installed (in either program), whereas the customer counts reported in Section 6.1 include all customers who had any measures installed in 2019. This modeling choice is required to preserve the integrity of the treatment and comparison groups.
[b] Results include line loss factors as they represent net savings.

### Reasons for Differences Between Consumption Analysis and Ex Ante Savings

The 2019 consumption analysis resulted in higher ex post net savings compared to ex ante net savings, as shown by the 140% realization rate. The realization rate is primarily attributable to substantially more accurate ex ante gross savings assumptions for 2019 compared to prior years. The Home Performance programs' planning assumptions and goals were a third of savings compared to 2018 on a per-participant basis. In 2018, the ex ante household daily energy savings estimate was 5.35, compared to 1.61 in 2019. In addition, we hypothesize that enhanced targeting to customers with higher potential to save energy drove higher savings results. In both 2018 and 2019, almost all HPDI participants had electric space heat. This is consistent with eligibility guidelines for the program. As a result, winter consumption, as well as potential savings, are more likely to be larger with these customers. The 2018 HPDI customers also had substantially higher average daily consumption (~45 kWh/day) than the 2017 HPDI customers (~39 kWh/day) who were used as the treatment group in the 2018 evaluation. This higher usage may afford a larger opportunity for savings, which was borne out by the observed household daily savings for the 2017 customers (1.34 kwh/day), compared to 2.3 kWh/day for the 2018 participants.

## 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 and HPDI programs moving forward:

- 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 savings that included beneficial electrification impacts.
  - Recommendation: We recommend that the program administrators provide increased granularity of projects 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 pre-installation lighting quantity and wattage values are not available in the program tracking database for many projects.
  - Recommendation: We recommend that the program administrators consistently track pre- and post-installation LED quantity and wattage values.
- Key Finding #3: The evaluation team found the HPDI program tracking database to be lacking heating and cooling system information.
  - Recommendation: Consider collecting and tracking, as separate program tracking database fields, heating and cooling system information including fuel (e.g. electric, natural gas, etc.) and system type (e.g. air source heat pump, furnace, etc.).
- Key Finding #4: The evaluation team found that the program administrator applied baseline and installed flow rate assumptions from REAP faucet aerator measures in the 2019 PSEG Long Island TRM instead of the HPDI measure assumptions.
  - Recommendation: Apply HPDI program assumptions from PSEG Long Island TRM for faucet aerator measures. These assumptions more accurately represent flowrate values installed as the

average delta flowrate from 2019 program tracking data is only 1% higher than delta flowrate assumption from 2019 PSEG Long Island TRM, compared to 61% higher than 2019 PSEG Long Island REAP delta flowrate assumption.

# 7. Home Energy Management Program

## 7.1 Home Energy Management Program Description

PSEG Long Island, in partnership with Uplight (formerly Tendril), administers the 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.[43] 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 Uplight initiated its plan to send periodic HERs to 341,570 customers. We refer to this group of customers as Cohort 1. The selection criteria for customers in Cohort 1 included targeting customers between 55 and 74 years old to improve the satisfaction of customers in this segment. In addition, one-third of these customers are "My Account" participants.[44] The program's initial goal, set in 2017, was to achieve over 30,000 MWh of behavior-based energy savings per year over a

[43] 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.
[44] "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.

two-year period. The new goal set for 2019 was to achieve 41,487 MWh in energy savings by both Cohorts 1 and 2.

In August 2018, Uplight started to send periodic HERs to an additional 159,348 customers, who represent the treatment customers in Cohort 2. Not all 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 (i.e., targeting customers between the ages of 55 and 74 and those that use "My Account").

Due to attrition, both the treatment and control groups for both cohorts in the 2019 program year are smaller than they were in 2017 and 2018 when they were established. Additional detail on attrition and current treatment numbers are provided below.

This evaluation provides energy savings estimates of the HEM program for the 2019 calendar year for Cohort 1 and Cohort 2.

## 7.1.2 Program Participation and Performance

In terms of verified ex ante savings, the HEM program achieved its 2019 goals, with its verified ex ante energy savings reaching 154% of the 41,487 MWh goal. Table 7-1 presents verified ex ante savings compared to goals for the 2019 HEM program[45].

Table 7-1. 2019 HEM Program Verified Ex Ante Program Performance Against Goals

| Metric | MWh |
|---|---|
| Goal | 41,487 |
| Verified Ex Ante Savings | 64,015 |
| % of Goal | 154% |

Table 7-2 presents HEM program participation in Cohorts 1 and 2.

Table 7-2. 2019 HEM Program Participation Summary[a]

| Cohort | Number of Treatment Customers | Number of Control Customers | Number of Customers per Cohort |
|---|---|---|---|
| Cohort 1 | 310,293 | 37,921 | 348,214 |
| Cohort 2 | 152,608 | 33,384 | 185,992 |
| Total | 462,901 | 71,305 | 534,206 |

[a] Excludes treatment and control customers who closed their account or moved out before January 1, 2019.

### Claimed and Verified Report Counts

According to PSEG Long Island, the claimed number of paper HERs sent to customers during 2019 totaled 2,216,826. Based on the program tracking data, the verified count of paper reports sent was slightly lower,

[45] Verified ex ante savings are calculated based upon a deemed savings of 0.3% usage reduction per report sent and not upon the results of a consumption analysis.

equaling 2,175,667 paper HERs, for a realization rate of 98%. The verified number of paper reports sent each month and the total for 2019 are presented in Table 7-3.

Table 7-3. HEM Program Paper HERs Sent by Month in 2019

| Month | Verified Report Count |
|---|---|
| January | 193,023 |
| February | 231,777 |
| March | 192,002 |
| April | 154,433 |
| May | 254,672 |
| June | 139,548 |
| July | 149,227 |
| August | 171,865 |
| September | 149,033 |
| October | 265,282 |
| November | 209,998 |
| December | 64,807 |
| Total | 2,175,667 |

### 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 in the summer months provide information to customers about rebates available on high efficiency air conditioners 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.

For 2019, PSEG Long Island added a promotion for its program that provides a $500 rebate towards the purchase of EV chargers. They also segmented the treatment group and targeted REAP promotion to low-income customers.

Despite the promotion activity, Opinion Dynamics did not find a statistically significant increase in cross-participation with other programs. This indicates that customers currently in the HEM Program did not broadly join other energy efficiency programs at a higher rate than their respective control group customers. In last year's evaluation, we found five programs with slightly higher, but statistically significant, rates of participation among HEM participants: HPwES, HPD, Home Comfort, REAP, and EEP.

### 7.1.4 Anticipated Changes in 2020

The HEM program anticipates continuing to send HERs to treatment customers in both Cohorts 1 and 2.

## 7.2 Home Energy Management Program Impacts

This section presents a summary of the claimed ex ante, verified ex ante, and evaluated ex post energy savings impacts for the 2019 HEM program. Opinion Dynamics compares the HEM program claimed ex ante savings to the verified ex ante savings, as well as the ex post savings estimated by Opinion Dynamics. The verified ex ante savings are estimated based on a deemed savings approach. For 2018, Opinion Dynamics estimated ex post energy savings using a consumption analysis. For 2019, we continue to evaluate the program using a consumption analysis. The result of this approach is referred to as the unadjusted ex post energy savings because we have not yet accounted for any savings jointly accounted 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, HEM programs can encourage 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, the savings from any programs with a statistically significant uplift are removed from the results of the consumption analysis to arrive at an adjusted ex post savings impact for the HEM program.

### 7.2.1 Evaluated Impacts

Table 7-4 presents a summary of the 2019 energy savings goal for the HEM program, the ex ante savings associated with the claimed number of reports sent, ex ante savings estimated based on the verified report count, and unadjusted and adjusted ex post savings. Recall that unadjusted ex post 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 ex post savings are the program savings with the removal of double counted savings. Because we did not find any statistically significant participation uplift, the adjusted savings is the same as the unadjusted savings. The realization rate of ex post savings to claimed ex ante savings is 51%. Overall, ex post savings were 76% of the program goal.

Table 7-4. 2019 HEM Program Ex Post Gross Impacts

| | Energy Savings (MWh) |
|---|---|
| Goal | 41,487 |
| Claimed Ex Ante | 61,313 |
| Verified Ex Ante | 64,015 |
| Unadjusted Ex Post Impacts | 31,405 |
| Uplift Adjustment | 0 |
| Adjusted Ex Post Impacts After Accounting for Uplift | 31,405 |
| Realization Rate of Claimed Ex Post to Ex Ante Savings | 51% |
| Ex Post Savings as Percent of Goal | 76% |

Note: Ex post savings for the HEM program are net savings due to the RCT experimental design of the program.

### 7.2.2 Claimed and Verified Ex Ante Savings

PSEG Long Island indicated that its 2019 plan assumed that treatment customers in Cohorts 1 and 2 would receive five HERs over the course of the year. Consistent with the verified ex ante savings analysis conducted in 2018, PSEG Long Island and Opinion Dynamics assumed that these reports would yield 1.5% annual savings (or 0.3% savings per report) relative to the average annual consumption per participant in PSEG Long Island's territory.[46] Opinion Dynamics used the number of verified paper reports sent, along with the assumed deemed savings per report to calculate the verified ex ante savings from the HEM program for the 2019 program year (see Table 7-5).

Table 7-5. HEM Program Ex Ante and Verified Ex Ante Savings

| | Number of Paper Reports Sent | Ex Ante Savings (MWh) |
|---|---|---|
| Claimed Ex Ante | 2,216,826 | 61,313[a] |
| Verified Ex Ante | 2,175,667 | 64,015 |

[a] Claimed ex ante savings from December 2019 Monthly Report.

### 7.2.3 Attrition Analysis

Cohorts 1 and 2 experienced some attrition in 2019, as customers opted out or closed accounts. Table 7-6 shows the attrition rates for 2019 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, 8.31% of participants moved out in 2019 and 0.16% opted out during 2019. The total rate of attrition in 2019 is 8.46%.

Table 7-6. 2019 HEM Program Attrition Rates by Cohort

| Cohort | Moved Out | Opted Out | Total Attrition |
|---|---|---|---|
| Cohort 1 | 7.86% | 0.15% | 8.00% |
| Cohort 2 | 9.23% | 0.19% | 9.40% |
| Total | 8.31% | 0.16% | 8.46% |

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, Opinion Dynamics conducted an equivalency analysis between the treatment and control customers in Cohort 1 and Cohort 2. The equivalency analysis is used to verify that for each cohort the treatment and control groups demonstrate 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.

Table 7-7 shows the average daily consumption (ADC) for Treatment and Control customers. Based on these findings, equivalence between these treatment and control groups in the cleaned data was confirmed for both cohorts.

[46] 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 0.3% savings per report, the deemed savings per report equals 29.42 kWh.

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

| Cohort | Pre-Period | Pre-Period ADC | |
|---|---|---|---|
| | | Treatment | Control |
| Cohort 1 | September 2016 - August 2017 | 28.2 | 28.1 |
| Cohort 2 | August 2017 - September 2018 | 27.8 | 27.8 |

### 7.2.5 Consumption Analysis

After testing various model specifications, Opinion Dynamics used a lagged dependent variable (LDV) model that takes full advantage of the experimental design of the HEM program. The models we tested adhere to the residential behavior evaluation protocols[47] and aligns with the approach used by Uplight in their savings estimations. 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 and weather. The purpose of the pre-period variables is to improve precision and increase model fit. Note that the results of all models tested yielded robust results. Full details of the different model specifications and estimated coefficients are presented in Section 9.7 for the HEM program evaluation.

Table 7-8 provides the cohort-specific and total unadjusted ex post energy savings per household; the program savings for 2019; and program savings as a percentage reduction of baseline ADC. We found statistically significant savings for both Cohorts. Because the analysis uses an ITT approach[48], we estimated program savings and applied them to treatment customers in Cohorts 1 and 2 for all of 2019.[49]

Table 7-8. 2019 HEM Unadjusted Ex Post Per-Household and Program Energy Savings

| Cohort | Number of Customers Treated in 2019[a] | Unadjusted Savings (% per household) | Unadjusted Energy Savings (kWh per household)[b] | Unadjusted Program Savings (MWh)[c] |
|---|---|---|---|---|
| Cohort 1 | 310,293 | 0.82% | 79.41 | 24,641 |
| Cohort 2 | 152,608 | 0.47% | 44.32 | 6,764 |
| Total | 462,901 | 0.70%[d] | 67.84[d] | 31,405 |

[a] The number of customers whom PSEG Long Island selected to provide HERs and who received at least one monthly bill in 2019.
[b] The per-household, per-day savings multiplied by the average number of days that the participating households were in the HEM program in 2019.
[c] The program savings, just like the per household energy savings, are pro-rated by the average number of days that the participating households were in the HEM program in 2019.
[d] Represents the weighted average.
Joint Savings Analysis

[47] Stewart, J.; Todd, A. (2017). Chapter 17: Residential Behavior Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68573. http://www.nrel.gov/docs/fy17osti/68573.pdf
[48] 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 (ATT), 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. Additionally, by using the ITT approach, we measure the true effect of the cost of the program intervention based on the intended participants, rather than the actual participants.
[49] Opinion Dynamics prorated the savings for those accounts that closed during 2019.

Opinion Dynamics 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, 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. 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.

In this case, there was no statistically significant uplift. This means we did not find differences between the treatment and control group customers in terms of PSEG Long Island energy efficiency program participation in 2019. As a result, no savings were removed from the HEM program consumption analysis results. Table 7-9 shows that for the 2019 HEM program year there were no necessary adjustments to the ex post savings resulting in adjusted ex post savings equaling the unadjusted ex post savings.

Table 7-9. 2019 HEM Program Savings Uplift Results

| Unadjusted Ex Post Savings (MWh) | 2019 Savings Uplift (MWh) | Percentage | Adjusted Ex Post Savings (MWh) |
|---|---|---|---|
| 31,405 | 0 | 0% | 31,405 |

### 7.2.6 Ex Post Net Impacts for Cost Effectiveness

To estimate ex post net impacts for cost-effectiveness purposes, the evaluation team used a similar approach to calculating gross savings, with the exception of using net values that incorporate line losses.[50] This results in ex post net savings of 33,410 MWh.

Table 7-10. 2019 HEM Ex Post Net Impacts for Cost Effectiveness

| Cohort | Ex Post Net Program Savings with Line Losses (MWh) |
|---|---|
| Cohort 1 | 26,214 |
| Cohort 2 | 7,196 |
| Total | 33,410[a] |

[a] Represents the weighted average.

### 7.2.7 Reasons for Differences in Impacts

Table 7-4 presented a 51% realization rate of the adjusted ex post savings (31,405 MWh) to the claimed ex ante savings (61,313 MWh) for the 2019 HEM program. The primary driver for the lower than claimed savings

[50] To calculate ex post net savings, we applied the consumption analysis realization rate (130%) to the ex ante net savings. All net impacts include line-losses. To calculate demand, we use a kW/kWh ratio from the engineering analysis.

value was the lower per-household percentage reduction for the ex post case (0.70%) than it is for the claimed ex ante case (1.5%) (see Table 7-11).

Table 7-11. 2019 HEM Program Comparison of Ex Ante and Adjusted Ex Post Metrics

| Metric | Claimed Ex Ante | Adjusted Ex Post Savings |
|---|---|---|
| Baseline ADC (kWh) | 26.87[a] | 27.48 |
| % Savings per Household | 1.5% | 0.70% |
| **Total Savings (MWh)** | **61,313** | **31,405** |

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

Additionally, ex post savings results demonstrate that Cohort 1 achieved a lower average ex post average daily savings value in 2019 as compared to 2018. Further, Cohort 1 has higher ex post savings than Cohort 2 (Table 7-12).

Table 7-12. Ex Post Savings by Cohort and Evaluation Year

| Cohort | 2018 Ex Post Per Participant Savings | | 2019 Ex Post Per Participant Savings | |
|---|---|---|---|---|
| | kWh / year | % Savings | kWh / year | % Savings |
| Cohort 1 | 113 | 1.06% | 84 | 0.82% |
| Cohort 2 | NA[a] | NA[a] | 47 | 0.47% |

[a] Cohort 2 ex post savings in 2018 were calculated by applying Cohort 1 estimates to Cohort given insufficient post-period data.

This evaluation leverages industry best practices and results are robust to methodological approaches. The evaluation team leveraged the UMP and DOE Behavior-Based EM&V Protocols[51] to estimate program impacts. In addition to utilizing evaluation best practices, this evaluation benefits from the RCT design, which is the gold standard for consumption analysis because it removes many of the traditional biases inherent in any quasi-experimental design. Despite having a control group that controls for exogenous factors, our modeling approach also incorporated terms to control for features that could affect savings estimates. As part of our due diligence, the evaluation team identified variations in energy and weather patterns[52] across the pre- and post-period for each cohort. To control for these variations, the evaluation team ran a series of model specifications that control for both pre-period average daily consumption as well as weather (heating degree days and cooling degree days). Modeled results were robust across all specifications. As a result, variations in pre-period usage and weather across cohorts is unlikely to affect the savings results produced by the models.

There are a variety of potential drivers for the lower than anticipated ex post savings compared to claimed ex ante values, as well as to prior year evaluation results. We outline some theoretical drivers that could potentially explain these results but note that further investigation should be conducted to confirm or rule out these hypotheses.

- **Data discrepancies could explain lower savings than claimed and in prior years.** As part of this effort, the evaluation team received three distinct versions of data from the program implementer and PSEG Long Island. Working closely with PSEG Long Island and the program implementer, we identified

[51] SEE Action Evaluation, "Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations." https://www4.eere.energy.gov/seeaction/system/files/documents/emv_behaviorbased_eeprograms.pdf NERL, "Chapter 17: Residential Behavior Evaluation Protocol The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures." https://www.nrel.gov/docs/fy17osti/68573.pdf

[52] Annual differences in energy consumption are demonstrated in Table 7-13. In terms of weather patterns, 2018 was a hotter summer and colder winter measured in terms of heating degree and cooling degree days than 2017 or 2019.

underlying data discrepancies related to estimated and actual meter reads. We note that the modeled savings estimates were robust across data cleaning and model specifications.

According to program staff, these issues may have been exacerbated in 2019 due to adjustments to meter reading schedules which reduced the number of meter reads. Based on these discussions, we can hypothesize that the increased number of "estimated" bills resulting from the decreased number of meter reads, could "average away" the effect of savings, and lead to misalignments in estimated consumption and weather over monthly periods. This could explain the differences in estimated savings for Cohort 1 between 2019 and 2018. It may also explain lower than average savings in general.

