REPORT

Evaluation of PSEG Long Island Energy Efficiency Programs

Prepared for PSEG Long Island

By Demand Side Analytics, LLC
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GLOSSARY

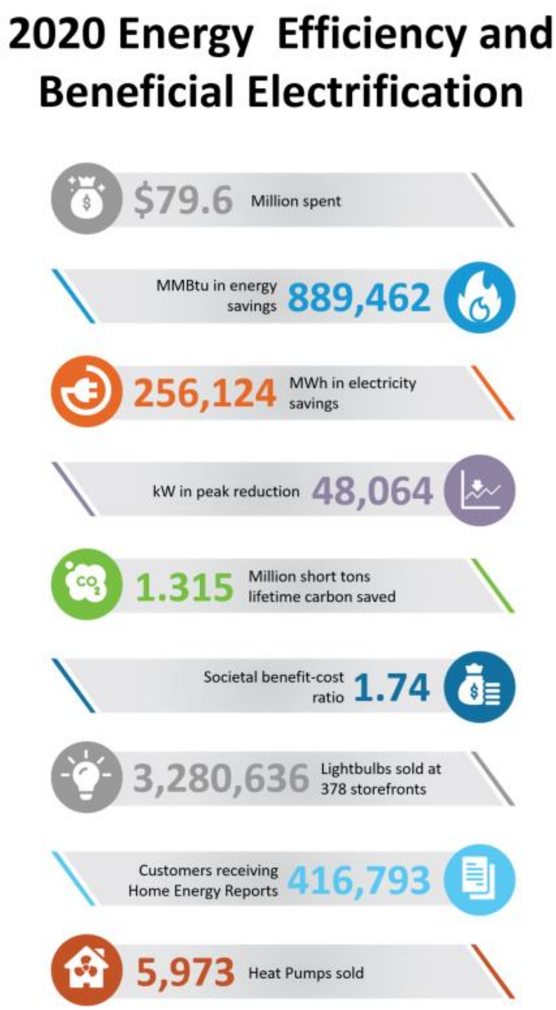
Key Term	Definition
Delta kWh	The total change in annual electric energy consumption. Equal to $kWh_{ee} - kWh_{be}$. A negative value of Delta kWh indicates the measure or program increases electric consumption on the PSEG Long Island system as a whole. A positive value of Delta kWh indicates the measure or program reduces electric consumption on the PSEG Long Island system.
Discount Rate	The time value of money is used to calculate the present value of future benefits and costs. 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 service territory's future supply needs. Based on these factors, we used a nominal discount rate of 6.16% in the 2020 evaluation.
Ex-Ante Gross Savings	The energy and demand savings recorded by the implementation contractor in the program tracking database. Ex-ante gross savings are sometimes referred to as claimed savings.
Ex-Post Gross Savings	The energy and demand savings estimated by the evaluation team, using the best methods and data available at the time of the evaluation.
Ex-Post Net Savings	The savings realized by the program after independent evaluation determines ex-post gross savings and applies NTGRs. 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.
Gross Impacts	The change in energy consumption or demand directly due to the participants' program-related actions, 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.
kW (Demand or Capacity)	The reduction in demand coincident with system peaking conditions due to energy efficiency measures. For Long Island, system peaking conditions typically occur on non-holiday summer weekdays. This report's peak demand savings values are based on system coincident demand impacts between 4 pm and 5 pm on non-holiday weekdays from June to August.
kWh Beneficial Electrification (kWh_{be})	The increase in weather-normalized annual electric energy consumption attributable to beneficial electrification measures.
kWh Energy Efficiency (kWh_{ee})	The reduction in weather-normalized annual electric energy consumption attributable to energy efficiency programs or measures.

Key Term	Definition
Levelized Cost of Capacity	To operate the electric grid, the system operator needs installed, operable capacity to meet peak demand conditions. The levelized cost of capacity is a metric that allows planners to compare the costs of different resources to meet (or lower) peak demand. The metric is typically expressed in terms of $kW/year.
Levelized Cost of Energy	The equivalent cost of energy (kWh) over the life of the equipment that yields the same present value of costs, using a nominal discount rate of 6.16%. The levelized cost of energy is a measure of the program administrator's program costs in a form that planners can compare to the cost of supply additions.
Line Loss Factor	The evaluation team applies line losses of 6.0% on energy consumption (resulting in a multiplier of 1.0638 = [1 ÷ (1 – 0.060)]) and of 8.5% on peak demand (resulting in a multiplier of 1.0929 = [1 ÷ (1 – 0.085)]) to estimate energy and demand savings at the power plant.
MMBtu Beneficial Electrification ($MMBtu_{be}$)	For fuel-switching measures, the reduction in site-level fossil fuel consumption minus the site level increase in the electric consumption (kWh_{be}) converted to MMBtu at 0.003412 MMBtu per kWh.
MMBtu Energy Efficiency ($MMBtu_{ee}$)	The reduction in site-level energy consumption due to energy efficiency expressed on a common MMBtu basis. $MMBtu_{ee}$ impacts are calculated by multiplying the kWh_{ee} impacts by a static 0.003412 MMBtu per kWh conversion factor and adding any fossil fuel conservation attributable to the measure. Secondary fossil fuel impacts, such as the waste heat penalty associated with LED lighting, are also deducted from the $MMBtu_{ee}$ estimates.
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) and line losses. 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 impacts are used for cost-effectiveness analysis.
Net-to-Gross Ratio (Free-Ridership and Spillover)	The factor that, when multiplied by the gross impacts, provides the net impacts for a program before any adjustments for line losses. The NTGR is defined as the savings attributable to programmatic activity after accounting for free-ridership (FR) and spillover (SO). Free ridership reduces the ratio to account for those customers who would have installed an energy-efficient measure without a program. The free ridership component of the NTGR can be viewed as a measure of naturally occurring energy efficiency. Spillover increases the NTGR to account for non-participants who install energy-efficient measures or reduce energy use 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
Realization Rate	The ratio of ex-post gross to ex-ante gross impacts. This metric expresses the evaluation savings as a percentage of ex-ante savings claimed by PSEG Long Island or the implementation contractor. The Home Energy Management program is

Key Term	Definition
	implemented by Uplight on behalf of PSEG Long Island. TRC and its subcontractors implement the remainder of the portfolio.
Societal Cost Test (SCT)	A test that measures an energy efficiency program's net costs as a resource option based on benefits and costs to New York. 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.
Technical Reference Manual (TRM)	A collection of algorithms and assumptions used to calculate resource impacts of PSEG Long Island's Energy Efficiency Portfolio. The PSEG Long Island TRM aligns with the New York State TRM in many respects but includes Long Island specific parameters and assumptions where available from saturation studies or prior evaluation research.
Total MMBtu	The primary performance metric for 2020. Equal to the sum of $MMBtu_{be}$ and $MMBtu_{ee}$. This metric represents the change in site-level fuel consumption attributable to the measure or program. This metric does not consider the amount of MMBtu required to generate a kWh of electricity – only the embedded energy in the delivered energy.
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.
Verified Ex-Ante Gross Savings	A key question is if the ex-ante gross energy impacts claimed by the implementation contractors were calculated consistently using the calculations and assumptions approved by PSEG Long Island and LIPA and used to develop annual savings goals. To verify claimed savings, the evaluation team independently calculates the saving using the calculations and assumptions pre-approved by PSEG Long Island. These savings estimates are used to determine if PSEG Long Island achieves its annual scorecard goals.

1 INTRODUCTION

PSEG Long Island's Energy Efficiency programs make a wide array of incentives, rebates, and programs available to PSEG Long Island residential and commercial customers to assist them in reducing their energy usage and thereby lowering their energy bills. The Energy Efficiency and Beneficial Electrification Portfolio is administered by PSEG Long Island and its subcontractor, TRC, on behalf of the Long Island Power Authority (LIPA). The sole exception is the residential behavioral program, Home Energy Management (HEM), which is administered by Uplight. This report presents the 2020 Energy Efficiency and Beneficial Electrification Portfolio program evaluation results and covers the period from January 1, 2020, to December 31, 2020.



The Demand Side Analytics evaluation team produced two volumes that together compose the entire Annual Evaluation Report. This document, the 2020 Annual Evaluation Report (Volume I), provides an overview of the portfolio-level evaluation findings. The 2020 Program Guidance Document (Volume II) provides detailed program-by-program impact analysis results, process evaluation findings, and a discussion of data collection and analytic methods.

For 2020, PSEG Long Island spent $79.6 million implementing the Energy Efficiency and Beneficial Electrification Portfolio. The investment led to 889,462 of total MMBtu savings and avoided 1.315 million short tons of CO2 emissions – the equivalent of removing 255,000 combustion engine cars for a year.[1] PSEG Long Island's efforts led to $55 million in net societal benefits, with a societal benefit cost ratio of 1.74. Overall, the 2020 activities reduced the Long Island's electricity use by 1.27% and peak demand by 0.91%.