- Timing of HER delivery. Based on conversations with Uplight, it appears that a disproportionate number of HERs were delivered in the winter of 2019. Because the expecation is that HERs are most effective when delivered during periods of high usage (e.g. the cooling season), it is possible that the concentration of HER delivery in the winter caused lower than expected savings in the 2019 Program Year. This issue was caused by the change in meter read routes and the conversion to AMI meters, which resulted in a decrease in the number of actual bills during the summer. As HERs are only sent in conjunction with actual (rather than estimated) bills, the reduced frequency of actual bills significantly lowered the number of HERs sent during the cooling period.
- Changes to the program intervention and associated differential participant energy management strategies could explain lower savings In 2019, Uplight changed the HER promotional strategy in 2019 to promote EV charger rebates in addition to promoting PSEG Long Island's portfolio of eligible energy efficiency programs. Importantly, given PSEG Long Island's continued goal of beneficial electrification, it is possible that program participants adopted fuel switching measures or Electric Vehicles at a greater frequency than their control group counterparts. The continued presence of messaging increases customer awareness of their energy usage and compels customers to make changes to their energy management, either through PSEG Long Island programmatic offerings or on their own. Despite a review of treatment and control group customer participation in Home Performance programs, which did not find a statistically significant difference in uptake between treatment and control group customers, a review of the uptake of heat pump and electric vehicle technologies (either through PSEG Long Island's programs or outside of any program rebates) could demonstrate or rule out differential adoption between groups. Because the consumption analysis controls for both participant (treatment) and non-participant spillover (control) in our results, if there was an increase in electric usage due to beneficial electrification measures or EV adoption compared to the control group, this would result in lower electric savings in the model.[53]
- Differences in participant characteristics could explain lower savings for Cohort 2. We understand that the same selection criteria were used to develop both Cohort 1 and Cohort 2[54], which included focusing on seniors and My Account users. However, one explanation for differences in Cohort 1 and Cohort 2 results may be the different pre-period average daily consumption between Cohort 1 and Cohort 2 within the same year. Table 7-13 provides a summary of pre-period average daily consumption in 2016 and 2017 by Cohort. Cohort 1 has marginally higher pre-period average daily consumption compared to Cohort 2 in each year prior to participation in the program. Higher pre-period usage often correlates with higher savings.

[53] While rooftop solar or battery storage adoption could also affect HEM savings, we remove NEM customers from the evaluation dataset. These measures are therefore less likely to affect the HEM evaluation results.

[54] We found no variation in My Account users in terms of incidence in the population of Cohort treatment customers, and are unable to assess the incidence of seniors in the population.

Table 7-13. Pre-Period Average Daily Consumption

| Cohort | 2016 | 2017 |
|---|---|---|
| Cohort 1 | 27.48 | 28.50 |
| Cohort 2 | 26.52 | 27.43 |

- **Energy savings can vary due to household characteristics and propensity to save.** Across the literature, we find that there is typically a ramping of savings over time, as customers receive and engage with more reports, and have time to either make capital investments in energy savings measures or habituate suggested behavioral changes. This could be one potential explanation for why Cohort 2 has lower first year savings than Cohort 1. However, this does not explain why Cohort 1 has lower savings in year 2 than year 1. Opinion Dynamics has conducted several evaluations using a multi-level modeling approach that suggests that some customers achieve substantial energy savings, while others make no changes or may even increase their consumption.[55] Investigating which customers drive savings, and are potentially more likely to adopt beneficial electrification measures, may support future achievement of not only energy savings, but also decarbonization goals.

## 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 demonstrates that the program reduced energy consumption among participants. Consumption analysis results show a reduction of 31,405 MWh in 2019. Program participants achieved an average of 67.8 kWh savings per household, or 0.70% of usage.
- Key Finding #2: The consumption analysis estimated lower savings compared to claimed ex ante values, as well as to prior years.
  - Recommendation: Given lower savings values, we recommend that PSEG Long Island consider conducting research to identify what might be driving lower than anticipated savings. Two possible sources of the lower savings that are worth investigating are: 1) underlying household characteristics, and 2) treatment induced adoption of energy savings measures. More specifically, we recommend two approaches:
    - Estimate impacts using a multi-level model to identify which customers save, do not save, or increase their consumption. This would help to identify key characteristics that drive savings and support future potential targeting. Once individual customer level savings are modeled, develop a second regression model that uses customer characteristics (load shape features where available, demographics, etc.) to predict savings. This second model will help inform which customer characteristics drive a strong response to the HEM program. The results will not only provide insight into past program performance but can be used for customer targeting going forward. For a similar study for PG&E, we found that some clusters of customers with increases in consumption had distinct load shapes that closely aligned with electric vehicle consumption patterns.

[55] Guillaume Calas and Kimberly Conley, Pacific Gas and Electric Company; Stefanie Wayland and Olivia Patterson, Opinion Dynamics. "Leveraging HER Analytics: Data Driven Approaches to Informing Program Redesign by Understanding Participant Performance" ACEEE Summer Study, 2018. https://www.aceee.org/files/proceedings/2018/index.html#/paper/event-data/p256

    - Field surveys with treatment and control group customers to understand actual or perceived customer barriers to energy management strategies as well as adoption patterns of other measures that affect energy consumption (such as electric vehicles and beneficial electrification measures).

- Key Finding #3: Cohort 2 customers saved less energy than Cohort 1.
  - Recommendation: We typically find that cohorts with fewer years of treatment have lower savings than those who have received more reports over a longer period. However, PSEG Long Island could examine the composition of Cohort 2 to identify what characteristics may be driving lower savings than anticipated – in addition to pre-period average daily consumption. If those characteristics can be identified, considerations could be made to enhance tips and recommendations for these customers.
- Key Finding #4: The joint savings analysis shows that there was no participation uplift.
  - Recommendation: PSEG Long Island may be able to increase the amount of cross-program promotion in its HERs since the current level is not leading to statistically significant increased participation in other programs.
  - Recommendation: Given that 2020 is an anomalous year, we recommend offering tips and strategies to reduce residential demand and energy burden for participants under the stay-at-home orders. Additional interventions offered through the program, such as High Usage Alerts, can also support residential customers during this time.

# 8. Solar Photovoltaic Program

## 8.1 Solar Photovoltaic Description

In 2019, PSEG Long Island continued to offer financing to residential and non-residential customers and rebates to low-income customers to promote the installation of solar photovoltaic (PV) systems. These offerings, along with the increased awareness and demand for solar in Long Island, 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 Non-Residential initiative for Long Island customers. Up until 2018, the NY-Sun program had utilized an MW block structure that allotted successive tiers of rebate rates such that early adopters received the highest rebates. Rebates were offered for residential projects as large as 25 kW and for non-residential projects of up to 500 kW. The NY-Sun funding for these rebates is no longer available on Long Island as all MW blocks have been allotted. However, the program continued to accept applications for solar PV installations through financing offered by Green Jobs – Green New York throughout 2019. Applications were also accepted for installations in low-income households incentivized through Affordable Solar. In 2019, rebates for new solar PV projects that were paired with energy storage were also offered through NY-Sun and implemented by PSEG Long Island for residential and commercial customers.

### 8.1.1 Program Participation and Performance

In 2019, PSEG Long Island supported rebates or financing for 633 solar PV systems, which is a 30% increase from 2018. The majority of the 2019 projects received financing through Green Jobs - Green New York (565), with the rest receiving rebates through Affordable Solar (99) or both rebates and financing (31). The increase in projects between 2018 and 2019 are primarily from an increase in financing projects (395 in 2018 versus 565 in 2019). The proportion of leased systems fell further in 2019, 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. Figure 8-1 illustrates changes in participation over the past seven years broken out by payment method.

Figure 8-1. PV Systems Installed per Year by Purchase Type (2012–2019)

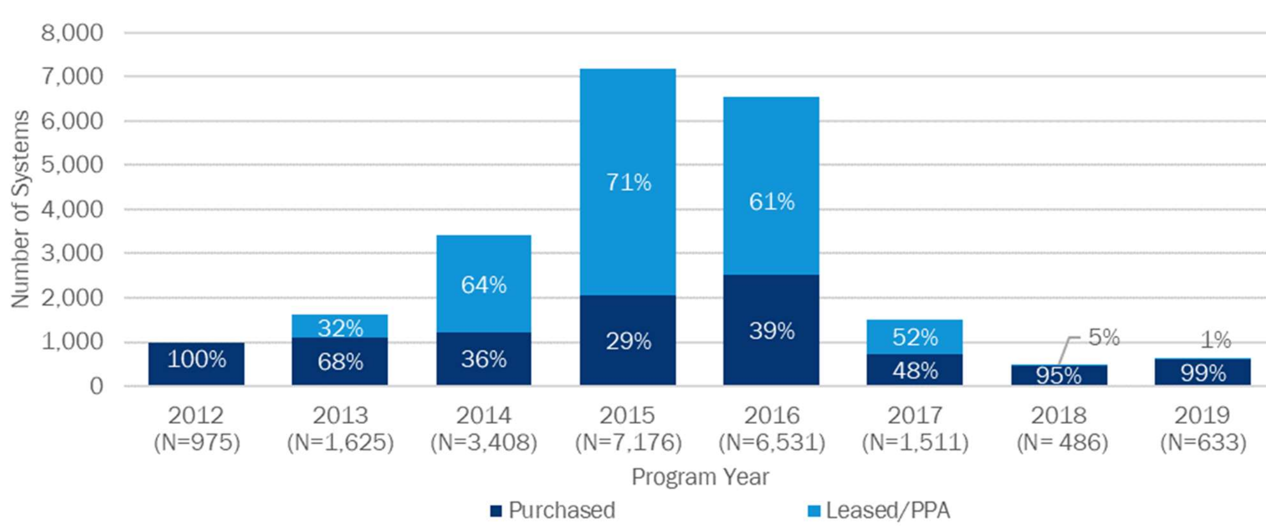
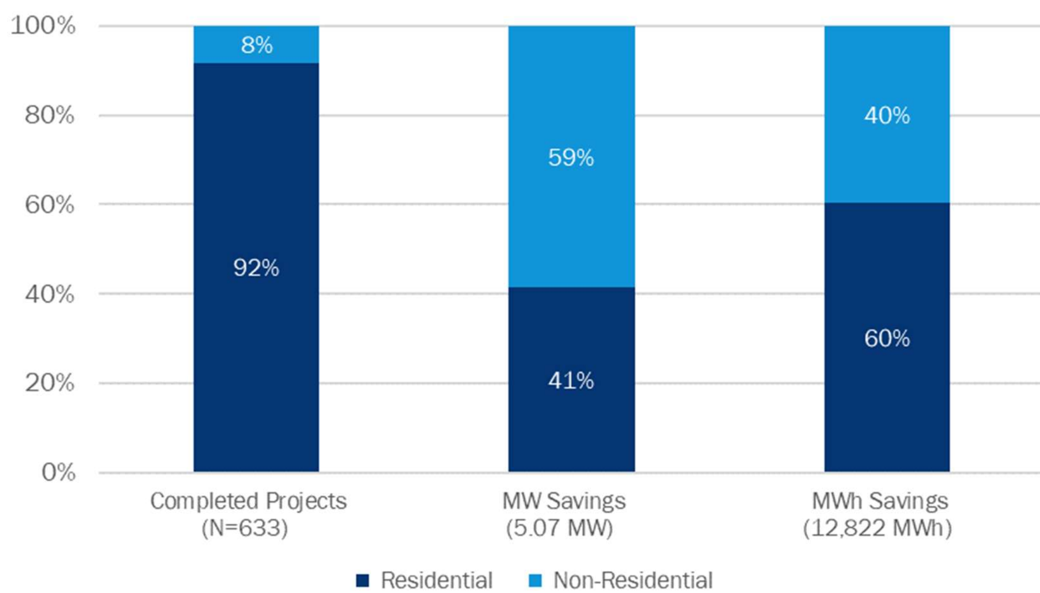


Figure 8-2 provides the 2019 completed projects and savings broken out by residential and non-residential sectors. Residential systems accounted for 92% of all installed systems in 2019, up slightly from 84% of installations in 2018. However, while non-residential projects accounted for only 8% of projects in 2019, they accounted for 59% of the capacity and 40% of the expected generation (i.e., demand and energy savings). By comparison, in 2018, non-residential installations accounted for 16% of installations and just under three-quarters of MW and MWh savings.

The trend of decreased non-residential system interconnections continued from the second half of 2018 to 2019, due to the Value of Distributed Energy Resources (VDER) compensation model. VDER takes into account the temporal and locational value of electricity sold to the grid, and its compensation is roughly two-thirds of what non-residential customers would have received under a net metering model, which existed prior to the first half of 2018 for non-residential systems. In a push to spur more non-residential interconnections, in August 2019, the program reverted to the net metering compensation model for projects of 750 kW or lower that primarily use the energy on-site.

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




There is a healthy solar market on Long Island, which continues to exhibit a high demand for solar PV. The strong network of contractors in the region continues to provide a robust supply chain and delivery infrastructure. Based on publicly available SIR Inventory Information data, PSEG Long Island receives approximately 600 applications per month for solar interconnection, demonstrating the healthy demand for solar PV systems even without financial incentives from PSEG Long Island or NYSERDA.

### 8.1.2 Changes in 2019

Under the Utility 2.0 process, PSEG Long Island began promoting energy storage in 2019, using modified Dynamic Load Management tariffs as the implementation mechanism. The New York State Energy Storage Roadmap has provided $55 million in rebates for battery storage. Of this, $25 million has already been allocated - $5 million for residential behind the meter, $10 million for non-residential behind the meter, and 10 million for utility-scale battery storage. The rest of the $30 million would be allocated in the future. Rebates for residential energy storage were offered only in conjunction with a new solar PV installation while non-residential customers received support for energy storage with or without an associated solar PV installation. According to program administrators, they have received about 190 residential and a small number of non-residential interconnection applications for battery storage systems since January 2019. The program achieved its aim of 90 interconnections for 2019 and is on course to achieve the 240 interconnections aimed for 2020.

### 8.1.3 Expected Changes in 2020

Program administrators expect to continue receiving applications for residential solar interconnections, as residential customers are interested in the resiliency provided by PV systems. The switch to net metering compensation model for smaller non-residential projects should result in more non-residential interconnections, but program administrators do not expect a substantial increase in behind the meter non-residential solar, unless NYSERDA starts offering rebates for these again. The new storage rebates are expected to result in a significant increase in residential storage in 2020. Time-of-use rates, to be introduced in 2021, may also increase the adoption of solar PV and battery storage.

## 8.2 Solar PV Impacts

### 8.2.1 Ex Post Gross Impacts

For the 2019 evaluation, the evaluation team completed a desk review of PSEG Long Island's Solar PV tracking data to arrive at ex post gross and net savings. The evaluated savings resulted in slightly lower energy and demand savings (by 8% and 7%, respectively). Table 8-1 provides a program-level comparison of ex post gross savings to ex ante savings by measure category.

Table 8-1. 2019 Solar PV Program Ex Post Gross Impacts

| Category | N | Ex Ante Gross Savings | | Ex Post Gross Savings | | Realization Rate | |
|---|---|---|---|---|---|---|---|
| | | kWh | kW | kWh | kW | kWh[1] | kW |
| Residential Solar Installations | 580 | 5,086,859 | 2,097 | 4,887,095 | 1,952 | 96% | 93% |
| Non-Residential Solar Installations | 53 | 7,735,602 | 2,975 | 6,938,264 | 2,771 | 90% | 93% |
| Total | 633 | 12,822,461 | 5,072 | 11,825,359 | 4,723 | 92% | 93% |

Similar to the previous evaluation of the Solar PV program, the evaluation team independently verified the accuracy of program performance test conditions (PTCs) output estimates. All 633 projects had sufficiently granular data; therefore, we 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 2019 installations to determine ex post savings for projects completed in 2019.

#### Reasons for Differences in Impacts

The ex post demand savings differed from ex ante savings for three reasons. First, the evaluation team applied an average rated DC kW to actual AC kW factor of 0.867 based on the interval data of 124 solar PV installations on Long Island in 2012. This value was slightly lower than the value of 0.90033 used for ex ante savings estimates. Second, ex ante calculations included a planning CF of 0.51, which is slightly higher than the evaluation team's 0.493 CF derived from the average 15-year peak day/hour information provided by PSEG Long Island in 2012. Additionally, the evaluation team applied an averaged rated DC kW to actual AC kWh factor of 1,071 from the 2012 data, in comparison to 1,161 used in ex ante calculations. The program did not provide the evaluation team with the source of their assumptions.

#### Future Impact Calculations

Since the 2013 program year, both planning and evaluation savings calculations have utilized key input assumptions based on interval data from 124 solar PV installations on Long Island in 2012. Beginning in 2020, the evaluation team intends to use the updated solar PV parameter assumptions for evaluating savings, to reflect better 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. The specific parameters from this study are included in the latest version of the 2020 PSEG Long Island TRM. The updated average rated DC kW to actual AC kW factor and the average rated DC kWh to actual AC kWh factor are significantly lower in the 2020 TRM than those used by the evaluation team and in program planning in previous years.

### 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 NTGR was set at 1.0 (equal to the program planning value).[56] Table 8-2 shows the savings by program for the cost-effectiveness calculations. Because the evaluation team and program administrator both utilize an NTGR of 1, the only difference between ex post gross (Table 8-1) and ex post net (Table 8-2), is the application of line loss energy and demand factors, resulting in higher net savings than gross savings.

Table 8-2. 2019 Solar PV 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 |
| Residential Solar Installations | 580 | 5,411,552 | 2,292 | 5,199,037 | 2,133 | 96% | 93% |
| Non-Residential Solar Installations | 53 | 8,229,364 | 3,251 | 7,381,131 | 3,028 | 90% | 93% |
| Total | 633 | 13,640,916 | 5,544 | 12,580,169 | 5,162 | 92% | 93% |

## 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.
  - Recommendation: Beginning in 2020, we recommend that PSEG Long Island utilize the updated solar PV parameter assumptions in the 2020 PSEG Long Island TRM while planning savings. The 2020 TRM is based on the results of the Solar PV Output Study conducted by Opinion Dynamics

[56] 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.

in 2018, which better reflects the output of solar PV systems installed on Long Island and is based on the latest available production data.

# 9. Detailed Methods

## 9.1 Overview of Data Collection

Our 2019 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 2019 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 2019. The remainder of this section describes key analytic approaches used in our evaluation for each program and 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 | ✓ | ✓ | | | ✓ | ✓ |
| EEP Program | ✓ | ✓ | | | ✓ | ✓ |
| Home Comfort Program | ✓ | ✓ | | | ✓ | |
| REAP program | ✓ | ✓ | ✓ | ✓ | ✓ | |
| Home Performance Programs | ✓ | ✓ | ✓ | ✓ | ✓ | |
| HEM Program | ✓ | ✓ | ✓ | ✓ | | |
| Solar PV Program | ✓ | ✓ | | | ✓ | |

## 9.3 Commercial Efficiency Program

Opinion Dynamics performed two data collection activities as part of the CEP evaluation:

- 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

The evaluation team conducted in-depth interviews in January 2019 with program staff members at TRC who are responsible for implementing the CEP. The evaluation team designed these interviews to elicit changes in program design, gather staff perspectives on program performance and efficiency, and better understand challenges faced by the program in 2019.

### 9.3.2 Engineering Analysis

Opinion Dynamics performed two types of engineering analyses:

- Database reviews -- A review of program tracking data and calculation of savings using engineering algorithms
- Desk reviews -- A review of a sample of projects and calculation of savings using detailed information from each sampled project.

Opinion Dynamics conducted engineering desk reviews of a sample of 37 projects – 22 refrigeration projects (within the Standard component) and 15 projects with occupancy sensors (within the Comprehensive Lighting component). Table 9-2 illustrates how the evaluation team reviewed each CEP program component in 2019.

Opinion Dynamics 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 2019. 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 and occupancy sensor measures within the Comprehensive Lighting component. We performed a database review for the remaining measure types (compressed air, building envelope, and motors and VFDs) within the Standard program component and the remaining measures within the Comprehensive Lighting component.