As part of its overall goal of reducing GHG emissions by 40% by 2030, New York set new statewide energy efficiency targets as part of its New Efficiency New York (NENY) Order in 2018. The New York goals establish savings targets on an energy (Btu) basis for New York State as a whole and Long Island. By laying out these targets, New York established fuel-

[1] The EPA estimates 4.6 metric tons of carbon per vehicle-year, the equivalent of 5.15 short tons per vehicle-year. See: https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references

neutral metrics to incorporate beneficial electrification in the building and transportation sectors, which is necessary to achieve the State's carbon reduction goals. In response, PSEG Long Island:

- **Included beneficial electrification measures in its offerings**. PSEG Long Island expanded energy efficiency programs to include rebates and incentives for customers to install measures that supply beneficial electrification to the grid, such as heat pumps, and allow customers to save on their fossil fuel-based costs. Adopting fuel-neutral savings targets allows PSEG Long Island to aggregate efficiency achievements across electricity, natural gas, and delivered fuels such as oil and propane, which in turn shifts investment towards more non-lighting opportunities.
- **Changed its primary performance metric from electric energy (kWh) and peak demand (kW) to MMBtu.** The switch allows PSEG Long Island to pursue beneficial electrification measures like heat pumps that increase electric consumption but lower overall energy consumption and emissions. The MMBtu performance metric is "MMBtu at the site" meaning saved or increased kWh is converted to MMBtu using a static factor of 0.003412 MMBtu per kWh - the thermal efficiency of the electric power generation fleet does not affect the calculations. The lack of algorithms tailored for MMBtu was a key challenge in planning for 2020. Many of the changes had to be built from the bottom up in short time. The transition was overall quite successful, and most of the variation between ex-ante and ex-post evaluated savings are attributable to this fundamental shift in resource accounting.

PSEG Long Island was the first utility in New York to shift to a MMBtu performance metric and one of the first utilities in the U.S. to do so. The shift placed beneficial electrification on par with energy efficiency. When 2020 activities were planned, guidance documents and algorithms were not available to PSEG Long Island.

Energy efficiency programs undergo a yearly cycle including planning, implementation, audit and verifications, evaluation, and cost-effectiveness. At each stage, the term "energy savings" is used, leading to the need to be precise about the type of savings. Figure 1-1 below shows the energy efficiency cycle, the main objectives at each step, and the key terms. Because energy efficiency has a unique lexicon, we include a comprehensive glossary with definitions immediately after the Table of Contents and encourage readers who are less familiar with the key terms to review them.

The planning activities for 2020 were conducted in 2019 and set the goals, rules, and algorithms for calculating energy savings. Because PSEG Long Island was the first utility to shift to a MMBtu performance metric, in 2019, statewide guidance documents for MMBtu impacts did not exist. On its own, PSEG Long Island developed the algorithms and assumptions required to estimate the MMBtu resource impacts of energy efficiency and beneficial electrification. The shift in metrics required PSEG Long Island to change it planning, tracking, and reporting infrastructure, and update its key performance indicators. The 2020 activities were evaluated nearly two years after planning occurred.

Figure 1-1: Energy Efficiency Cycle, Objectives, and Key Terms

	Planning	Implementation	Audit & Verification	Evaluation	Cost-Effectiveness
Objective	Set goals for future years and set rules for how savings will be calculated for settlement with implementer	Recruit participants, maximize energy savings, and track activities	Determine if the Implementer used the assumptions and calculations pre-approved by PSEG Long Island	Produce the best after-the-fact estimate of savings delivered using the best methods and data available.	Assess if the portfolio of energy efficiency activities was cost-effective from a (New York) societal perspective using Ex-Post Net savings
Timeline	• **Spring 2019**: Planning for 2020 using draft 2020 TRM assumptions.	• **2020**: Portfolio Programs implemented	• **January 2021**: Verified Ex-Ante Savings Calculated using assumptions from 2019	• **Spring 2021**: Ex-Post evaluation of 2020 portfolio using most up-to-date methods (including PSEG-LI TRMs 2019-2021, NYS TRMs v7 and v8)	• **Spring 2021**: Using Ex-Post Net evaluation values
Key terms	• Planned Savings • Technical Resource Manual (TRM)	• Gross Ex-ante Savings (Claimed Savings)	• Verified Ex-Ante Savings	• Ex-post Gross Savings • Ex-Post Net Savings • Realization Rate • Net-to-Gross Ratio (NTGR)	• Societal Cost Test (SCT) • Utility Cost Test (UCT) • Levelized Cost of Energy • Levelized Cost of Capacity

A notable event in 2020 was the COVID-19 pandemic. It affected all aspects of life during 2020 and PSEG Long Island's energy efficiency and beneficial electrification portfolio was no exception. New York was among the country's hardest hit areas during the first wave of the pandemic in spring 2020 and the state was under comprehensive stay-at-home orders for several months. In March, PSEG Long Island paused all residential and commercial onsite work and did not resume any onsite activities until the summer. Implementation contractors were forced to adapt program processes to accommodate virtual audits and inspections. Despite the significant disruptions to program delivery, PSEG Long Island showed strong performance compared to goals.

In 2020, PSEG Long Island administered six programs, described in Table 1-1.

Table 1-1: Energy Efficiency and Beneficial Electrification Program Descriptions

Program	Description
Commercial Efficiency Program	The program assists non-residential customers in saving energy by offering customers rebates and incentives to install energy conservation measures as well as beneficial electrification measures. In addition, Technical Assistance rebates are available under the CEP to offset the cost of engineering and design services for qualifying projects.
Energy Efficient Products (Residential)	The program's objective is to increase the purchase and use of energy-efficient appliances and lighting among PSEG Long Island residential customers. The program provides rebates or incentives for ENERGY STAR® certified lighting and appliances through upstream and downstream promotions. This program also supported Beneficial Electrification measures in 2020 such as Battery-Operated

Program	Description
	Lawn Equipment. The program supports the stocking, sale, and promotion of efficient residential products at retail locations.
Home Energy Management (Residential)	Home energy reports are behavioral interventions designed to encourage energy conservation by leveraging behavioral psychology and social norms. The paper or electronic reports compare a customer's energy consumption to similar neighboring households and provide targeted tips on reducing energy use.
Home Comfort (Residential)	The Residential "Home Comfort" HVAC program, formerly the Cool Homes Program, aims to reduce the energy usage of residential customers with heat pumps. The program seeks to influence PSEG Long Island customers to make high-efficiency choices when purchasing and installing ENERGY STAR ducted air-source heat pumps (ASHP), ductless mini split heat pumps, and ground source heat pumps (GSHP). Using a single application for all measures (heat pumps and weatherization), the Program seeks to promote Whole House solutions. The program has established strong business partnerships with heating and cooling contractors, manufacturers, and program support contractors.
Home Performance (Residential)	The program has two main branches: Home Performance with ENERGY STAR® and Home Performance Direct Install. The goal of the Home Performance with ENERGY STAR® Program (HPwES) is to reduce the carbon footprint of customers who utilize gas, oil, or propane as a primary heat source. The Home Performance Direct Install targets customers with electric heating and includes an energy assessment and select free efficiency upgrades. After the free direct install measures are delivered, customers receive a free home energy assessment and are eligible for HPwES rebates.
Residential Energy Affordability Partnership (Residential)	The program is designed for income-eligible customers and aims to save energy, provide education, help participants reduce electric bills, and make their homes healthier and safer. This program encourages whole-house improvements to existing homes by promoting home energy surveys and comprehensive home assessment services identifying potential efficiency improvements at no cost to the customer.

1.1 PORTFOLIO ENERGY SAVINGS AND PERFORMANCE

Figure 1-2 compares planned, claimed, verified, and ex-post gross and net savings under the primary performance metric, MMBtu. A few observations stand out. The claimed and verified ex-ante values exceeded planning targets. Implementation contractor performance is best judged using the verified ex-ante metric. The evaluation team independently verified that the main contractor, TRC, calculated the savings consistently with the algorithms and assumptions used for planning. However, the goals, rules, and algorithms for calculating energy savings were developing in spring of 2019, during the infancy of MMBtu goals in New York, and before the 2019 evaluation results were available. The ex-post evaluation results are lower, 86% of the goal, because of a small number of overstated planning assumptions that PSEG has since identified and updated.

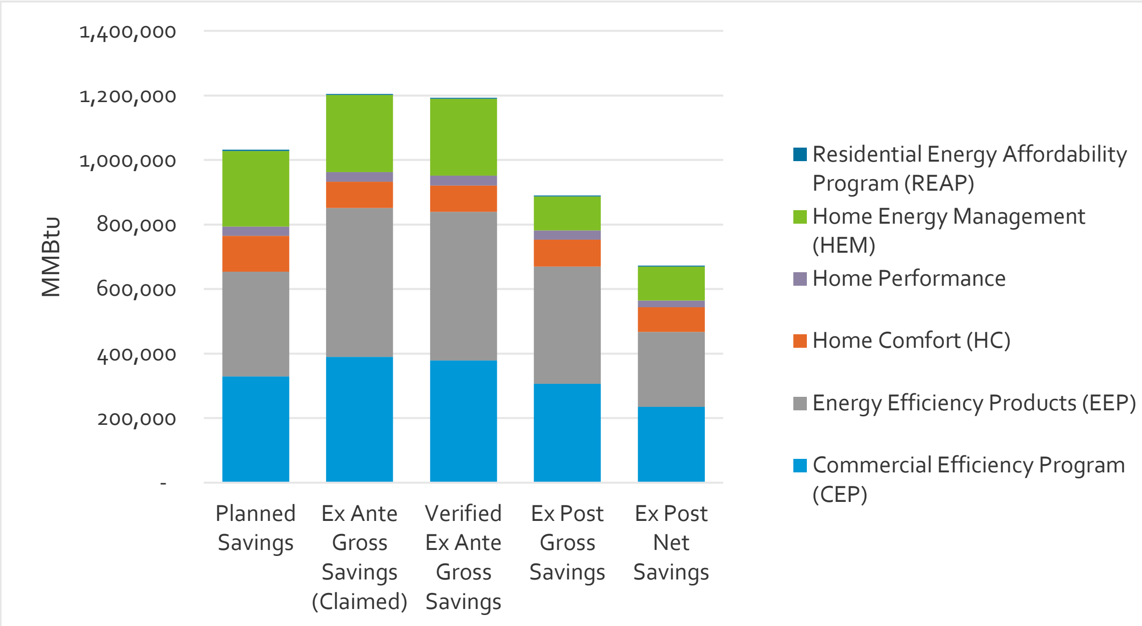
Table 1-2: Summary of 2020 Energy Program Performance