Table 9-2. 2019 CEP Engineering Analysis by Program Component

| Program Component | Database Review | Desk Review | On-Site M&V |
|---|---|---|---|
| Comprehensive Lighting | X | X | |
| Fast Track Lighting | X | | |
| Custom (non-lighting) | | | X (2012) |
| Standard | X | X | |
| Exterior Lighting | X | | |
| Custom (CHP) | | X | X (2017) |

| Program Component | Database Review | Desk Review | On-Site M&V |
|---|---|---|---|
| HVAC | X | | |
| Custom (lighting) | | | X (2012) |
| Online Marketplace | X | | |

All evaluations that include sampling have inherent levels of uncertainty in the estimates based on the fact that they are assessing only a portion of the population.[57] 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 the sample frame has equal probability of being chosen for inclusion in the 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.

For refrigeration projects, the evaluation team used a simple random sampling approach within 9 individual sample frames defined by each type of refrigeration measure. We determined samples sizes for projects of high frequency measures based on the proportion of ex ante energy savings those measures contributed to the program. For sample frames with fewer than six projects, we conducted desk reviews of all projects (i.e., a census).

For occupancy sensor projects, the evaluation team used a stratified random sampling approach with one sample frame for all types of comprehensive lighting occupancy sensors. Stratified random sampling increases the efficiency of the sampling process and the precision of the results by oversampling the projects with the largest contribution to portfolio energy savings. The stratified random sample design made use of the Dalenius-Hodges technique to determine appropriate strata for each sample frame, and the Neyman allocation method to obtain optimal samples by stratum, as detailed below.

## 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[58] is to multiply the f(y) by the width of the interval, take the square root of this value, and cumulate the values $\sqrt{d_y f(y)}$. Finally, as in the above case, the total of cumulative $\sqrt{d_y f(y)}$ is then divided by the number of desired strata to determine the division points on the cumulative $\sqrt{d_y f(y)}$ scale.

57 We note that all evaluations contain levels of uncertainty, some of which can be calculated (e.g., sampling error, measurement error for engineering instruments) and some of which cannot (e.g., non-response bias in surveys).
58 Kish, L. (1995). *Survey Sampling.* Wiley Classics Library Edition.

## Optimal Allocation

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

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

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 $N_h$. This problem can arise in the plan for the verification of rebate program savings since the overall sampling fraction is large and some strata are much more variable than others. If the original allocation gives, for example, 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 design for Comprehensive Lighting, Standard (refrigeration projects only), 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.

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

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

| Program/Measure | Sample Design | Total Ex Ante Gross Savings (kWh) | Projects in Population | Projects in Sample |
|---|---|---|---|---|
| Occupancy Sensors (Comprehensive Lighting) | Stratified Random | 1,076,589 | 163 | 15 |
| Combined Heat and Power | Census | 8,584,753 | 3 | 3 |
| ECMs | Simple Random | 665,865 | 18 | 4 |
| Anti-Sweat Controls | Simple Random | 1,463,119 | 17 | 9 |
| ENERGY STAR Freezers – Solid Door | Simple Random | 4,242 | 9 | 1 |
| Evaporators | Simple Random | 207,084 | 6 | 2 |
| Refrigerated Case Night Covers | Census | 55,440 | 2 | 2 |
| ENERGY STAR Refrigerator – Solid Door | Census | 511 | 1 | 1 |
| Floating Head Pressure Controls | Census | 50,737 | 1 | 1 |
| Refrigerator Case Door Retrofit – Install Doors | Census | 68,854 | 1 | 1 |
| Walk-in Cooler Door Strip Curtains | Census | 2,268 | 1 | 1 |
| Standard Refrigeration Total | | 2,518,120 | 56 | 22 |

Note: Totals may not sum due to rounding.

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

Table 9-4. 2019 CEP Occupancy Sensor (Comprehensive Lighting) Strata Boundaries

| Stratum | Boundaries (kWh) | Total Ex Ante Gross Savings (kWh) | Projects in Population | Projects in Sample |
|---|---|---|---|---|
| 1 | 0 – 7,000 | 241,354 | 127 | 5 |
| 2 | >7,000 – 25,000 | 310,382 | 25 | 4 |
| 3 | >25,000 – 125,000 | 524,853 | 11 | 6 |
| Total | | 1,076,589 | 163 | 15 |

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 CFs to the ex post gross savings values and dividing the resulting savings by ex ante utility gross savings.
- Applied the sample design weighting factors to arrive at a gross realization rate for each program component.

For the desk reviews, we used the ratio adjustment method[60] to extrapolate results for the sampled sites back to the overall 2019 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, we describe 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:

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, ex post gross, and ex post net savings for Standard refrigeration projects.

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

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:

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

$N_h =$ 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, ex poste gross, and ex post net savings for Comprehensive Lighting occupancy sensor projects.

## 9.4 Home Comfort Program

Opinion Dynamics conducted an in-depth interview with the Home Comfort program administrator, reviewed program materials, and reviewed program tracking data for the 2019 Home Comfort program evaluation. To estimate program impacts, we performed a detailed engineering analysis of all measures offered through the Program. The evaluation team reviewed program tracking data and assumptions for all measures installed during 2019.

For geothermal heat pumps, we reviewed a sample of 26 projects. To develop the sample, we used a stratified random sampling approach based on project-level ex ante gross kWh savings, targeting ±10% relative precision at the 80% confidence interval. We developed a realization rate for the sample by completing desk reviews for each of the 26 projects, and calculated ex post gross savings by applying this realization rate to the total ex ante savings for the population of GSHPs installed in 2019.

## 9.5 Residential Energy Affordability Partnership Program Consumption Analysis Methods

This section presents detailed consumption analysis methods used to support the REAP program impact evaluation. Given limited post-period data for 2019 participants, we based our 2019 savings estimates on an analysis of 2018 REAP participants and used the 2019 participants as a comparison group based on their pre-participation period. This approach is consistent with prior evaluations.

### 9.5.1 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 2018 and 2019. PSEG Long Island also provided a consumption history to represent both pre- and post-period data for both 2018 and 2019 program participants. Prior to carrying out the statistical modeling, we merged, cleaned, and conducted quality assurance for all data. We used the same data-cleaning procedures for both 2018 and 2019 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 2020 included complete 2018 and 2019 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. 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 ex ante electric savings or zero quantities in the participant tracking data. One account was dropped due to zero measure-level ex ante electric savings, and 18 accounts were dropped due to missing ex ante measure-level electric savings. We also dropped 338 accounts from the tracking data because their projects began earlier than 2018.

The evaluation team's analysis plan called for estimating REAP-related 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 cross-participants removed 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 (2017), HPDI (2017–2019), HPwES (2017–2019), and Cool Homes/Home Comfort (2017–2019). We identified 119 cross-participation accounts in the treatment group and removed them from the analysis.[61]

After cleaning the measure data, we calculated annual expected savings for the program based on the sum of gross deemed energy savings for all the measures installed by 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 2018 and 2019 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. 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-steps below.

- Cleaning of Individual Billing Periods: We removed records with 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. We did not include billing periods occurring after a 2019 participant's first installation date, as the 2019 participants served as the comparison group, and their billing records after beginning their participation can't be used as the counterfactual for 2018 participants. The removal of these billing records did not result in the removal of any accounts.
- 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 2018 and 2019 program participants, and nine months (or the 270-day equivalent) after participation for 2018 participants. We dropped 76 treatment customers and no comparison customers based on the post-participation period criterion, and 287 treatment group and 260 comparison customers based on insufficient pre-participation period bills. Notably, for some 2019 participants, PSEG Long Island was unable to provide pre-period observations for January – April 2017 (see discussion below).

[61] We did not remove cross-participants from the comparison group, which is different from our methodology in previous years. Our rationale for keeping the cross-participants for the comparison group is that it more accurately reflects the counterfactual behavior of the comparison group; i.e. what they would have done absent the REAP program.

- **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 realistic savings estimates. We dropped 11 treatment customers, but no comparison customers based on the summer period criterion after participation, and 16 treatment group and four comparison customers based on insufficient summer bills before participation.
- **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 (less than 2 kWh daily) average usage. We dropped six households due to low usage (four from the treatment group and two from the comparison group) and dropped two households 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.

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

| Drop Reason | Treatment | | Comparison | |
|---|---|---|---|---|
| | Total Accounts | Percent of Accounts | Total Accounts | Percent of Accounts |
| Total Unique Accounts | 1,889 | 100.0% | 1,894 | 100.0% |
| Billing Periods Longer Than 90 Days | - | | - | |
| Accounts Remaining | 1,889 | 100.0% | 1,894 | 100.0% |
| Billing Periods Under a Week | - | | - | |
| Accounts Remaining | 1,889 | 100.0% | 1,894 | 100.0% |
| No Usage | - | | - | |
| Accounts Remaining | 1,889 | 100.0% | 1,894 | 100.0% |
| Usage Over 10,000 kWh for a Single Billing Period | - | | - | |
| Accounts Remaining | 1,889 | 100.0% | 1,894 | 100.0% |
| Multiple Bills within Month | - | | - | |
| Accounts Remaining | 1,889 | 100.0% | 1,894 | 100.0% |
| Too Few Pre-Participation Period Bills (Less than 9) | 287 | | 260 | |
| Accounts Remaining | 1,602 | 84.8% | 1,634 | 86.3% |
| Too Few Pre-Participation Period Summer Bills | 16 | | 4 | |
| Accounts Remaining | 1,586 | 84.0% | 1,630 | 86.1% |
| Too Few Post-Participation Period Bills (Less than 9) | 76 | | - | |
| Accounts Remaining | 1,510 | 79.9% | 1,630 | 86.1% |
| Too Few Post-Participation Period Summer Bills | 11 | | - | |
| Accounts Remaining | 1,499 | 79.4% | 1,630 | 86.1% |
| Low Overall Average Usage (under 2kWh/day) | 4 | | 2 | |
| Accounts Remaining | 1,495 | 79.1% | 1,628 | 86.0% |
| High Overall Average Usage (over 300kWh/day) | 2 | | 0 | |
| Accounts Remaining (FINAL) | 1,493 | 79.0% | 1,628 | 86.0% |

In total, our REAP program dataset included 3,783 accounts after program-based cleaning; after cleaning billing data, 3,121 remained. Approximately 83% of the total participant population (including the treatment and future-participant comparison group) 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 assigned 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 days occurred (e.g., if the read period started on June 15 and ended on July 20, we assigned that period to July).

### 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, making the intervening period a "dead band" period. The evaluation team excluded months between their first participation date and last installation. For customers with a single date of participation, we excluded only one billing month from the model as the "dead band." 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 2017 due to the need to exclude the year 2018 (as well as 2019) since the evaluated treatment group began their post-participation period sometime during 2018.

Graphing average energy consumption during the baseline period makes the similarities and differences between the groups visible. Figure 9-1 shows the average daily consumption (ADC) for January through December 2017 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 in the period between January and April 2017. However, the reason for the difference in those first few months of 2017 is that many of the "future" participants (in 2019) were lacking billing data in that time period. The remaining comparison group customers apparently used less energy during that time than the evaluated participants. However, they converge well starting in May 2017. The initial period where there were missing records later caused us to make adjustments in the model. 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.

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

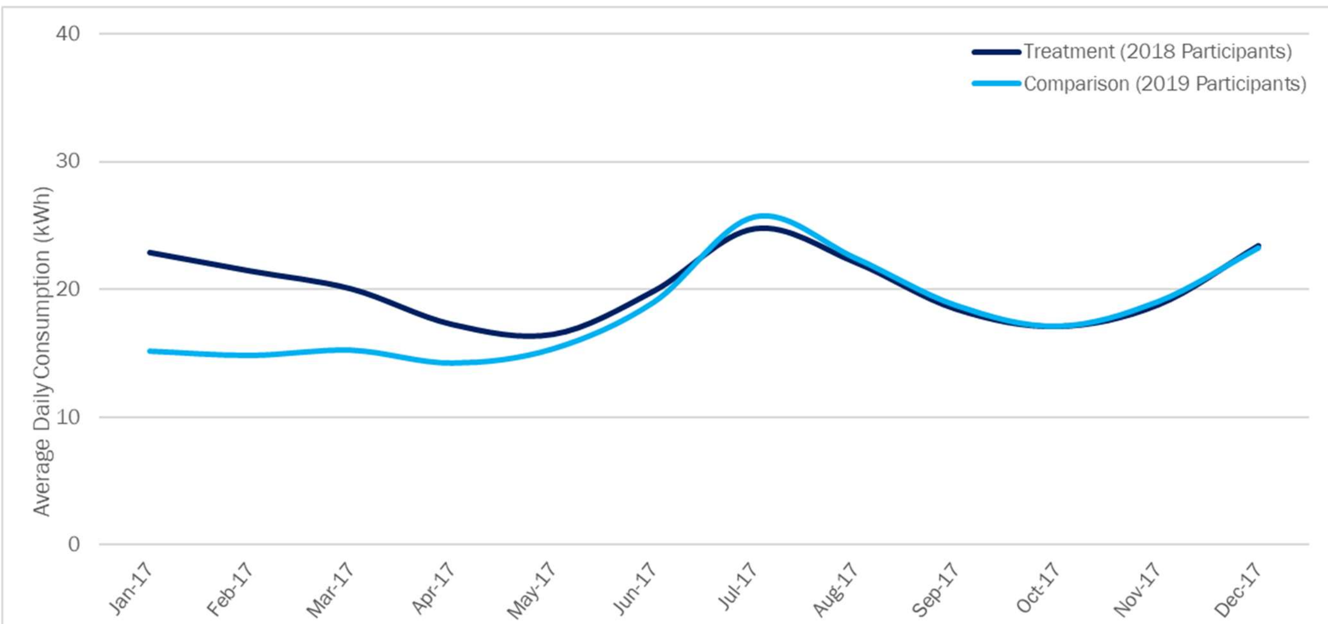



Figure 9-2 and Figure 9-3 demonstrate striking similarities in the weather patterns experienced by both groups over the course of the period covered by the consumption analysis. The heating degree days appear visually equivalent in the 2017 pre-period, but a two-sample t-test provides evidence that the two groups are statistically significantly different. Meanwhile, the cooling degree days appear higher for the 2018 participants compared to the 2019 participants, but the t-test fails to provide evidence of statistically significant difference between the two groups in the 2017 pre-period. Thus, the groups likely 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

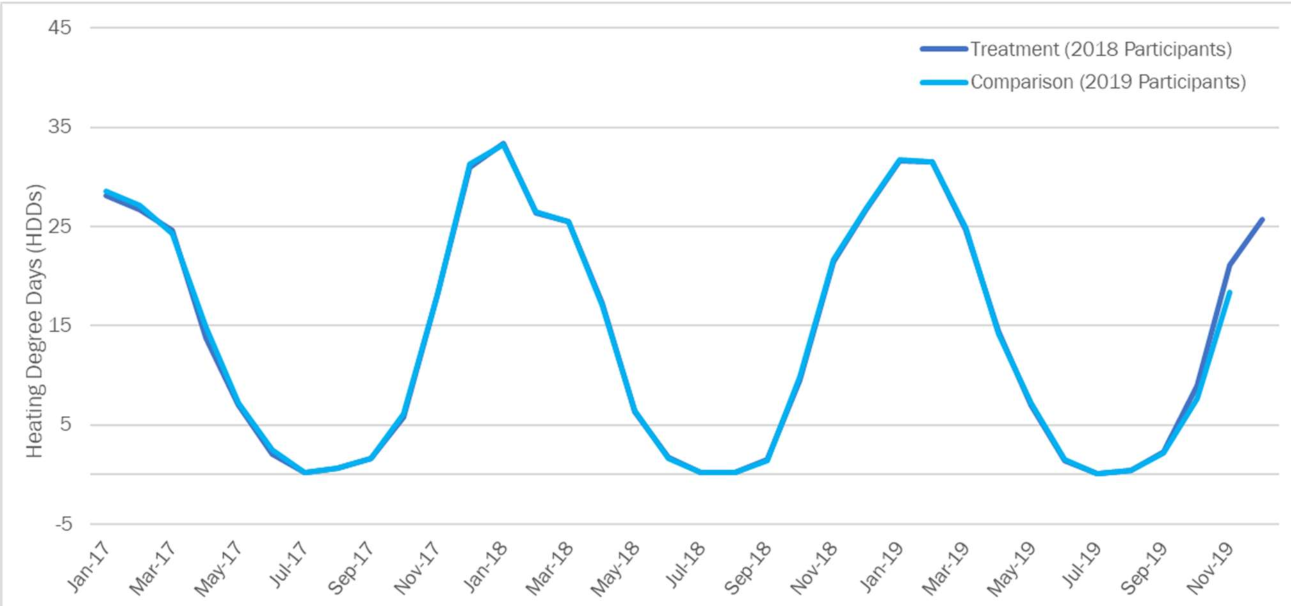
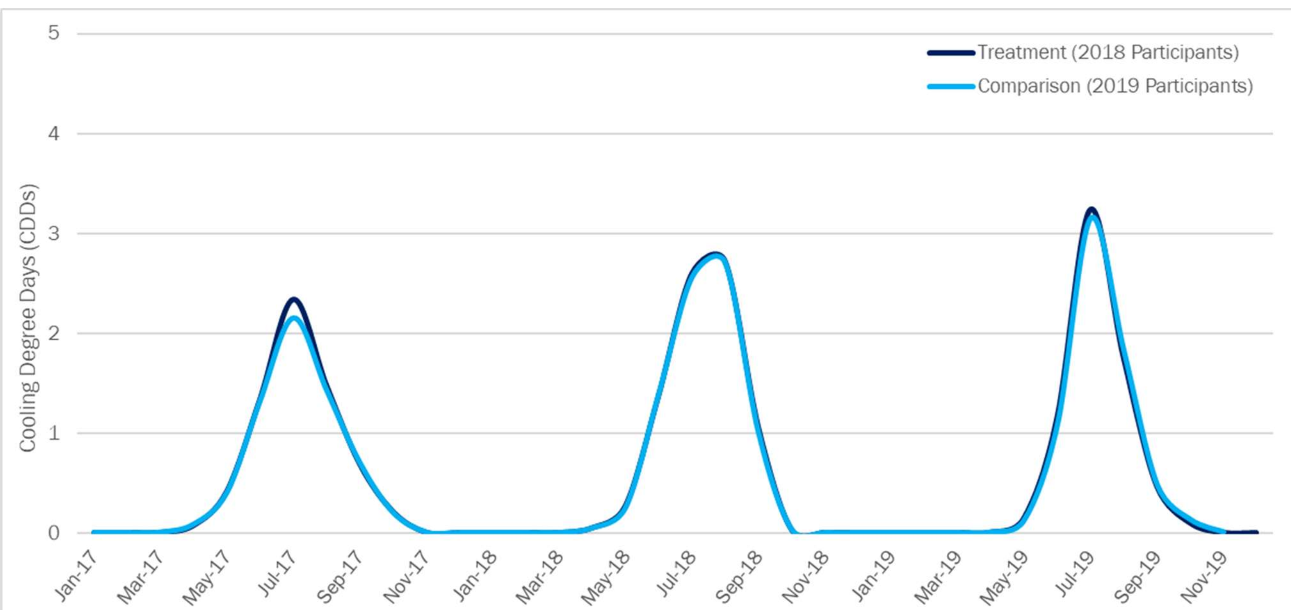



Figure 9-3. REAP Program Analysis: CDDs by Sample Group




## Developing the Model

Opinion Dynamics' evaluation design includes a comparison group consisting of households that participated in 2019 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. Notably, there were larger discrepancies in consumption between the treatment and comparison group in January through April 2017, and so we included indicator terms for those months individually in order to control for this in the pre-period. 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.