Sector	Program	Planned Savings (Goals)	Ex-Ante Gross Savings (Claimed)	Verified Ex-Ante Gross Savings	Ex-Post Gross Savings (Evaluated)	Ex-Post Net Savings
		MMBtu	MMBtu	MMBtu	MMBtu	MMBtu
Commercial	Commercial Efficiency Program (CEP)[1]	329,232	390,069	378,438	306,343	235,044
Residential	Energy Efficiency Products (EEP)	324,990	460,988	461,136	363,522	231,890
	Home Comfort (HC)	111,021	81,264	81,266	83,487	76,546
	Home Performance	28,387	30,247	30,260	28,329	21,259
	Home Energy Management (HEM)	233,883	238,507	238,507	105,204	105,204
	Residential Energy Affordability Program (REAP)	3,903	3,038	3,048	2,577	2,577
	Subtotal Commercial:	329,232	390,069	378,438	306,343	235,044
	Subtotal Residential:	702,184	814,044	814,217	583,119	437,476
	Total Portfolio:	1,031,416	1,204,113	1,192,655	889,462	672,520

[1] CEP includes a fuel cell project initiated in 2019 before PSEG Long Island ended support of on-site generation projects. Planned and ex-ante savings for the fuel cell project reflect a simple conversion of electricity produced to MMBtu at 0.003412 MMBtu per kWh. Ex-post savings take into account the increased natural gas use at the facility and the heat rate of the grid and represent the total MMBtu impact "at source". The ex-ante gross savings for the fuel cell project was 49,031 MMBtu and the ex-post gross savings was 55,732 MMBtu (realization rate = 114%). For all other measures in Table 1-2, the MMBtu savings are "at site"

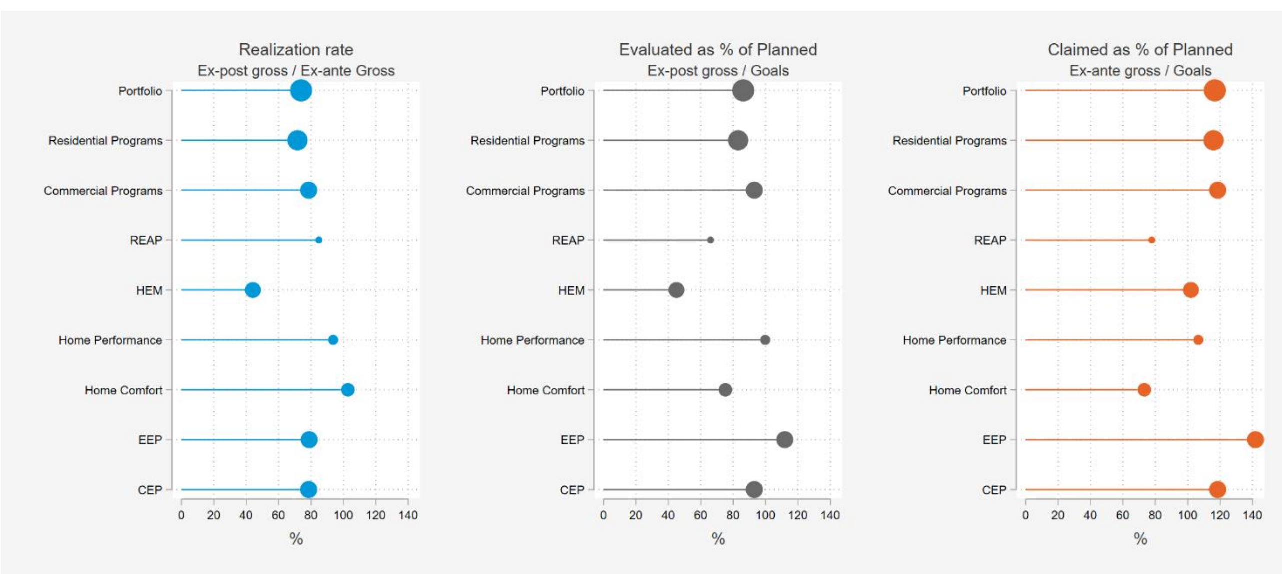
Figure 1-2 and Figure 1-3 visualize the program performance. Because the goals are based on MMBtu gross savings, the appropriate comparisons are between MMBtu planned, claimed, and evaluated gross savings. Each program section provides the energy (MWh) and demand (kW) savings to facilitate comparison with prior years. We caution that measures that reduce fossil fuel use, such as heat pumps and heat pump water heaters, can increase electricity consumption and peak demand (MW) metrics.

Figure 1-2: Portfolio MMBtu Savings



The ex-post results are driven by a handful of measures in the three most prominent programs, Energy Efficient Product (EEP), Commercial Efficiency Program (CEP), and Home Energy Management (HEM), which were identified and resolved in advance of the evaluation report. Figure 1-3 visualizes how evaluated results compare to claimed savings (the Realization Rate), how evaluated savings compare to planned savings, and how claimed savings compare to planned savings. The size of the circle in the plots is scaled based on the goals for the program.

Figure 1-3: Portfolio Performance Metrics



As Figure 1-3 shows, the biggest driver of the gap between claimed and ex-post gross savings are the results for the behavioral program, HEM. The HEM program was a relatively new offering when planning for 2020 occurred in spring of 2019. At the time, PSEG Long Island assumed savings would mature to 1.5% of household annual energy use, consistent with other utilities in the area. The 2019 evaluation indicated the savings were lower than expected, 0.7% of annual consumption, but by the time the evaluation results were available, the 2020 program year planning assumptions had been cemented nine months earlier. For EEP, the main driver for differences between claimed and ex-post evaluated results are heat pump pool heaters, a new electrification measure at the time. For CEP, the gap between claimed and ex-post gross (evaluated) saving is the application of waste heat factors, an issue arising due to the shift from electricity (MWh) and peak demand (kW) metrics to MMBtu.

Table 1-3 summarizes the primary reasons as to why portfolio ex-post gross (evaluated) savings departed from the planned and claimed savings. These five items almost entirely account for the 314,651 MMBtu difference between ex-ante gross and ex-post gross portfolio savings shown in Table 1-2. As noted earlier, the change in the primary performance metric from electric energy (kWh) and peak demand (kW) to MMBtu required significant modifications to PSEG Long Island's planning, tracking, and reporting infrastructure. Except for HEM, most of the differences between claimed and evaluated savings for EEP and CEP are linked to the transition to the MMBtu metric and were identified and resolved in advance of the evaluation.

Table 1-3: Summary of Differences between Ex-Ante and Ex-Post Savings

Portfolio Component	Difference Between Ex-Ante Gross and Ex-Post MMBtu Savings	Summary of Savings Difference
Home Energy Management	▪ Ex-post gross < ex-ante gross ▪ 133,303 MMBtu difference ▪ 44.1% realization rate	▪ In planning, PSEG Long Island assumed saving would mature to 1.5% of household annual energy use. ▪ Ex-post savings were 0.7% of annual consumption, consistent with the 2019 evaluation results, and lower than most behavioral programs. ▪ 2020 planning assumptions were established before the 2019 evaluation results were available. 2021 planning assumptions assume a reduced per-home savings for HEM.
CEP Comprehensive and Fast Track Lighting Calculations	▪ Ex-post gross < ex-ante gross ▪ ~ 90,000 MMBtu ▪ Primary driver of 71% MMBtu realization rate	▪ LED lighting equipment produces less waste heat than traditional lighting technologies. These HVAC interactive effects reduce cooling load in the summer and increase heating consumption in the winter.