Because of the apparent divergence of usage in the initial months of 2017 between treatment and comparison groups, we fitted pre-post, participant-only models as a check of our choice to continue the consumption analysis in spite of those differences, which provide results consistent with those provided by models using the treatment and comparison groups.

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

$$\begin{aligned} ADC_{it} = {} & a_i + B_1 Treat_{it} + B_2 HDD_{it} + B_3 CDD_{it} + B_4 Treat \cdot HDD_{it} + B_5 Treat \cdot CDD_{it} + B_6 Jan2017 \\ & + B_7 Feb2017 + B_8 Mar2017 + B_9 Apr2017 + B_{t1} M + B_{t2} M \cdot CDD + B_{t3} M \cdot HDD + B_{t4} M \\ & \cdot PreADC + \varepsilon_{it} \end{aligned}$$

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, and 1 for treatment group in their post period)

$HDD$ = Average daily HDDs from NOAA

$CDD$ = Average daily CDDs from NOAA

$Jan2017$ = Flag for bills in January 2017

$Feb2017$ = Flag for bills in February 2017

$Mar2017$ = Flag for bills in March 2017

$Apr2017$ = Flag for bills in April 2017

$M$ = 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 CDDs for participants in the post-participation period

$B_6$ = Increment in ADC associated with participants who have bills in January 2017

$B_7$ = Increment in ADC associated with participants who have bills in February 2017

$B_8$ = Increment in ADC associated with participants who have bills in March 2017

$B_9$ = Increment in ADC associated with participants who have bills in April 2017

$B_{t1}$ = Coefficients for each month period

$B_{t2}$ = Coefficients for each month period for each increment in CDD

$B_{t3}$ = Coefficients for each month period for each increment in HDD

$B_{t4}$ = Coefficients for each month period for the increment in pre-participation period ADC

$\varepsilon_{it}$ = Error term for household i at time t

This model is identical to the model used in the 2018 evaluation, with the addition of the four month-year dummy terms for January, February, March, and April 2017.

### 9.5.2 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 characteristics 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 9-6. Average usage went down from 20.63 to 19.47 kWh from pre- to post-participation periods. However, while heating degrees days went down, cooling degree days went up, signaling a potential interplay of effects due to weather as well as to the program. It is also reassuring that usage went down despite a hotter summer in the post period, and the billing analysis will provide the program effect, net of the weather changes.

Table 9-6. REAP Program Analysis: Average Values of Key Variables by Time Period for 2019 Treatment Group

| Variable | Statistic | Period | |
|---|---|---|---|
| | | Pre-Participation | Post-Participation |
| Daily kWh | Mean | 20.63 | 19.47 |
| | SD | 18.60 | 17.31 |
| HDDs | Mean | 14.02 | 12.71 |
| | SD | 12.07 | 11.58 |
| CDDs | Mean | 0.57 | 0.68 |
| | SD | 0.86 | 1.08 |

Note: SD = standard deviation.

Table 9-7 shows the final model results, excluding the dummy variables representing the fixed effects of each household. 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 terms) 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 have reason to believe that this reduced energy consumption is attributable solely to participation in the REAP program.

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

| Predictor | Coefficient | Robust Std. Err. | T | P > \|t\| | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower | Upper |
| post2 | -1.316049 | 0.286294 | -4.6 | 0 | -1.877393 | -0.7547056 |
| hdd | 0.2406294 | 0.1474302 | 1.63 | 0.103 | -0.0484407 | 0.5296995 |
| cdd | 5.176015 | 0.3879028 | 13.34 | 0 | 4.415444 | 5.936585 |
| postHDD | -0.0011683 | 0.0187347 | -0.06 | 0.95 | -0.0379018 | 0.0355652 |
| postCDD | -0.3602749 | 0.1470114 | -2.45 | 0.014 | -0.6485236 | -0.0720261 |
| Jan-17 | -0.55225 | 0.7375701 | -0.75 | 0.454 | -1.998422 | 0.8939219 |
| Feb-17 | -1.728994 | 0.6344227 | -2.73 | 0.006 | -2.972922 | -0.4850658 |
| Mar-17 | -1.627394 | 0.8052862 | -2.02 | 0.043 | -3.206338 | -0.0484495 |
| Apr-17 | -0.1515907 | 0.4548805 | -0.33 | 0.739 | -1.043486 | 0.7403048 |
| January | -22.69385 | 2.707029 | -8.38 | 0 | -28.00158 | -17.38611 |
| February | -8.983328 | 2.103735 | -4.27 | 0 | -13.10817 | -4.858483 |
| March | -14.36082 | 2.288259 | -6.28 | 0 | -18.84747 | -9.874179 |
| April | -5.962472 | 1.314036 | -4.54 | 0 | -8.538934 | -3.386009 |
| May | 1.04108 | 0.8461661 | 1.23 | 0.219 | -0.6180186 | 2.700179 |
| June | -1.59031 | 1.090891 | -1.46 | 0.145 | -3.729246 | 0.5486257 |
| July | -1.87851 | 1.597676 | -1.18 | 0.24 | -5.011113 | 1.254093 |
| August | 0.0819162 | 1.447323 | 0.06 | 0.955 | -2.755885 | 2.919718 |
| October | 1.308479 | 0.8455316 | 1.55 | 0.122 | -0.3493753 | 2.966334 |

| Predictor | Coefficient | Robust Std. Err. | T | P > \|t\| | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower | Upper |
| November | -7.870367 | 1.264895 | -6.22 | 0 | -10.35048 | -5.390256 |
| December | -12.41903 | 1.929567 | -6.44 | 0 | -16.20238 | -8.635678 |
| January * CDD | -2936.576 | 922.7188 | -3.18 | 0.001 | -4745.774 | -1127.379 |
| February *CDD | 152.3245 | 176.1451 | 0.86 | 0.387 | -193.0475 | 497.6965 |
| March * CDD | 13.50114 | 25.00624 | 0.54 | 0.589 | -35.52921 | 62.53148 |
| April * CDD | -2.101826 | 1.820522 | -1.15 | 0.248 | -5.671368 | 1.467717 |
| May * CDD | -2.714295 | 0.8161727 | -3.33 | 0.001 | -4.314585 | -1.114005 |
| June * CDD | -1.980889 | 0.5790841 | -3.42 | 0.001 | -3.116314 | -0.8454648 |
| July * CDD | -2.405785 | 0.6177851 | -3.89 | 0 | -3.617092 | -1.194479 |
| August * CDD | -2.230593 | 0.59777 | -3.73 | 0 | -3.402655 | -1.05853 |
| October * CDD | -2.095391 | 1.022973 | -2.05 | 0.041 | -4.101159 | -0.0896229 |
| November * CDD | 41.1126 | 11.04069 | 3.72 | 0 | 19.46484 | 62.76036 |
| December * CDD | 0 | (omitted) | | | | |
| January * HDD | 0.3750755 | 0.1596742 | 2.35 | 0.019 | 0.0619984 | 0.6881527 |
| February *HDD | -0.0114233 | 0.1599165 | -0.07 | 0.943 | -0.3249755 | 0.3021288 |
| March * HDD | 0.2636274 | 0.1608029 | 1.64 | 0.101 | -0.0516627 | 0.5789176 |
| April * HDD | 0.1008896 | 0.1529416 | 0.66 | 0.51 | -0.1989867 | 0.4007659 |
| May * HDD | -0.26197 | 0.1677598 | -1.56 | 0.118 | -0.5909006 | 0.0669607 |
| June * HDD | 0.1943632 | 0.2570103 | 0.76 | 0.45 | -0.3095632 | 0.6982895 |
| July * HDD | 2.367017 | 1.374887 | 1.72 | 0.085 | -0.3287576 | 5.062791 |
| August * HDD | -1.662125 | 0.9474806 | -1.75 | 0.079 | -3.519874 | 0.1956234 |
| October * HDD | -0.1087292 | 0.1454259 | -0.75 | 0.455 | -0.3938693 | 0.1764109 |
| November * HDD | 0.1768441 | 0.1492907 | 1.18 | 0.236 | -0.1158739 | 0.469562 |
| December * HDD | 0.1422813 | 0.156134 | 0.91 | 0.362 | -0.1638544 | 0.4484171 |
| January * PreADC | 0.1381765 | 0.0371353 | 3.72 | 0 | 0.0653644 | 0.2109887 |
| February * PreADC | 0.0150431 | 0.0234516 | 0.64 | 0.521 | -0.0309389 | 0.0610252 |
| March * PreADC | -0.110483 | 0.0314752 | -3.51 | 0 | -0.1721971 | -0.0487689 |
| April * PreADC | -0.2967965 | 0.038479 | -7.71 | 0 | -0.3722432 | -0.2213498 |
| May * PreADC | -0.4513395 | 0.0482182 | -9.36 | 0 | -0.5458821 | -0.356797 |
| June * PreADC | -0.3643864 | 0.0570076 | -6.39 | 0 | -0.4761626 | -0.2526102 |
| July * PreADC | -0.1994819 | 0.0642651 | -3.1 | 0.002 | -0.325488 | -0.0734758 |
| August * PreADC | -0.2253461 | 0.0637483 | -3.53 | 0 | -0.350339 | -0.1003532 |
| October * PreADC | -0.4328005 | 0.0573387 | -7.55 | 0 | -0.5452258 | -0.3203751 |
| November * PreADC | -0.4700664 | 0.0436377 | -10.77 | 0 | -0.5556279 | -0.3845048 |
| December * PreADC | -0.2682391 | 0.0295852 | -9.07 | 0 | -0.3262476 | -0.2102305 |
| Constant | 24.43208 | 1.140944 | 21.41 | 0 | 22.195 | 26.66915 |

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 9-8 shows the estimate of per-household savings based on these calculations.

Table 9-8. Adjusted Estimate of Daily REAP Program Savings

| Savings Estimate (kWh) | Std. Err. | T | P >\|t\| | 90% Confidence Interval | |
|---|---|---|---|---|---|
| | | | | Lower | Upper |
| -1.57131 | 0.17613 | -8.91235 | <0.001 | -1.86619 | -1.28661 |

The value of the estimate represents the energy change in average daily consumption (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 1.29 kWh and 1.87 kWh per day per participant.

Consumption Analysis Compared to Expected Savings

Table 9-9 compares the observed (evaluated) savings from the consumption analysis to the 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, with and without line loss factors added. Evaluated participants in the REAP program saved an estimated 574 kWh per year. This compares to 685 kWh per year planned savings, for a realization rate of 84%.

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

| Program | N[a] | Observed Savings | | Planned Savings | | Realization Rate |
|---|---|---|---|---|---|---|
| | | Household Daily Savings | Household Annual Savings | Household Daily Savings | Household Annual Savings | |
| REAP (excludes line losses) | 2,155 | 1.57 | 574 | 1.88 | 685 | 84% |
| REAP (includes line losses) | 2,155 | 1.67 | 608 | 2.00 | 728 | 84% |

[a] This is the number of unique accounts that completed a REAP project in 2019.

## 9.6 Home Performance Program Consumption Analysis Methods

This section presents detailed consumption analysis methods used to support the Home Performance programs impact evaluation. PSEG Long Island runs two Home Performance programs, HPDI and HPwES. Some customers that participate in the HPDI program will go on to participate in the HPwES program (and vice versa). Thus, there are customers who participate in HPDI, HPwES, and both programs.

Since there is insufficient post-period data to evaluate 2019 Home Performance participants directly, we instead estimate savings using 2018 participants, and then apply the resulting per-participant savings to the 2019 participant count. This is consistent with prior evaluations. Because the program measures were slightly different between 2018 and 2019, this approach requires a minor calibration of the engineering assessment when calculating the realization rate (discussed further in Section 9.6.2.) Consistent with previous Home Performance evaluations, we used a comparison group approach to produce an estimate of net savings from the consumption analysis. The comparison group consists of customers who participated in 2019 as we expect them to possess similar characteristics as customers who participated in 2018. This is discussed in more detail in Section 9.6.1.

### 9.6.1 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 HPDI and HPwES programs in 2018 and 2019. PSEG Long Island also provided the consumption history to represent both pre- and post-period data for both 2018 and 2019 program participants. Prior to carrying out the statistical modeling, Opinion Dynamics matched, cleaned, and provided quality assurance for all data. We used the same data-cleaning procedures for both 2018 and 2019 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 analyze. Program tracking records provided in January 2020 included complete 2018 and 2019 participant data. We cleaned the participant data files based on the following criteria:

- Customers who installed beneficial electrification measures: We removed customers who installed fuel switching measures that resulted in increased electric consumption (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.
- Customers who cross-participated in another program: 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 (2016–2019), REAP (2016–2019), EEP (2016–2019), Cool Homes/Home Comfort (2016–2019). Note that we retained all HEM program participants as they represent a substantial proportion (~40%) of overall participants. 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.
- Customers whose projects were conducted before 2018: We also dropped accounts from the program tracking data that had projects originating earlier than 2018. For purposes of the consumption analysis projects were assigned to a year based on the start date of their project.

#### Matching Participant Information with PSEG Long Island Account Information

The Home Performance programs track PSEG Long Island customer account information within the TRC Captures system. As a result, we could use the customer account numbers provided with participant data to match billing histories to program participants.

## Cleaning Billing Data

Opinion Dynamics cleaned the data for customer accounts with anomalous or insufficient data for consumption analysis. We describe each billing data cleaning sub-step below. The evaluation team's cleaning procedures were consistent with those employed in prior years' evaluations. These included:

- Excluding customers with inadequate billing history before or after program participation: Many energy savings measures in these programs are expected to generate energy savings throughout the year. In order 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 2018 and 2019 program participants, and nine months (or the 270-day equivalent) after participation for 2018 participants.
- Excluding customers with inadequate billing history in the heating and cooling seasons before and after program participation: We also required that participants have a minimum billing history of 60 days in the summer (cooling season) and winter (heating 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, August, and September as well as November, December, January, and February we were able to provide more realistic savings estimates.
- Excluding customers with no billing data: We removed customers with no billing data from the model.

Table 9-10 and Table 9-11 provide a summary of our cleaning steps by account and by billing record, respectively. The evaluation team began with 3,860 participant accounts, 2,078 from 2018 (the treatment group) and 1,782 from 2019 (the comparison group). Based on the cleaning steps outlined above, we modeled 2,206 customers (57%), representing 764 treatment and 1,442 comparison group customers. Overall, a total of 1,654 accounts (43% of the total) were dropped. The primary driver for account cleaning was insufficient pre-period billing data, program cross participation, and beneficial electrification. We also removed individual billing records in the cleaning process. Overall, a total of 30,575 bills (45% of the total) were dropped.

Table 9-10. Home Performance Billing Data Cleaning Drops – Customer Accounts

| Reason for Drop | Treatment | | Comparison | | Total | |
|---|---|---|---|---|---|---|
| | Number | Percent | Number | Percent | Number | Percent |
| Initial Number | 2,078 | 100% | 1,782 | 100% | 3,860 | 100% |
| Beneficial Electrification | 123 | 6% | 122 | 7% | 245 | 94% |
| Cross-Participation | 222 | 11% | - | 0% | 222 | 88% |
| Insufficient Post-Period Billing Data | 124 | 6% | - | 0% | 124 | 85% |
| Insufficient Post-Period Summer Billing Data | - | 0% | - | 0% | - | 85% |
| Insufficient Post-Period Winter Billing Data | 20 | 1% | - | 0% | 20 | 84% |
| Insufficient Pre-Period Billing Data | 629 | 30% | 168 | 9% | 797 | 64% |
| Insufficient Pre-Period Summer Billing Data | 65 | 3% | 8 | 0% | 73 | 62% |
| Insufficient Pre-Period Winter Billing Data | 7 | 0% | 6 | 0% | 13 | 61% |
| Account lost due to billing data quality (Table 9-11) | - | 0% | 4 | 0% | 4 | 61% |
| Account lost due to truncation in 10/19 | - | - | 2 | 0% | 2 | 61% |
| No Billing Data | 124 | 6% | 30 | 2% | 154 | 57% |
| Final Number | 764 | 37% | 1,442 | 81% | 2,206 | 57% |

Table 9-11. Home Performance Billing Data Cleaning Drops – Customer Records

| Reason for Drop | Treatment | | Comparison | | Total | |
|---|---|---|---|---|---|---|
| | Number | Percent | Number | Percent | Number | Percent |
| Initial Number | 37,164 | 100% | 30,429 | 100% | 67,593 | 100% |
| Cross-Participation | 4,647 | 13% | - | 0% | 4,647 | 93% |
| Control group post period | - | 0% | 3,949 | 13% | 3,949 | 87% |
| >90-day bill period | 70 | 0% | 45 | 0% | 115 | 87% |
| Before model start | 1,353 | 4% | 1,303 | 4% | 2,656 | 83% |
| No bill days | 1,339 | 4% | 1,333 | 4% | 2,672 | 79% |
| Usage outlier | 7 | 0% | 6 | 0% | 13 | 79% |
| Zero/negative usage | 44 | 0% | 48 | 0% | 92 | 79% |
| Insufficient Pre-Period Billing Data | 11,547 | 31% | 736 | 2% | 12,283 | 61% |
| Insufficient post-period data | 2,134 | 6% | - | 0% | 2,134 | 58% |
| Insufficient Pre-Period Summer Billing Data | 1,381 | 4% | 57 | 0% | 1,438 | 56% |
| Insufficient Pre-Period Winter Billing Data | 119 | 0% | 51 | 0% | 170 | 55% |
| Insufficient Post-Period Summer Billing Data | - | 0% | - | 0% | - | 55% |
| Insufficient Post-Period Winter Billing Data | 406 | 1% | - | 0% | 406 | 55% |
| Final Number | 14,117 | 38% | 22,901 | 75% | 37,018 | 55% |

## 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. To ensure the analysis is comparable across customers and time periods, we assigned each billing period to a specific calendar month based on the midpoint of the billing period, so that the month would refer to the month in which the majority of energy use days occurred (e.g., if the read period started on June 15 and ended on July 20, we assigned that period to July). We also dropped bills of longer than 90 days, as described above.

The evaluation team also checked for other time period issues, including overlapping billing periods, but did not identify any.