Portfolio Component	Difference Between Ex-Ante Gross and Ex-Post MMBtu Savings	Summary of Savings Difference
		▪ The ex-ante savings calculations account for waste heat impacts on cooling consumption and electric heating systems, but do not account for increased fossil fuel heating consumption. ▪ Our ex-post savings calculations leverage the HVAC interactive assumptions developed by the evaluation team to estimate the fossil fuel heating increases and incorporate these increases into the final MMBtu totals. ▪ Fossil fuel interactive effects were not included in the 2020 PSEG Long Island TRM or 2020 planning assumptions, so this variance only appears in the ex-post results and not the verified ex-ante totals.
EEP - Heat Pump Pool Heaters	▪ Ex-post gross < ex-ante gross ▪ 80,336 MMBtu difference ▪ 37% MMBtu realization rate	▪ In 2020 planning assumptions, electric baseline pool heaters were assumed to deliver ten times more heat to the pool water than the HPPH. Standardizing the algorithm assumptions about heat load lowers the baseline electric use significantly. This variance only appears in the ex-post results and not the verified ex-ante totals. ▪ Unless there is a mid-year correction, we expect the 2021 evaluation will show the same variance between ex-ante and ex-post as the 2020 evaluation. The realization rate volatility from this evaluation should lessen considerably in 2022 once planning assumptions are aligned with the PSEG Long Island TRM. ▪ Ex-post evaluation results use a federal standard baseline efficiency (82%) for beneficial electrification installations. This change increases the MMBtu savings slightly. ▪ The actual efficiency of HPPH rebated in 2020 was higher than planning assumptions (COP = 5.98 versus 5.0). Using the actual efficiency values increases MMBtu savings.
EEP – LED Lighting	▪ Ex-post gross < ex-ante gross ▪ 20,474 MMBtu difference ▪ 93% MMBtu realization rate	▪ The first-year installation rate assumption of 89% was included in the ex-ante kWh and kW savings formulas but omitted from the MMBtu

Portfolio Component	Difference Between Ex-Ante Gross and Ex-Post MMBtu Savings	Summary of Savings Difference
		equation. Ex-post savings estimates include the 89% installation rate assumption for MMBtu. ▪ The ex-ante MMBtu savings values for in-storage LEDs that were incented in prior years but installed in 2020 do not include a waste heat penalty. Our ex-post savings calculations apply the same waste heat factors to new and in-storage LEDs.
CEP Fuel Cell Project	▪ Ex-post gross > ex-ante gross ▪ 6,701 MMBtu difference ▪ 114% realization rate	▪ Consistent with state policy, PSEG Long Island no longer sponsors new distributed generation (DG) measures. This project was initiated prior to the change. ▪ PSEG Long Island, LIPA, and the CEP implementer had extensive discussions and agreed to claim impacts from any remaining DG projects with a simple conversion of electricity produced to MMBtu at 0.003412 MMBtu per kWh. The evaluation team's approach considers both the increased natural gas consumption at the facility, line losses, and an estimated heat rate for a natural gas power plant (9,413 Btu/kWh) to estimate MMBtu impacts at source. The thermal efficiency of the fuel cell is much better than a marginal generating unit on the downstate New York grid, so the project generates significant MMBtu impacts at source.

1.2 COST-EFFECTIVENESS RESULTS

In New York, the primary metric for screening portfolios for cost-effectiveness is the Societal Cost Test (SCT), which includes benefits accrued to New York as a whole. The perspective enables New York to factor in the avoided costs of energy production and delivery and carbon impacts. It also enables the inclusion of beneficial electrification technologies that increase electricity use but lead to overall lower energy consumption or reduced carbon impacts by shifting energy use from fossil fuels (fuel oil, propane, and natural gas) to electricity. Finally, the SCT considers the full incremental measure costs.[2]

Consistent with PSEG Long Island's Benefit-Cost Analysis (BCA) Handbook, we applied the SCT test as the primary method of determining cost-effectiveness. We also ensured that key assumptions including avoided costs, discount rates, and line losses match those used for PSEG Long Island's latest Utility 2.0 filing.

In addition, all calculated benefits and cost benefit ratios reflect net impacts. Net impacts are 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.

Critical drivers of portfolio SCT ratio and net benefit changes in 2020 compared to prior years include:

- **Removal of the non-energy benefit adder**: in 2019, an adder of 15% was applied to all measures to account for non-energy benefits, except for in the residential low-income segment, where a 30% non-energy benefits adder was applied. Following guidance from the New York Department of Public Service, PSEG Long Island discontinued the approach for the 2020 program year.
- **Reduced realization rates**: The lower realization rates were due in part to corrections in savings calculations related to the transition to the MMBtu savings metric.
- **Expansion of the heat pump measures**: beneficial electrification measures now make up a more substantial portion of the Home Comfort program.
- **Use of retail rates for avoided fuel oil and propane**: Avoided costs should reflect the cost of an avoided marginal unit of energy. For regulated resources such as electricity and natural gas this is the marginal cost is well established as the cost of production. For unregulated resources such as fuel oil or propane, the cost to society is the retail market rate of these fuels. Historically, wholesale prices had been used for these fuels but beginning in 2020 retail market rates are used to ensure consistency with the methodology applied elsewhere in

[2] Incremental costs are defined as the efficient measure cost (including labor) minus the equipment and labor costs of any baseline measure(s) that would otherwise have been installed. In the few cases where incentives surpass incremental costs, the incentive cost is included in the Societal Cost Test rather than the incremental measure cost.