## 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.

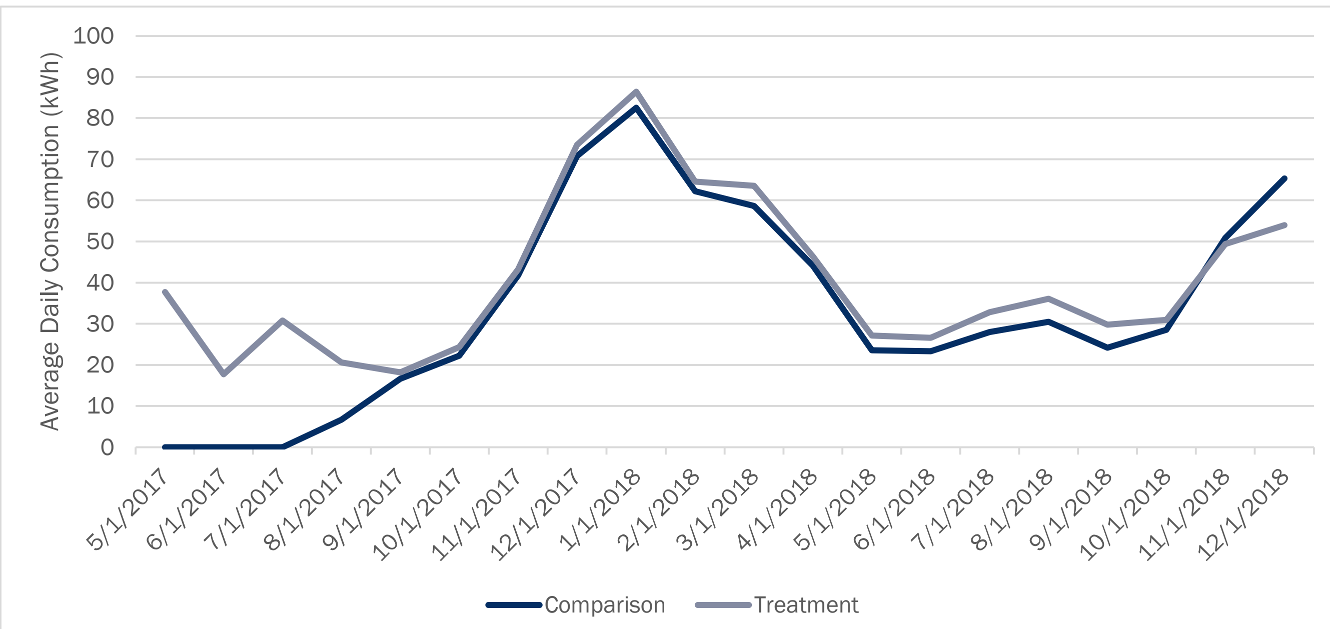
## Assessing Comparison Group Equivalency

Before performing any modeling, the evaluation team assessed the comparability of our treatment group (2018 participants) and comparison group (2019 participants). This is important because if the comparison group is not very similar to the treatment group on important variables, the comparison group cannot act as an effective point of comparison for the treatment group.

To assess the comparability of the groups, we compared the overall average baseline daily energy consumption and the average daily CDDs and HDDs for both groups during the same calendar period. The evaluation team graphed average energy consumption during the pre-period to visually inspect for similarities and differences between the treatment and comparison groups. Figure 9-4 through Figure 9-6 show the ADC for January 2017 (where available) through December 2018 for the HPDI program, the HPwES program, and for those who participated in both, to determine how similar households in the two design groups (treatment and comparison) are in terms of energy consumption patterns prior to their participation for each program.[62]

The team determined that the 2019 participants (comparison group) are similar enough to the evaluated 2018 participants (treatment group) to justify using this group as a point of comparison to estimate net savings.

Figure 9-4. Pre-Period Energy Use—HPDI




[62] Some 2018 participants may have a pre period that includes the first few months of 2019 because those customers entered the program in 2018 but completed their installations in 2019, and we defined the post period as the date the last measure installation was completed. This is typical with programs where enrollment occurs throughout the course of the program year.

Figure 9-5. Pre-Period Energy Use—HPwES

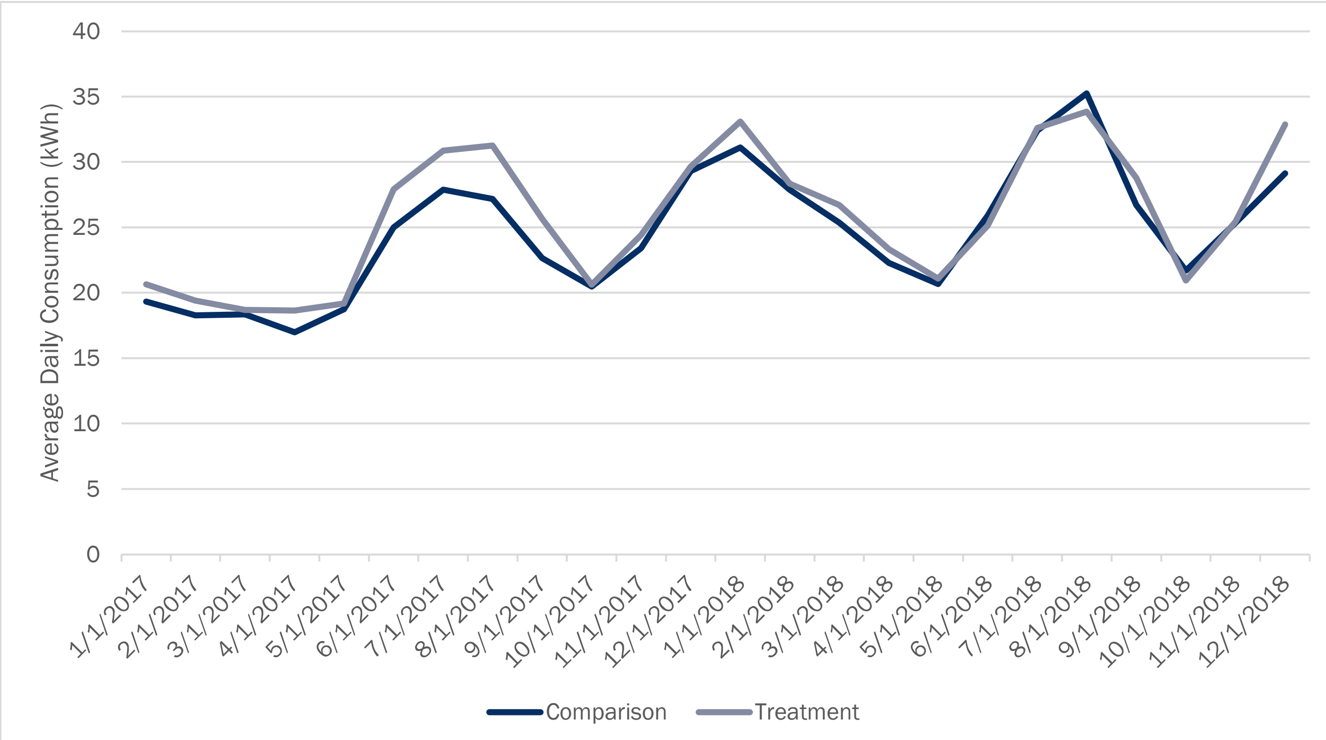
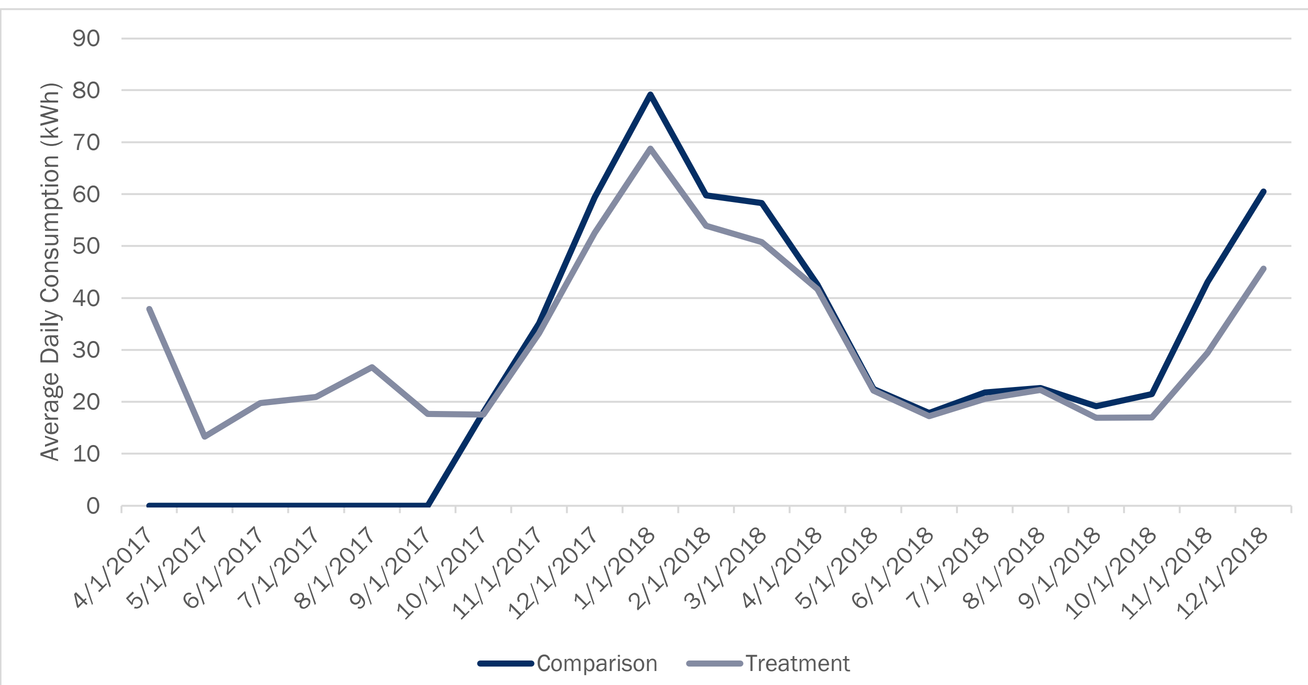



Figure 9-6. Pre-Period Energy Use—Participated in Both Programs



Weather is another possible area of difference between the treatment and comparison groups that could result in a difference in usage. However, as shown in Figure 9-7 and Figure 9-8, the two groups appear to have virtually the same weather patterns, with just a few atypical periods at the beginning and ending months of the evaluation period.

Figure 9-7. Home Performance Program Analysis: HDDs

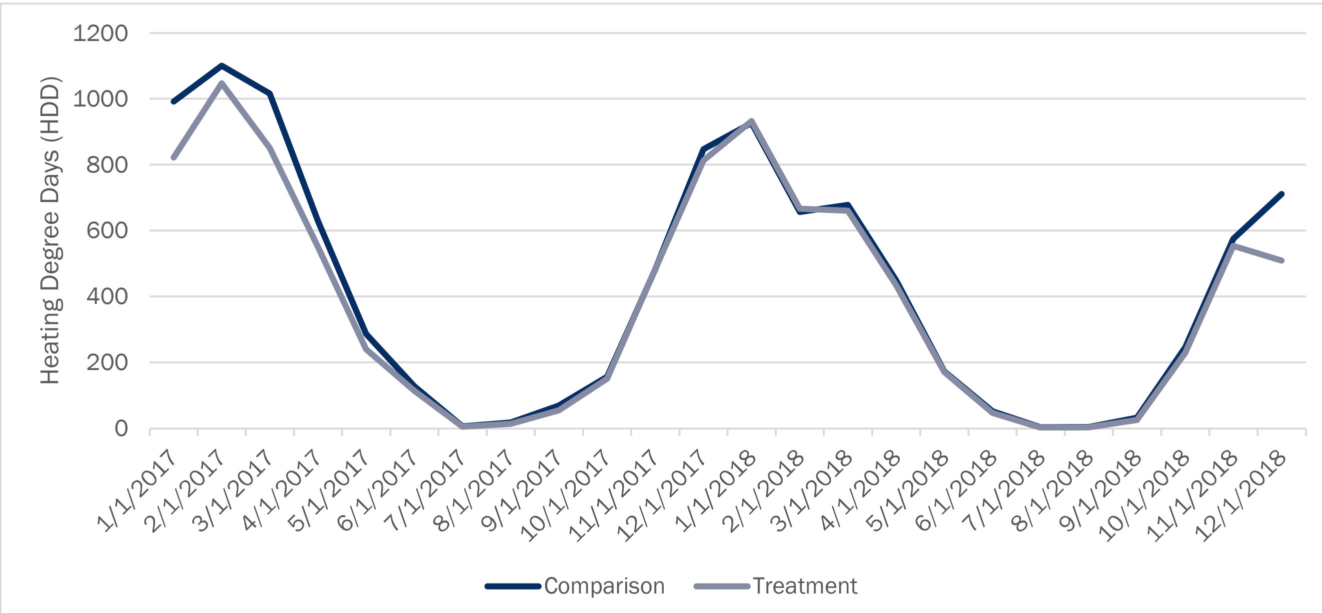
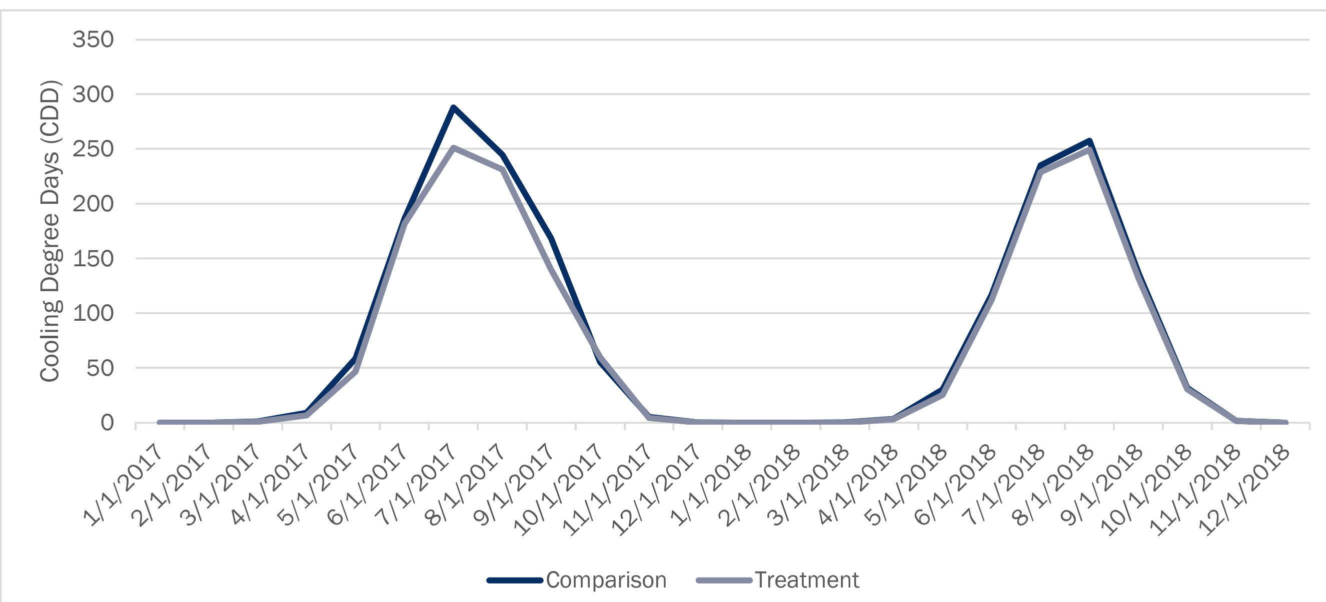



Figure 9-8. Home Performance Program Analysis: CDDs



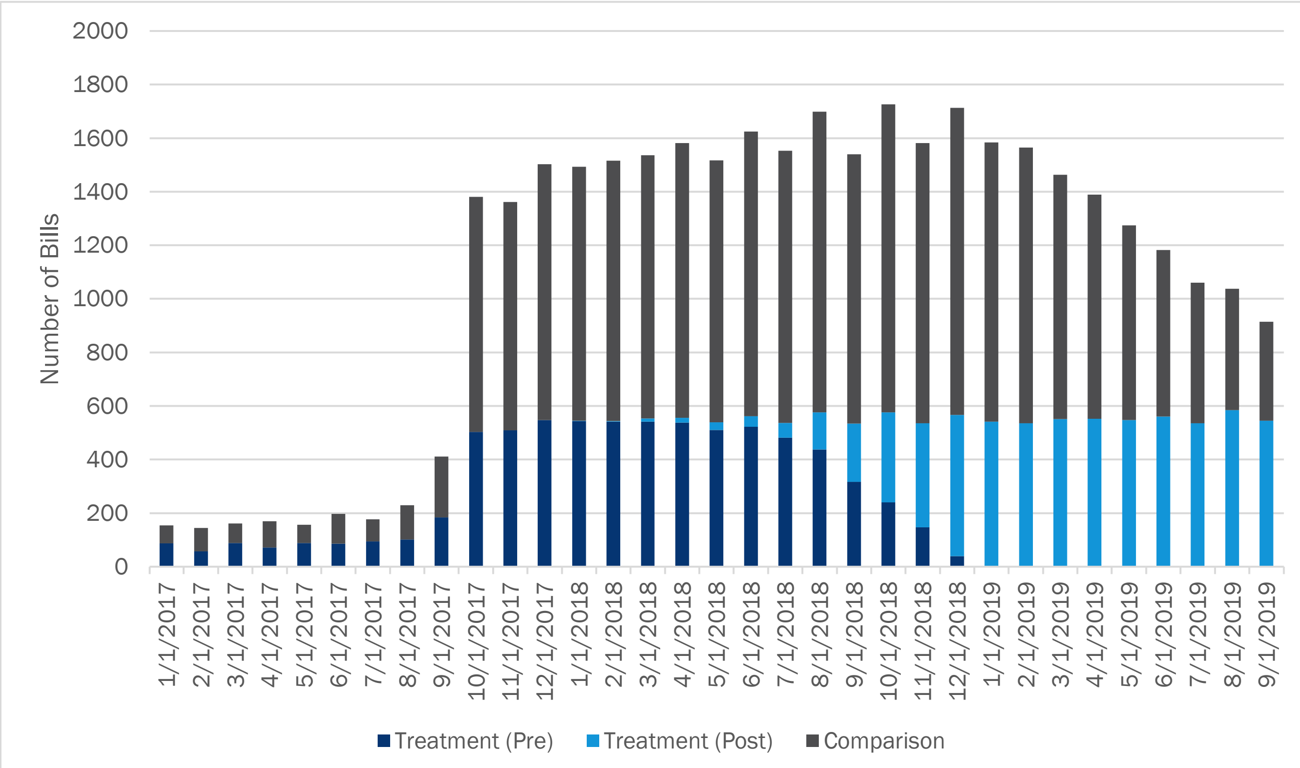

The evaluation team also compared the groups (2018 and 2019 participants, HPDI and HPwES) on their prevalence of electric space heat (ESH) and found that there was equivalent ESH prevalence in both years for the HPDI program. Treatment and comparison customers also participated in the HEM program at similar rates.

We also evaluated the usage patterns for similarity across the programs. As Figure 9-4 through Figure 9-6 show, the usage patterns across programs are dissimilar. Some of the differences were due to the different prevalence of ESH between programs, and some are directly related to different patterns of missing data. Figure 9-4 through Figure 9-6, demonstrate that missing 2017 billing records vary by program. For instance, the 2019 HPDI participants (our comparison group during their pre period) would be in their pre period in all of 2017 and 2018, but we did not have all of their billing data for January through August of 2017. We had much more billing data for early 2017 for HPwES participants.

Given these differences across the programs, the evaluation team estimated separate models to assess program impacts instead of including program-specific terms in one model as was done in previous evaluations. We estimated one set of models for HPDI-only participants, one for HPwES-only participants, and one for those who participated in both programs. We also ran a combined model for the Home Performance programs overall, which was used to calculate the final realization rate.

Figure 9-9 portrays the rolling nature of the future-participants comparison-group design. The comparison group billing data become more and more limited in the last half of 2019 as 2019 participants entered their post-installation period. This is typical for a program with rolling enrollment. But it also means that models will be vulnerable to unstable results as the comparison group becomes smaller and smaller such that there are very few at the end of 2019. Initial models did experience that type of instability, which led the evaluation team to truncate the end of 2019 such that all periods in the model have sufficient data to support rigorous estimates. Figure 9-9 also illustrates the issue of missing data in early 2017 that was discussed above.

Figure 9-9. Bill Periods Available for Treatment and Comparison Groups, Pre- & Post-Installation in this Future-Participants Design




## Developing the Model

For the 2019 evaluation, the evaluation team estimated savings based on 2018 participants, using 2019 participants as our comparison group, and applied the savings to the count of 2019 participants to generate total program savings.

We selected a fixed effects model to control for changes that occur for everyone over time (such as weather and economic factors). In the development of the final model, we tested a series of progressively inclusive specifications, including weather and temporal variables. 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 evaluation 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. We were also unable to include ESH as a variable, as it is almost perfectly co-linear with HPDI participation and participation in both HPDI and HPwES programs (98% and 95% of participants had ESH in each program, respectively). As a result, the final HPDI and Both models are only applicable to ESH customers and should not be extrapolated to non-ESH customers.

Because customers in each program (HPDI only, HPwES only, and Both) had substantially different load shapes (largely due to the higher prevalence of ESH in the HPDI program), we ran separate models for each program. We also ran a version of the same model specification for the program as a whole. This combined model was used to calculate the overall program realization rate and is reported here.

We selected the final model 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 along with normalized month variables. Our final model specification is shown in Equation 9-1. Model fit results are shown in Table 9-12.

Equation 9-1. Final Home Performance Model

$$ADC_{it} = \alpha_i + \beta_1 HP_i \cdot Post_t + \beta_2 HDD_{it} + \beta_3 CDD_t + \beta_4 HP_i \cdot Post_t \cdot HDD_t + \beta_5 HP_i \cdot Post_t \cdot CDD_t$$

$$+\beta_{6-16} M_t + \varepsilon_{it}$$

Where:

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

$\alpha_i$ = Intercept for household i

$\beta_1$ = Coefficient for the change in consumption between pre- and post-participation periods for program participants.

$HP_i \cdot Post_t$ = A vector that represents whether a given billing observation is in the post-period (where Post=1 if in the post-period, and 0 if not). We run this model specification separately for participants who participate in HPDI-only, HPwES-only, and Both programs as well as for the Combined Home Performance program overall, adjusting $HP_i$accordingly.

$\beta_2$ = Coefficient for effect of HDD (Base 65o F) at time t

$HDD_t$ = Monthly average Heating Degree Days

$\beta_3$ = Coefficient for effect of CDD (Base 65o F) at time t

$CDD_t$ = Monthly average Cooling Degree Days

$\beta_4$ = Coefficient for change in consumption between pre- and post-participation for participant i for HDD at time t

$\beta_5$ = Coefficient for change in consumption between pre- and post-participation for participant i for CDD at time t

$\beta_{6-16}$ = Set of coefficients for monthly dummy variables

$M_t$ = Monthly dummy variables

$\varepsilon_{it}$= Error term for participant i at time t

Table 9-12. Home Performance Final Model Parameters and Fit

| Program | $R^2$ | Adjusted $R^2$ |
|---|---|---|
| HPDI | 0.76 | 0.75 |
| HPwES | 0.58 | 0.56 |
| Both | 0.78 | 0.76 |
| Combined | 0.59 | 0.57 |

## 9.6.2 Home Performance Programs Estimation of Savings Using Consumption Analysis

In this section, we present the methods used to translate the results of a consumption analysis to Home Performance programs savings.

### Electric Savings Results

Examining some basic characteristics of the participants, their usage, and the weather for the analysis period provides an indication of what we can expect in terms of program savings. 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 9-6. We see that average usage went down from 30.8 to 28.8 kWh from pre- to post-participation periods. However, heating degrees days went down, and cooling degree days went up, signaling a potential interplay of effects due to weather as well as to the program. The billing analysis provides the program effect, net of the weather changes.

Table 9-13. Home Performance Program Analysis: Average Values of Key Variables by Time Period for 2018 Modeled Treatment Group

| Variable | Statistic | Period | |
|---|---|---|---|
| | | Pre-Participation | Post-Participation |
| Daily kWh | Mean | 30.1 | 28.2 |
| | SD | 24.7 | 22.6 |
| HDDs | Mean | 382 | 355 |
| | SD | 553 | 540 |
| CDDs | Mean | 64 | 68 |
| | SD | 131 | 138 |

Table 9-14 shows the final model results for the program, excluding the dummy variables representing the fixed effects of each household. The models show changes in electricity use after participation in the program, controlling for weather and household characteristics (reflected in the account or household constant terms). The program effects term (Post) is negative, indicating that program participants did reduce energy consumption in the post-participation period (after controlling for weather). Because we did not include customers who participated in other PSEG Long Island energy efficiency programs in this analysis (other than HEM), we have reason to believe that this reduced energy consumption is attributable to participation in the programs.

Table 9-14. Final Home Performance Programs Model Coefficients – Home Performance Overall

| Equation Terms | Coefficient | Robust Std. Err. | T | P > \|t\| |
|---|---|---|---|---|
| Post | -2.07 | 0.35 | -5.86 | 0.00 |
| CDD | 0.02 | 0.00 | 10.83 | 0.00 |
| HDD | 0.00 | 0.00 | -9.23 | 0.00 |
| February | -5.57 | 0.41 | -13.43 | 0.00 |
| March | -8.83 | 0.40 | -21.90 | 0.00 |
| April | -17.26 | 0.44 | -38.95 | 0.00 |
| May | -22.11 | 0.47 | -47.21 | 0.00 |
| June | -21.15 | 0.48 | -44.11 | 0.00 |

| Equation Terms | Coefficient | Robust Std. Err. | T | P > \|t\| |
|---|---|---|---|---|
| July | -16.01 | 0.49 | -32.69 | 0.00 |
| August | -15.91 | 0.49 | -32.26 | 0.00 |
| September | -21.16 | 0.47 | -44.66 | 0.00 |
| October | -22.87 | 0.46 | -49.23 | 0.00 |
| November | -13.57 | 0.42 | -32.14 | 0.00 |
| December | -5.07 | 0.41 | -12.32 | 0.00 |
| Post: HDD | 0.00 | 0.00 | 0.87 | 0.38 |
| Post: CDD | 0.00 | 0.00 | -1.67 | 0.09 |

Due to the weather interaction terms in the model, the model has multiple treatment terms, thus requiring us to complete 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, we must include those terms in the calculation of the total treatment impact. We calculated these effects by multiplying the treatment:post variable (0 or 1) by the actual mean heating and cooling degree days during the post-participation period. Table 9-15Table 9-8 presents the results of the consumption analysis described above for the Home Performance program overall, including the estimate of per-household savings and the confidence intervals around those estimates. The treatment effect is statistically significant.

Table 9-15. Consumption Analysis Modeling Results of Daily Home Performance Program Savings

| Program | Baseline | Per-Participant ADC Savings (kWh) | Robust SE Savings | Percent Savings | 90% Lower CI | 90% Higher CI | p Value |
|---|---|---|---|---|---|---|---|
| HP Program | 29.04 | 2.12 | 0.26 | 7.3% | 2.55 | 1.69 | 0.00 |

## Consumption Analysis Compared to Ex Ante Savings

Home Performance participants saved an average of 2.1 kWh per day, or 7% of their baseline consumption. Table 9-16 shows the daily and annual program savings.

Table 9-16. Program Savings Calculations

| Program | 2019 Participant Count | Per-Participant ADC Savings (kWh) | % of Baseline | Daily Program Savings (kWh) | Annual Savings (kWh) |
|---|---|---|---|---|---|
| HP Program | 1,782[a] | 2.1 | 7% | 3,780 | 1,379,583 |

[a] The total count of participants to which we applied the consumption analysis results includes the 122 HPwES accounts who installed beneficial electrification measures. These customers were excluded from the actual consumption analysis modeling because fuel switching will cause their electric usage to increase. However, the non-beneficial electrification measures installed by these customers are included in the engineering measure results. In order to ensure an apples-to-apples comparison between the consumption analysis total annual savings and the engineering analysis total annual savings, we need to include the non-beneficial electrification measures installed by beneficial electrification customers in our consumption analysis results. We do this by assuming that beneficial electrification customers have the same average savings from non-beneficial electrification measures as customers who did not install beneficial electrification.

Due to the lack of post-period data for 2019 participants, our model evaluation used 2018 participants as a proxy for 2019 participants. However, because there were some differences between the measures included in the 2018 and the 2019 Home Performance programs, we adjusted the 2019 ex ante net savings before calculating the realization rate. Essentially, we “true up” the 2019 ex ante net savings to make them mimic the measures included in 2018 by adding or subtracting the savings associated with new/removed measures, as appropriate. For example, HPD 0.3 Watt Nightlight is a new measure for 2019 (and is therefore not included in the consumption analysis). For the purposes of calculating the realization rate, we do not include the savings associated with the HPD 0.3 Watt Nightlight in the ex ante net savings estimate. Similarly, the HPwES Thank You Kit included 2 extra lightbulbs and an advanced power strip in 2018, which were not included in 2019. The savings associated with those extra measures were subtracted from the 2019 ex ante net savings when calculating the realization rate. Note that these adjustments are strictly for the purpose of calibrating the realization rate.

Table 9-17 compares the observed ex post net savings from the consumption analysis to the expected ex ante net 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, with line loss factors added. Evaluated participants saved an estimated 824 kWh per year. This compares to 589 kWh per year adjusted ex ante net savings, for a realization rate of 140%.

Table 9-17. Net Savings from the Home Performance Program Consumption Analysis Compared to Net Savings Expected from Program Planning Estimates

| N[a] | Observed Savings (kWh) | | Planned Savings (kWh) | | Realization Rate |
|---|---|---|---|---|---|
| | Household Daily Savings | Household Annual Savings | Household Daily Savings | Household Annual Savings | |
| 1,782 | 2.3 | 824 | 1.61 | 589 | 140% |

## 9.7 Home Energy Management Program Consumption Analysis Methods

This section presents a summary of the methods used to quantify the evaluated energy savings impacts for the 2019 HEM program. Implementation of the HEM program relies on a HER engagement campaign leveraging an RCT design.[63] Given this design, we used a consumption analysis approach to estimate ex post net energy savings impacts of the program. The result of this approach is the unadjusted ex post 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, the HEM program may encourage an increase, or "uplift," in participation in other PSEG Long Island residential energy efficiency programs among the members of the treatment group since they are promoted 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, any statistically significant cross-participating programs' savings are removed from the results of the consumption analysis to arrive at an adjusted ex post savings impact for the HEM program. For evaluation year 2019, there was no statistically significant increased participation among HEM treatment customers in other energy efficiency programs, which meant the evaluation team did not need to subtract any savings from the consumption analysis result.

[63] 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.

## 9.7.1 Program Design

Treatment of customers began in September 2017 when Uplight (formerly 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. Uplight targeted customers between 55 and 74 years old to improve customer satisfaction in this segment. In addition, one-third of the customers were "My Account" participants.[64]

In August 2018, Tendril started to send periodic HERs to an additional 159,348 customers, the treatment customers in Cohort 2. Not all of these customers received their first HERs in August 2018, as initial HERs were sent 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.

Due to attrition, both the treatment and control groups in both cohorts in the 2019 program year are smaller than they were in 2017 and 2018. Additional detail on attrition and current treatment numbers are provided below.

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

### Preparing and Cleaning the Data

Opinion Dynamics followed a rigorous and systematic process of inspecting the data received from PSEG Long Island and Uplight. 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 it with the participant file. Following this, the team obtained weather data and appended it to the merged file.

### Cleaning Participant Data

#### Cohort 1 and Cohort 2 Participant Counts

Opinion Dynamics received HEM participant files for customers in Cohorts 1 and 2.[65] The Cohort 1 file began with 348,214 accounts, which included 310,293 treatment and 37,921 control customers. There were no Net Energy Metering solar PV customers in Cohort 1 that required removal from the analysis.

The Cohort 2 customer dataset began with 185,992 accounts, which included 152,608 treatment and 33,384 control customers. The evaluation team removed 13 Net Energy Metering solar PV customers who participated in the HEM Program in 2019 because including these customers would confound the estimate of energy savings from the receipt of HERs.

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[64] "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.

[65] Unlike last year, no Super Savers customers are included in the HEM analysis.

## Experiment Start Dates

Consistent with the ITT approach,[66] Opinion Dynamics used one experiment start date for all participants in Cohort 1 and one experiment start date for all participants in Cohort 2. For Cohort 1, the start date was September 8, 2017, and for Cohort 2 it was August 27, 2018. While customers received their first reports on a rolling basis after the experiment start date, using a common experiment start date defines the pre-period and post-period for our analysis and reflects the intended treatment effort. We set the pre-period for each cohort as 12 months before their respective experiment start dates. The post period for each cohort is the full year of 2019.

## Time Periods in Billing Data

Typically, bills for electricity usage are sent to customers monthly. However, usage data for some customers indicated a 2-month billing cycle due to PSEG Long Island's practice of conducting meter reads every other month. 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 cases where there were two months included on one record, we calculated the ADC, and assigned a month and year to the bill according to the midpoint between the starting and ending time of the bill.

In addition, if the billing cycle was longer than 90 days, the evaluation team removed the record. Similarly, if the bill covered less than 10 days, the record was dropped.

## Cleaning Billing Data

Opinion Dynamics found that some billing records were represented more than once in the billing data received from PSEG Long Island. The team dropped one of each set of perfect duplicates. This step 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 75% of the 365 days in a year, as well as accounts with less than two summer months in the post-period or less than 30 summer days in the pre-period. We applied this cleaning step as we expect most electric savings to accrue in the summer.

We also removed accounts having no usage or extremely low average daily consumption (less than 2 kWh). Additionally, we dropped a small number of accounts for very high average daily usage values (over 300 kWh/day).

There was also a large proportion of overlapping bills in the 2019 data from PSEG Long Island (about 40% of the bills overlapped, by on average 30 days), which is a much higher incidence in data from previous years where the proportion of overlapping bills ranges from 0.03% to 1.2%. Opinion Dynamics dealt with these overlaps in the following ways:

1. If the usage and dates of the bill are the same, drop one bill.

[66] 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 (ATT), 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. Additionally, by using the ITT approach, we measure the true effect of the cost of the program intervention based on the intended participants, rather than the actual participants.

2. If the dates of the bills are the same, and one bill is an actual bill while the other is estimated, drop the estimated bill.
3. If the dates of the bills are the same, but one bill shows zero usage, and both are estimated bills, drop the zero-usage bill.
4. If the dates of the bills are the same, usage is non-zero for both bills, and both bills are estimated bills, average their usage.
5. If the dates of the bills overlap but not exactly, and the midpoint of the bill is in the same year, then average the days and the usage of the bills that overlap.

Note that Opinion Dynamics tested the model after data cleaning and found that the model results were robust to the cleaning steps. In other words, the model results showed stability even as we cleaned the data.

Table 9-18 shows a summary of the records and accounts that were removed.

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

| Drops Reason | Treatment | | | Control | | |
|---|---|---|---|---|---|---|
| | Observation Count | Customer Count | Percent Accounts Remaining | Observation Count | Customer Count | Percent Accounts Remaining |
| Total Program Participation: Customer Counts in Tracking Data | -- | 462,901 | 100% | -- | 71,305 | 100% |
| Keep Billing Data Customers in Enrollment File | 15,891,369 | 462,901 | 100% | 2,441,322 | 71,305 | 100% |
| Only 12 Months of Pre-Period | 10,730,073 | 462,901 | 100% | 1,611,883 | 71,305 | 100% |
| Remove Perfect Duplicate Observations | 10,725,458 | 462,901 | 100% | 1,611,250 | 71,305 | 100% |
| Zero Days in Billing Period | 9,726,016 | 462,901 | 100% | 1,479,756 | 71,305 | 100% |
| Billing Period > 90 days | 9,457,048 | 462,901 | 100% | 1,436,923 | 71,305 | 100% |
| Billing Period < 10 days | 9,422,267 | 462,901 | 100% | 1,431,385 | 71,305 | 100% |
| Less Than 9 Months in Pre-Period | 8,930,359 | 432,010 | 93% | 1,326,380 | 64,719 | 91% |
| Less Than 9 Months in Post-Period | 8,770,700 | 418,432 | 90% | 1,302,163 | 62,634 | 88% |
| Less Than or Equal to Zero Usage | 8,767,140 | 418,432 | 90% | 1,301,570 | 62,634 | 88% |
| NEM Customers | 8,766,973 | 418,424 | 90% | 1,301,484 | 62,630 | 88% |
| Inactive Dates - Observations | 8,741,561 | 418,424 | 90% | 1,297,753 | 62,630 | 88% |
| VIPs | 8,741,561 | 418,424 | 90% | 1,297,753 | 62,630 | 88% |
| Missing Usage Values | 8,741,561 | 418,424 | 90% | 1,297,753 | 62,630 | 88% |
| Super Savers | 8,741,561 | 418,424 | 90% | 1,297,753 | 62,630 | 88% |

| Drops Reason | Treatment | | | Control | | |
|---|---|---|---|---|---|---|
| | Observation Count | Customer Count | Percent Accounts Remaining | Observation Count | Customer Count | Percent Accounts Remaining |
| Control Customers with HERs | 8,741,561 | 418,424 | 90% | 1,297,753 | 62,630 | 88% |
| Move Outs/ Inactive Before 2019 | 8,741,561 | 418,424 | 90% | 1,297,753 | 62,630 | 88% |
| Insufficient Days in Summer Periods Pre/Post | 8,735,139 | 418,424 | 90% | 1,296,753 | 62,630 | 88% |
| High Usage Values | 8,733,167 | 418,424 | 90% | 1,296,395 | 62,630 | 88% |
| Overlapping Bills | 7,568,135 | 418,424 | 90% | 1,122,530 | 62,630 | 88% |
| Accounts Remaining to Use in Modeling | 7,568,135 | 418,424 | 90% | 1,122,530 | 62,630 | 88% |

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

Opinion Dynamics acquired daily weather data based on customers' zip codes from the National Oceanic and Atmospheric Administration (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 issues, usually by selecting the next best weather station if there were too many missing values for the originally assigned station. We 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 418,424 treatment and 62,630 control group customers, totaling 481,054. The analysis period covered 12 months before the experiment start dates, with distinct pre-periods for each cohort, and the post-period beginning in January 2019 and ending in December 2019.

## 9.7.3 HEM Program Estimation of Savings Using Consumption Analysis

### Attrition Analysis Results

Cohorts 1 and 2 experienced some attrition in 2019, as customers closed accounts or opted out. Table 9-19 shows the attrition rates for 2019 by cohort and reason for attrition, based on a review of the HEM program participant data. The overall attrition rate for Cohort 1 is 8.00% and 9.4% for Cohort 2, both driven mostly by customer move-outs. Overall, the total rate of attrition across cohorts in 2019 is 8.46%.

Table 9-19. 2019 HEM Program Attrition Rates by Cohort

| Cohort | Moved Out | Opted Out | Total Attrition |
|---|---|---|---|
| Cohort 1 | 7.86% | 0.15% | 8.00% |
| Cohort 2 | 9.23% | 0.19% | 9.40% |
| Both Cohorts | 8.31% | 0.16% | 8.46% |

## 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 Cohorts 1 and 2. The purpose of the equivalency analysis is 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.

Table 9-20shows the average daily consumption (ADC) by treatment and control groups for the modeling dataset both prior to data cleaning and after data cleaning. Figure 9-10 and Figure 9-11 compare the average daily consumption across each month for each cohort's pre-period for the final model dataset. The treatment and control groups are equivalent in both cohorts after data cleaning occurred.

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

| Cohort | Pre-Period | Pre-Period ADC (Pre Data Cleaning) | | Pre-Period ADC (Post Data Cleaning) | |
|---|---|---|---|---|---|
| | | Treatment | Control | Treatment | Control |
| Cohort 1 | September 2016 - August 2017 | 28.2 | 28.4 | 28.2 | 28.1 |
| Cohort 2 | August 2017 - September 2018 | 27.7 | 27.6 | 27.8 | 27.8 |

Figure 9-10. Pre-Period Average Daily Consumption, Cohort 1 Treatment vs. Control – Post Data Cleaning

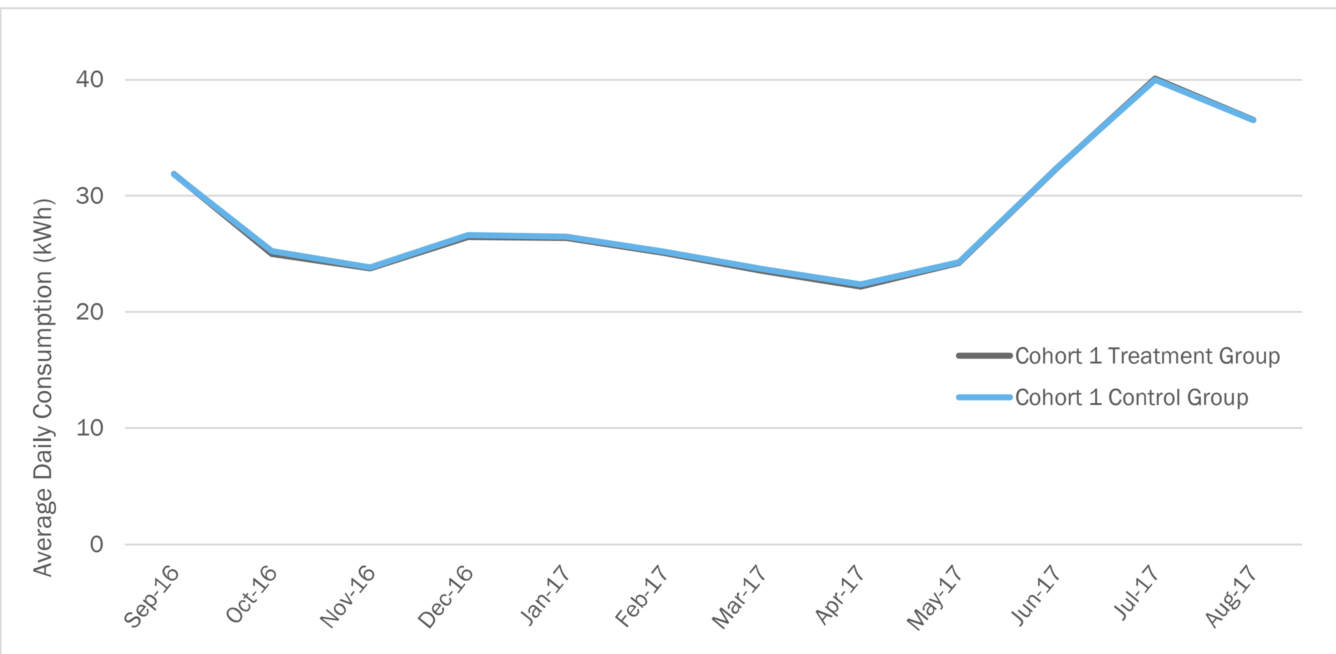
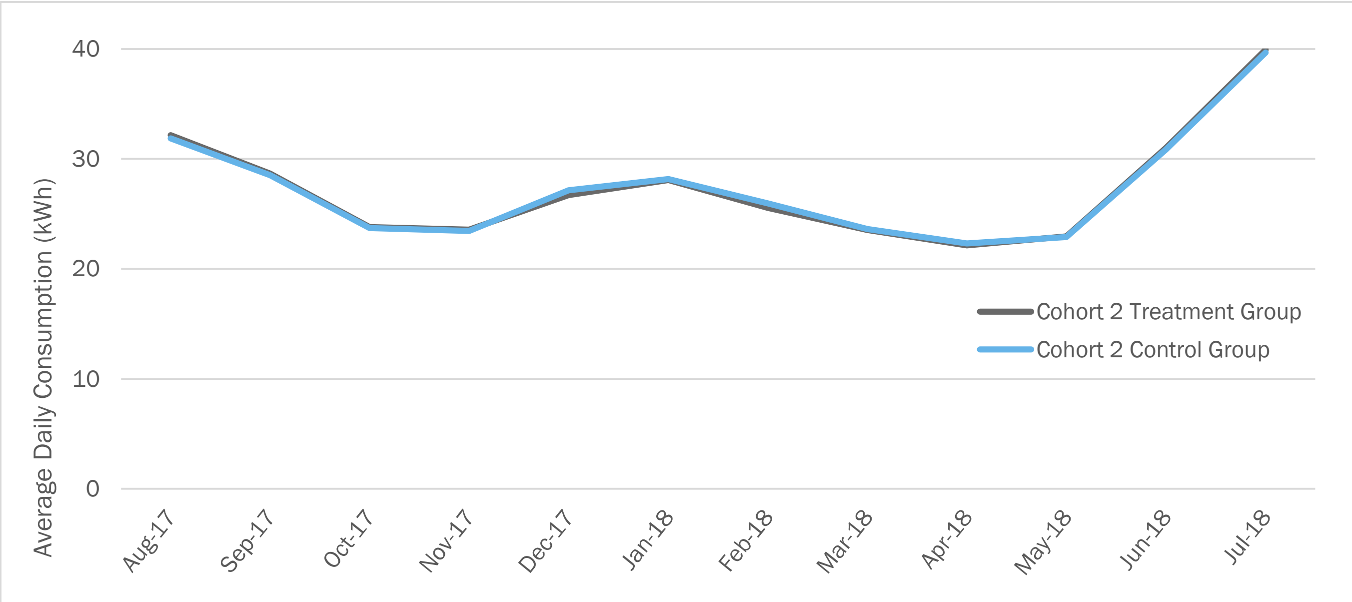


Figure 9-11. Pre-Period Average Daily Consumption, Cohort 2 Treatment vs. Control – Post Data Cleaning




## Statistical Method Used

Opinion Dynamics estimated a lagged dependent variable model that takes full advantage of the experimental design. It is based on a comparison of the post-period only between treatment and control groups but adds 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. Opinion Dynamics tested a range of models and controlled for exogenous variables such as pre-period ADC and weather. We selected the LDV model based on the best fit. Opinion Dynamics ran the LDV twice, once for Cohort 1 and once for Cohort 2. The $R^2$ for the Cohort 1 model was 73%, and $R^2$ the for the Cohort 2 model was 76%. The model is shown in the following equation. Note that our model results were robust across the various model specifications we ran.

Lagged Dependent Variable Model

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

Where:

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

$\alpha$ = Intercept

$\beta_1$ = Coefficient for the change in consumption for the treatment group

$\beta_2$ = Coefficient for the average daily usage across household i available pre-treatment meter reads

$\beta_3$ = Coefficient for the average daily usage over the months of December through March across household i available pre-treatment meter reads

$\beta_4$ = Coefficient for the average daily usage over the months of June through September across household i available pre-treatment meter reads

$\beta_5$ = Vector of coefficients for month-year dummies

$\beta_6$ = Vector of coefficients for month-year dummies by average daily pre-treatment usage

$\beta_7$ = Vector of coefficients for month-year dummies by average daily winter pre-treatment usage

$\beta_8$ = 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

$\varepsilon_{it}$ = Error term for household i at time t

## Savings Results

Below we present the results from the LDV model with estimated coefficients and standard errors.

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

| Cohort | Term | Estimate | Standard Error |
|---|---|---|---|
| Cohort 1 | (Intercept) | 1.57 | 0.04 |
| Cohort 1 | treat | -0.23 | 0.02 |
| Cohort 1 | pre_adc | 0.44 | 0.01 |
| Cohort 1 | pre_adc_win | 0.66 | 0.00 |
| Cohort 1 | pre_adc_summ | -0.15 | 0.00 |
| Cohort 1 | my022019 | -0.19 | 0.05 |
| Cohort 1 | my032019 | -0.07 | 0.05 |
| Cohort 1 | my042019 | 0.02 | 0.05 |
| Cohort 1 | my052019 | -0.42 | 0.05 |
| Cohort 1 | my062019 | -0.11 | 0.05 |
| Cohort 1 | my072019 | 2.66 | 0.05 |
| Cohort 1 | my082019 | 1.93 | 0.05 |
| Cohort 1 | my092019 | 0.61 | 0.05 |
| Cohort 1 | my102019 | 1.06 | 0.05 |
| Cohort 1 | my112019 | 0.86 | 0.05 |

| Cohort | Term | Estimate | Standard Error |
|---|---|---|---|
| Cohort 1 | my122019 | 0.62 | 0.07 |
| Cohort 1 | pre_adc:my022019 | 0.08 | 0.01 |
| Cohort 1 | pre_adc:my032019 | 0.17 | 0.01 |
| Cohort 1 | pre_adc:my042019 | 0.23 | 0.01 |
| Cohort 1 | pre_adc:my052019 | 0.48 | 0.01 |
| Cohort 1 | pre_adc:my062019 | 0.36 | 0.01 |
| Cohort 1 | pre_adc:my072019 | 0.46 | 0.01 |
| Cohort 1 | pre_adc:my082019 | 0.34 | 0.01 |
| Cohort 1 | pre_adc:my092019 | 0.35 | 0.01 |
| Cohort 1 | pre_adc:my102019 | 0.35 | 0.01 |
| Cohort 1 | pre_adc:my112019 | 0.18 | 0.01 |
| Cohort 1 | pre_adc:my122019 | 0.05 | 0.01 |
| Cohort 1 | pre_adc_win:my022019 | -0.05 | 0.00 |
| Cohort 1 | pre_adc_win:my032019 | -0.25 | 0.00 |
| Cohort 1 | pre_adc_win:my042019 | -0.55 | 0.00 |
| Cohort 1 | pre_adc_win:my052019 | -0.86 | 0.00 |
| Cohort 1 | pre_adc_win:my062019 | -0.94 | 0.00 |
| Cohort 1 | pre_adc_win:my072019 | -1.01 | 0.00 |
| Cohort 1 | pre_adc_win:my082019 | -0.95 | 0.00 |
| Cohort 1 | pre_adc_win:my092019 | -0.91 | 0.00 |
| Cohort 1 | pre_adc_win:my102019 | -0.78 | 0.00 |
| Cohort 1 | pre_adc_win:my112019 | -0.42 | 0.00 |
| Cohort 1 | pre_adc_win:my122019 | -0.20 | 0.01 |
| Cohort 1 | pre_adc_summ:my022019 | -0.05 | 0.00 |
| Cohort 1 | pre_adc_summ:my032019 | -0.03 | 0.00 |
| Cohort 1 | pre_adc_summ:my042019 | 0.06 | 0.00 |
| Cohort 1 | pre_adc_summ:my052019 | 0.21 | 0.00 |
| Cohort 1 | pre_adc_summ:my062019 | 0.55 | 0.00 |
| Cohort 1 | pre_adc_summ:my072019 | 0.77 | 0.00 |
| Cohort 1 | pre_adc_summ:my082019 | 0.68 | 0.00 |
| Cohort 1 | pre_adc_summ:my092019 | 0.47 | 0.00 |
| Cohort 1 | pre_adc_summ:my102019 | 0.21 | 0.00 |
| Cohort 1 | pre_adc_summ:my112019 | 0.05 | 0.00 |
| Cohort 1 | pre_adc_summ:my122019 | 0.04 | 0.01 |
| Cohort 2 | (Intercept) | 1.15 | 0.06 |
| Cohort 2 | treat | -0.13 | 0.02 |
| Cohort 2 | pre_adc | 0.28 | 0.01 |
| Cohort 2 | pre_adc_win | 0.73 | 0.00 |
| Cohort 2 | pre_adc_summ | -0.07 | 0.00 |
| Cohort 2 | my022019 | -0.07 | 0.08 |

| Cohort | Term | Estimate | Standard Error |
|---|---|---|---|
| Cohort 2 | my032019 | 0.31 | 0.08 |
| Cohort 2 | my042019 | 0.42 | 0.08 |
| Cohort 2 | my052019 | -0.38 | 0.08 |
| Cohort 2 | my062019 | -0.53 | 0.08 |
| Cohort 2 | my072019 | 1.21 | 0.08 |
| Cohort 2 | my082019 | 0.54 | 0.08 |
| Cohort 2 | my092019 | 0.23 | 0.08 |
| Cohort 2 | my102019 | 1.16 | 0.08 |
| Cohort 2 | my112019 | 1.19 | 0.08 |
| Cohort 2 | my122019 | 1.01 | 0.11 |
| Cohort 2 | pre_adc:my022019 | 0.00 | 0.01 |
| Cohort 2 | pre_adc:my032019 | 0.13 | 0.01 |
| Cohort 2 | pre_adc:my042019 | 0.28 | 0.01 |
| Cohort 2 | pre_adc:my052019 | 0.41 | 0.01 |
| Cohort 2 | pre_adc:my062019 | 0.55 | 0.01 |
| Cohort 2 | pre_adc:my072019 | 0.37 | 0.01 |
| Cohort 2 | pre_adc:my082019 | 0.49 | 0.01 |
| Cohort 2 | pre_adc:my092019 | 0.47 | 0.01 |
| Cohort 2 | pre_adc:my102019 | 0.36 | 0.01 |
| Cohort 2 | pre_adc:my112019 | 0.21 | 0.01 |
| Cohort 2 | pre_adc:my122019 | 0.16 | 0.01 |
| Cohort 2 | pre_adc_win:my022019 | -0.01 | 0.00 |
| Cohort 2 | pre_adc_win:my032019 | -0.24 | 0.00 |
| Cohort 2 | pre_adc_win:my042019 | -0.59 | 0.00 |
| Cohort 2 | pre_adc_win:my052019 | -0.81 | 0.00 |
| Cohort 2 | pre_adc_win:my062019 | -0.99 | 0.00 |
| Cohort 2 | pre_adc_win:my072019 | -0.95 | 0.00 |
| Cohort 2 | pre_adc_win:my082019 | -0.99 | 0.00 |
| Cohort 2 | pre_adc_win:my092019 | -0.95 | 0.00 |
| Cohort 2 | pre_adc_win:my102019 | -0.78 | 0.00 |
| Cohort 2 | pre_adc_win:my112019 | -0.42 | 0.00 |
| Cohort 2 | pre_adc_win:my122019 | -0.27 | 0.01 |
| Cohort 2 | pre_adc_summ:my022019 | -0.01 | 0.00 |
| Cohort 2 | pre_adc_summ:my032019 | -0.03 | 0.00 |
| Cohort 2 | pre_adc_summ:my042019 | 0.03 | 0.00 |
| Cohort 2 | pre_adc_summ:my052019 | 0.21 | 0.00 |
| Cohort 2 | pre_adc_summ:my062019 | 0.43 | 0.00 |
| Cohort 2 | pre_adc_summ:my072019 | 0.77 | 0.00 |
| Cohort 2 | pre_adc_summ:my082019 | 0.60 | 0.00 |
| Cohort 2 | pre_adc_summ:my092019 | 0.39 | 0.00 |

| Cohort | Term | Estimate | Standard Error |
|---|---|---|---|
| Cohort 2 | pre_adc_summ:my102019 | 0.19 | 0.00 |
| Cohort 2 | pre_adc_summ:my112019 | 0.03 | 0.00 |
| Cohort 2 | pre_adc_summ:my122019 | 0.00 | 0.01 |

Table 9-22 shows the summary of per-household savings for the two cohorts for 2019.

Table 9-22. 2019 HEM Unadjusted Per-Household Net Savings

| Cohort | Number of Customers Treated in 2019[a] | Unadjusted Savings (% per household) | Unadjusted Energy Savings (kWh per household)[b] | 90% Confidence Intervals Around Savings | P Value | Unadjusted Program Savings (MWh)[c] |
|---|---|---|---|---|---|---|
| Cohort 1 | 310,293 | 0.82% | 79.41 | 68.7 - 90.1 | 0.0 | 24,641 |
| Cohort 2 | 152,608 | 0.47% | 44.32 | 32.3 - 56.4 | 0.0 | 6,764 |
| Total | 462,901 | 0.70% | 67.84[d] | - | - | 31,405 |

[a] The number of customers whom PSEG Long Island selected to provide HERs and who received at least one monthly bill in 2019.
[b] The per-household, per-day savings multiplied by the average number of days that the participating households were in the HEM program in 2019.
[c] The program savings, just like the per household energy savings, are pro-rated by the average number of days that the participating households were in the HEM program in 2019.
[d] Represents the weighted average.

### 9.7.4 Joint Savings Analysis

Opinion Dynamics 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, we first determine whether there was participation uplift through the joint savings analysis. If so, then we deduct the double counted savings from the HEM program unadjusted ex post savings.

Opinion Dynamics compared the participation rates and ex post evaluated savings claimed between treatment and control groups by measuring differences in participation rates and average ex post evaluated 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 the participation rate, 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 2019 (e.g., an increase in participation in other energy efficiency programs in 2019 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.

Opinion Dynamics cross-referenced the HEM program database—both treatment and control groups—with the databases of other residential energy efficiency programs in 2019. We included five residential programs in our analysis for 2019:

- Home Comfort
- 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, we determined whether each customer in either a treatment or control group participated a statistically significantly greater amount in any other PSEG Long Island residential energy efficiency program during the 2019 program year due to HEM program treatment.

## Joint Savings Analysis Results

The evaluation team calculated participation rates claimed between treatment and control groups. Table 9-23 presents the participation uplift rate by program. In this case, we detected no statistically significant uplift, so we made no adjustment to the savings.

Table 9-23. Participation Uplift Rate by Program

| Cohort | Program | Control Group Post-Period Participation Rate | Treatment Group Post-Period Participation Rate | Post Only Difference | Statistically Significant |
|---|---|---|---|---|---|
| Cohort 1 | Home Comfort | 0.016007 | 0.0168389 | 0.000832 | no |
| Cohort 1 | EEP | 0.0522402 | 0.0514997 | -0.0007405 | no |
| Cohort 1 | HPDI | 0.0012394 | 0.0011119 | -0.0001276 | no |
| Cohort 1 | HPwES | 0.0041929 | 0.0039028 | -0.0002902 | no |

| Cohort | Program | Control Group Post-Period Participation Rate | Treatment Group Post-Period Participation Rate | Post Only Difference | Statistically Significant |
|---|---|---|---|---|---|
| Cohort 1 | REAP | 0.0046412 | 0.00515 | 0.0005087 | no |
| Cohort 2 | Home Comfort | 0.0137491 | 0.0144684 | 0.0007193 | no |
| Cohort 2 | EEP | 0.0479871 | 0.0481561 | 0.000169 | no |
| Cohort 2 | HPDI | 0.0014977 | 0.0015268 | 2.906E-05 | no |
| Cohort 2 | HPwES | 0.0051522 | 0.0050587 | -9.346E-05 | no |
| Cohort 2 | REAP | 0.0058711 | 0.0062775 | 0.0004064 | no |

Notes: Totals may not sum due to rounding.

The post-only difference statistic is obtained by subtracting the control group post-period HEM program participation rate from the treatment group post-period EE program participation rate.

# 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 | Component/Measure | Ex Ante – Calculated Program Values (all values calculated from gross and net values provided by the program) | | | Ex Post Values | | |
|---|---|---|---|---|---|---|---|
| | | FR | SO | NTGR | FR | SO | NTGR |
| Home Comfort | Traditional Split CAC Equipment (kW) | 10% | 0% | 90% | 48% | 0% | 52% |
| Home Comfort | Traditional Split CAC Equipment (kWh) | 10% | 0% | 90% | 48% | 0% | 52% |
| Home Comfort | Traditional Split CAC – QI (kW) | 10% | 0% | 90% | 0% | 49% | 149% |
| Home Comfort | Traditional Split CAC – QI (kWh) | 10% | 0% | 90% | 0% | 41% | 141% |
| Home Comfort | Traditional Split CAC – Total (kW) | 10% | 0% | 90% | * | * | 84% |
| Home Comfort | Traditional Split CAC – Total (kWh) | 10% | 0% | 90% | * | * | 65% |
| Home Comfort | GSHP (kW) | 0% | 0% | 100% | 0% | 0% | 100% |
| Home Comfort | GSHP (kWh) | 0% | 0% | 100% | 0% | 0% | 100% |
| Home Comfort | ASHP – Equipment (kW) | 10% | 0% | 90% | 10% | 0% | 90% |
| Home Comfort | ASHP – Equipment (kWh) | 10% | 0% | 90% | 10% | 0% | 90% |
| Home Comfort | ASHP – Quality Installation | 10% | 0% | 90% | 10% | 0% | 90% |
| Home Comfort | Ductless Mini-Split (kW) | 10% | 0% | 90% | 10% | 0% | 90% |
| Home Comfort | Ductless Mini-Split (kWh) | 10% | 0% | 90% | 10% | 0% | 90% |
| HPDI | Lighting (kW) | 0% | 0% | 100% | * | * | 52% |
| HPDI | Lighting (kWh) | 0% | 0% | 100% | * | * | 56% |
| HPDI | Non-Lighting (kW) | 0% | 0% | 100% | * | * | 103% |
| HPDI | Non-Lighting (kWh) | 0% | 0% | 100% | * | * | 107% |
| HPwES | All Measures (kW) | 0% | 0% | 100% | * | * | 74% |
| HPwES | All Measures (kWh) | 0% | 0% | 100% | * | * | 75% |
| EEP | ENERGY STAR Refrigerator | 20% | 10% | 90% | 20% | 10% | 90% |
| EEP | ENERGY STAR Dehumidifier | 30% | 15% | 85% | 67% | 0% | 33% |
| EEP | Solid State Lighting | 45% | 0% | 55% | * | * | 55% |
| EEP | Refrigerator Recycle | 48% | 0% | 52% | 52% | 0% | 48% |
| EEP | Pool Pumps | 20% | 10% | 90% | 20% | 10% | 90% |
| EEP | Smart Power Strips | 0% | 0% | 100% | 0% | 0% | 100% |
| EEP | Room A/C Recycle | 43% | 0% | 57% | 52% | 0% | 48% |
| EEP | Dehumidifier Recycle | 43% | 0% | 57% | 52% | 0% | 48% |
| EEP | Super-Efficient Dryer | 20% | 10% | 90% | 20% | 10% | 90% |
| EEP | ENERGY STAR Room Air Purifiers | 30% | 15% | 85% | 30% | 15% | 85% |
| EEP | Smart Thermostat | 23% | 0% | 77% | 23% | 0% | 77% |
| EEP | Dishwasher | 20% | 10% | 90% | 20% | 10% | 90% |

| Program | Component/Measure | Ex Ante – Calculated Program Values (all values calculated from gross and net values provided by the program) | | | Ex Post Values | | |
|---|---|---|---|---|---|---|---|
| | | FR | SO | NTGR | FR | SO | NTGR |
| EEP | Clothes Washer | 20% | 10% | 90% | * | * | 90% |
| EEP | Heat Pump Water Heater | 0% | 0% | 100% | * | * | 100% |
| REAP | All Measures (kW) | 0% | 0% | 100% | 0 | 0 | 100% |
| REAP | All Measures (kWh) | 0% | 0% | 100% | 0 | 0 | 100% |
| CEP - Custom | (kW) | * | * | 90% | 30% | 1.87% | 71.87% |
| CEP - Custom | (kWh) | * | * | 90% | 30% | 1.55% | 71.55% |
| CEP - Lighting | Exterior Lighting (kW) | * | * | 92% | 30% | 1.87% | 71.87% |
| CEP - Lighting | Exterior Lighting (kWh) | * | * | 92% | 30% | 1.55% | 71.55% |
| CEP - Lighting | Online Marketplace Lighting (kW) | * | * | 92% | 30% | 1.87% | 71.87% |
| CEP - Lighting | Online Marketplace Lighting (kWh) | * | * | 92% | 30% | 1.55% | 71.55% |
| CEP - Lighting | Comprehensive Lighting (kW) | * | * | 92% | 30% | 1.87% | 71.87% |
| CEP - Lighting | Comprehensive Lighting (kWh) | * | * | 92% | 30% | 1.55% | 71.55% |
| CEP - Lighting | Fast Track Lighting (kW) | * | * | 92% | 30% | 1.87% | 71.87% |
| CEP - Lighting | Fast Track Lighting (kWh) | * | * | 92% | 30% | 1.55% | 71.55% |
| CEP - Lighting | Prescriptive Lighting (kW) | * | * | 92% | 30% | 1.87% | 71.87% |
| CEP - Lighting | Prescriptive Lighting (kWh) | * | * | 92% | 30% | 1.55% | 71.55% |
| CEP - Non-Lighting | Online Marketplace Non-Lighting (kW) | * | * | 90% | 30% | 1.87% | 71.87% |
| CEP - Non-Lighting | Online Marketplace Non-Lighting (kWh) | * | * | 90% | 30% | 1.55% | 71.55% |
| CEP - Non-Lighting | HVAC (kW) | * | * | 90% | 30% | 1.87% | 71.87% |
| CEP - Non-Lighting | HVAC (kWh) | * | * | 90% | 30% | 1.55% | 71.55% |
| CEP - Non-Lighting | Compressed Air (kW) | * | * | 91% | 30% | 1.87% | 71.87% |
| CEP - Non-Lighting | Compressed Air (kWh) | * | * | 91% | 30% | 1.55% | 71.55% |
| CEP - Non-Lighting | Refrigeration (kW) | * | * | 100% | 30% | 1.87% | 71.87% |
| CEP - Non-Lighting | Refrigeration (kWh) | * | * | 100% | 30% | 1.55% | 71.55% |
| CEP - Non-Lighting | Refrigeration (vending) (kW) | * | * | 99% | 30% | 1.87% | 71.87% |
| CEP - Non-Lighting | Refrigeration (vending) (kWh) | * | * | 99% | 30% | 1.55% | 71.55% |
| CEP - Non-Lighting | Motors and VFDs (kW) | * | * | 64% | 30% | 1.87% | 71.87% |
| CEP - Non-Lighting | Motors and VFDs (kWh) | * | * | 64% | 30% | 1.55% | 71.55% |
| CEP - Non-Lighting | Building Envelope (kW) | * | * | 100% | 30% | 1.87% | 71.87% |
| CEP - Non-Lighting | Building Envelope (kWh) | * | * | 100% | 30% | 1.55% | 71.55% |
| CEP - Non-Lighting | Thermal Energy Storage (kW) | * | * | 100% | * | * | 100% |
| CEP - Non-Lighting | Thermal Energy Storage (kWh) | * | * | 100% | * | * | 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.

# Appendix B. 2019 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 2019 energy efficiency and renewable energy programs. This memorandum defines "verified ex ante" savings and presents the 2019 verified ex ante savings for each program.

## Definition of Verified Ex Ante

Beginning with the 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 2019, 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 2019 program year.

It should be noted that the verified ex ante savings presented below are not equivalent to the evaluated savings and ex post 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 2019 evaluated and ex post savings estimates for the 2019 program year are ongoing. The reported verified ex ante savings result from the evaluation team's efforts to verify that the ex ante savings claimed by each program are developed using methods (i.e., calculations, assumptions, and net-to-gross factors) that are consistent with those used in the planning and goal-setting process.

The table below summarizes our 2019 verified ex ante savings.

## Summary of 2019 Verified Ex Ante Savings and Goals[a]

| Program | 2019 Gross Savings Goals | | Ex Ante Gross Savings | | Verified Ex Ante Gross Savings | | Verified Ex Ante RR | |
|---|---|---|---|---|---|---|---|---|
| | MWh | MW | MWh | MW | MWh | MW | MWh | MW |
| **Total Commercial** | **95,953** | **19.78** | **98,720** | **17.59** | **97,743** | **17.81** | **99%** | **101%** |
| Energy Efficient Products | 130,599 | 34.08 | 159,804 | 42.95 | 159,809 | 42.95 | 100% | 100% |
| Home Comfort | 2,728 | 1.81 | 3,707 | 1.33 | 3,472 | 1.17 | 94% | 88% |
| Residential Energy Affordability Partnership | 1,472 | 0.32 | 1,475 | 0.41 | 1,472 | 0.36 | 100% | 87% |
| Home Performance[b] | 2,761 | 2.19 | 2,298 | 1.65 | 2,300 | 1.65 | 100% | 100% |
| Home Energy Management | 41,487 | N/A | 61,313 | N/A | 64,015 | N/A | 104% | N/A |
| **Total Residential** | **179,047** | **38.40** | **228,598** | **46.34** | **231,068** | **46.13** | **101%** | **100%** |
| **Energy Efficiency Total** | **275,000** | **58.18** | **327,318** | **63.93** | **328,811** | **63.94** | **100%** | **100%** |
| **Renewable Total** | **5,596** | **2.20** | **12,822** | **5.07** | **12,814** | **5.05** | **100%** | **100%** |

| Program | 2019 Gross Savings Goals | | Ex Ante Gross Savings | | Verified Ex Ante Gross Savings | | Verified Ex Ante RR | |
|---|---|---|---|---|---|---|---|---|
| | MWh | MW | MWh | MW | MWh | MW | MWh | MW |
| Total Portfolio | 280,596 | 60.38 | 340,140 | 69 | 341,625 | 68.99 | 100% | 100% |

Note: Values may not sum due to rounding.

[a] PSEG Long Island also claimed 2,360 MWh of savings from 'Dusk to Dawn Lighting' measures and 1,222 MWh of savings from LED bulbs given away as part of the 'Online Home Energy Analyzer' customer engagement tool. These savings were not included in the Energy Efficiency Plan for 2019, are not included in this verified ex ante analysis and the savings and goals presented in this table.

[b] Energy savings do not account for negative savings (increased electric use) associated with fuel switching measures, such as electric HVAC and DHW heat pumps that replace fossil fuel units.

## Commercial Efficiency Program (CEP)

The CEP had a 99% overall realization rate for energy savings and a 101% realization rate for demand savings. We identified several factors accounting for the differences between verified ex ante (VEA) and ex ante savings, as described below.

### Lighting

- The evaluation team found that the CEP Fast Track and Online Marketplace lighting components do not include waste heat factors (WHFs) in ex ante gross savings. In contrast, the Comprehensive lighting component does include WHFs in ex ante gross savings. The evaluation team includes WHFs in VEA savings. This increases VEA savings compared to ex ante savings. Additionally, VEA savings for the Fast Track lighting component reference hours of use from the NY TRM V6 while ex ante applies hours from an abridged list of building types, resulting in lower energy RRs for the Fast Track component.
- The evaluation team found one project in Captures that claimed zero ex ante savings at the project-level but had approximately 18 MWh of ex ante savings at the measure-level. This project was not included in the year-end monthly ex ante savings report, but the evaluation team did include these in the VEA, leading to an increase in lighting realization rates.

### Non-Lighting

- The evaluation team had insufficient planning information and Captures data to verify the ex-ante savings for refrigeration. We applied measure-specific RRs developed from refrigeration project desk reviews conducted during the 2018 evaluation.
- The evaluation team found five Cool Roof projects that did not apply the correct kWh/sf savings, leading to 93% realization rate for Cool Roof projects. Overall, Cool Roof discrepancies resulted in a slight decrease to Standard Non-Lighting VEA realization rates.

### Custom

- Verified savings for CEP 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 evaluation team did not perform any verification of 2019 custom projects.

## Energy Efficient Products (EEP)

Although the overall VEA realization rates for the EEP program are 100%, the evaluation team found slight differences in per-unit impact (PUI) assumptions applied in the Captures database than that used for annual planning for several measures. Additionally, the evaluation team found a minor difference in total measure counts between the Captures database and that reported as program ex ante savings. This difference was observed in only six measures where one more unit per measure was tracked in the Captures database than claimed in program ex ante savings. Both findings had minimal impact on program VEA savings as compared to claimed savings.

## Home Comfort

The evaluation team found that the greatest contributor to the 94% and 88% energy and demand realization rates is a misalignment between baseline efficiency values used to calculate ex ante savings and those used for program planning. These baseline efficiency misalignments include:

- Baseline EER values deviating from the planning assumption value of 11.76 for all Ground Source Heat Pump measures and a portion of Air Source Heat Pump Measures.
- Baseline SEER values deviating from the planning assumption value of 14.00 for all Ground Source Heat Pump measures and a portion of Air Source Heat Pump Measures.
- Baseline HSPF values deviating from the planning assumption value of 8.20 for all Ground Source Heat Pump measures.

In reviewing the program data in the Captures database, the evaluation team found instances of ex ante savings being claimed where units (quantities) are reported as zero. The evaluation team assigned zero savings to measures indicating zero claimed units.

- Additionally, the evaluation team identified several other misalignments of ex ante savings assumptions with the assumptions used for program planning. Applied EFLH heating and cooling values were misaligned with those of the planning documentation across all Heat Pump and Air Conditioner measures with the greatest effect on VEA realization rates for Ductless Minisplit Heat Pump measures. Other notable discrepancies between ex ante applied and planning assumptions include: misaligned CFs for Air Source Heat Pump and Ductless Minisplit Heat Pump measures, misaligned Quality Install (QI) factors for Central Air Conditioner and Air Source Heat Pump measures, and the misalignment of per unit energy savings for two Smart Thermostat measures.

## Residential Energy Affordability Partnership (REAP)

The 87% demand realization rate is primarily attributable to Room Air Conditioner measures utilizing a coincidence factor of 0.8 in ex-ante savings calculations, as recorded in the Captures database, in contrast to the 0.3 coincidence factor value reflected in planning documentation. For LED nightlight measures, the evaluation team manually adjusted the efficient wattage of the nightlights to 0.3 (from 0), as indicated in the measure name. Planning assumptions were unavailable for nightlights, so the evaluation team relied on tracking data to define the preexisting wattages, leading to a low VEA realization rate for this measure. Additionally, the evaluation team found that the planning PUI assumptions were not appropriately applied for dehumidifiers and refrigerators in the Captures database; however, this difference has minimal impact on the realization rate.

## Home Performance Programs

The evaluation team was unable to perform comprehensive VEA savings for Home Performance with Energy Star projects due to limited visibility into the program contractors' building energy modeling 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 LEDs to estimate the VEA. For the Home Performance Direct Install program, the evaluation team made two adjustments having a minimal impact on savings. A slight rounding discrepancy in ex ante demand PUI savings was found for Advanced Power Strip Measures in addition to an adjustment to LED nightlight measure efficient wattage values, which is consistent with the adjustment made for the REAP program.

## Home Energy Management

The evaluation team used the deemed savings planning assumption of 29.42 kWh per mailed home energy report and applied this to the total number of HEM reports mailed in 2019. Because there were no overlapping participants between the HEM and Super Saver programs, there was no need to exclude cross-participants. This analysis resulted in 2,175,667 reports attributed to the HEM for the VEA, compared to 2,216,826 claimed (ex ante) reports.

## Solar PV

The overall VEA realization rates for energy and demand savings are both very close to 100%. The performance test conditions calculation for one project did not match the value reported in the program's monthly report. This is the only instance of a mismatch and it has minimal impact on the overall VEA realization rates.

# Appendix C. Glossary of Terms

| | |
|---|---|
| AC | Air Conditioner |
| AC | Alternating Current |
| ADC | Average Daily Consumption |
| AHRI | The Air Conditioning, Heating, and Refrigeration Institute |
| AIC | Akaike Information Criterion |
| AMI | Advanced Metering Infrastructure |
| ASHP | Air-Source Heat Pump |
| ASHRAE | American Society of Heating, Refrigerating, and Air-Conditioning Engineers |
| ATT | Average Treatment Effect on the Treated |
| BPI | Building Performance Institute |
| BTU | British Thermal Unit |
| CAC | Central Air Conditioner |
| CDD | Cooling Degree Day |
| CEER | Combined Energy Efficiency Ratio |
| CEP | Commercial Efficiency Program |
| CF | Coincidence Factor |
| CHP | Combined Heat and Power |
| DC | Direct Current |
| DHW | Domestic Hot Water |
| DOE | U.S. Department of Energy |
| EEP | Energy Efficiency Products |
| EER | Energy Efficiency Ratio |
| EFLH | Equivalent Full-Load Hours |
| EISA | Energy Independence and Security Act |
| ESF | Energy Savings Factor |
| ESH | Electric Space Heat |
| FR | Free Ridership |
| GPM | Gallons per Minute |
| GSHP | Ground Source Heat Pump |
| HDD | Heating Degree Day |
| HEA | Home Energy Assessment |
| HEM | Home Energy Management |
| HER | Home Energy Report |
| HOU | Hours of Use |
| HPDI | Home Performance Direct Install |
| HPwES | Home Performance with ENERGY STAR |
| HSPF | Heating Seasonal Performance Factor |
| HVAC | Heating, Ventilation, and Air Conditioning |
| IECC | International Energy Conservation Code |
| ISR | In-Service-Rate |

| | |
|---|---|
| ITT | Intention-to-Treat |
| KPI | Key Performance Indicator |
| kW | Kilowatt |
| kWh | Kilowatt Hour |
| LDV | Lagged Dependent Variable |
| LED | Light-Emitting Diode |
| LEED | Leadership in Energy and Environmental Design |
| LFER | One-Way Linear Fixed Effects Regression |
| LIPA | Long Island Power Authority |
| LM | Lockheed Martin |
| M&V | Measurement and Verification |
| NCDC | National Climatic Data Center |
| NEEP | Northeast Energy Efficiency Partnerships Inc. |
| NOAA | National Oceanic and Atmospheric Administration |
| NEB | Non-Energy Benefit |
| NTC | National Theater for Children |
| NTGR | Net-to-Gross Ratio |
| NYSERDA | New York State Energy Research and Development Authority |
| PEP | Prime Efficiency Partners |
| POD | Post-Only Difference |
| PTC | Performance Test Condition |
| PUI | Per-Unit Impact |
| PV | Photovoltaic |
| QI | Quality Installations |
| RAC | Room Air Conditioner |
| RCT | Randomized Control Trial |
| REAP | Residential Energy Affordability Partnership |
| SCT | Societal Cost Test |
| SD | Standard Deviation |
| SEER | Seasonal Energy Efficiency Ratio |
| SIR | Standardized Interconnection Requirements |
| SO | Spillover |
| TRM | Technical Reference Manual |
| UCT | Utility Cost Test |
| UMP | Uniform Methods Project |
| VDER | Value of Distributed Energy Resources |
| VEA | Verified Ex Ante |
| VFD | Variable Frequency Drives |
| WEF | Weighted Energy Factors |

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