New York.[3] Retail rates are higher than wholesale rates and their use increases waste heat penalties for efficient lighting but also increases benefits for electrification measures.

Table 1-4 presents the benefit-cost results for the portfolio and for each program using the primary Societal Cost Test perspective. The portfolio-level SCT values are 1.18 and 2.35 for Commercial and Residential Energy Efficiency programs, respectively. The full energy efficiency portfolio SCT value is 1.74. From a societal perspective the Energy Efficiency and Beneficial Electrification Portfolio is cost-effective. The Commercial subtotal is close to 1.0 and the Residential program subtotal is well over 1.0 (a benefit/cost ratio greater than 1 indicates that portfolio benefits outweigh costs).

Table 1-4: Societal Cost Test Results for Energy Efficiency and Beneficial Electrification Portfolio

Sector	Program	NPV Benefits ($1,000)	Costs ($1,000)	B/C Ratio
Commercial	Commercial Efficiency Program	**$58,710**	**$49,563**	**1.18**
Residential	Energy Efficient Products	$72,326	$25,402	2.85
	Home Comfort	$36,959	$13,640	2.71
	Residential Energy Affordability Partnership	$725	$1,534	0.47
	Home Performance	$8,025	$8,315	0.97
	Home Energy Management	$3,357	$2,734	1.23
	Total Residential Portfolio:	**$121,392**	**$51,625**	**2.35**
	Total Portfolio[1]:	***$180,101***	***$103,428***	***1.74***

[1] Portfolio costs include $2M of advertising that was not allocated to individual programs

Figure 1-4 shows SCT ratios for each program. Note that the size of markers are proportional to the planned MMBtu savings for each program. The SCT ratio was less than 1.0 for two programs in 2020: REAP and Home Performance, though the reasons for each and the change relative to prior years vary by program. Some key observations are:

- **CEP**: The SCT ratio for CEP is 1.18 in 2020. Because it is close to 1.0, all inputs have the potential to tip the outcome. SCT results for the CEP program are driven substantially by incremental costs which are largely a function of project costs. However, the project costs are high relative to energy savings compared to the rest of the portfolio. These higher costs lead to a lower SCT ratio for CEP compared to other programs. Further, administrative costs are about a quarter of total costs at the portfolio level. Given that energy savings are relatively low compared to the incremental costs for CEP, spreading these costs proportionately to energy savings further reduces the cost effectiveness margin for CEP.

[3] "Because these fuels are not regulated, retail rates reflect the marginal societal costs". NYSERDA Commercial Baseline Study, Appendix 2, page 12: https://www.nyserda.ny.gov/-/media/Statewide-Commercial-Baseline-Study-Report/NYSERDA-CBS-Appendix-2-Potential-Study.pdf

- **EEP:** The SCT ratio for EEP is 2.85 in 2020. The residential energy efficiency portfolio was the most cost-effective program in portfolio. However, it relies heavily on lighting and the role of lighting is expected to diminish as LEDs become the code baseline.
- **Home Comfort**: The SCT ratio for Home Comfort is 2.71 in 2020. The cost effectiveness increased due to the shift to predominantly electrification measures. The economics of Home Comfort, and beneficial electrification measures in general, are sensitive to assumptions about the benefits of avoided emissions and the avoided cost of delivered fuels like oil and propane. The substantial improvement in program cost-effectiveness reflects the increase in fuel avoided due to electrification and the increase in the value placed on avoided delivered fuels. Because the avoided cost is so much higher, electrification of homes with delivered fuel end uses (oil and propane) are much more cost effective for society than homes with natural gas. Similar economics exist for participants making beneficial electrification offerings more cost-effective and attractive for homes and businesses with delivered fuel. Not surprisingly, most electrification projects in 2020 were for sites with delivered fuels.
- **REAP**: The cost-effectiveness of REAP SCT ratio is 0.47. The SCT ratio dropped mostly due to the removal of the non-energy benefit adder. Notably, cost-ineffectiveness is not unusual for income-qualified programs, which typically are not required to be cost-effective.
- **Home Performance**: The SCT for Home Performance is 0.97 in 2020 despite the removal of the non-energy benefit adder.
- **HEM**: Despite removal of the non-energy benefit adder, the SCT is 1.23 in 2020. Benefits were higher due to the inclusion of peak demand benefits, which were not included in prior years. In addition, implementation costs were about 10% lower in 2020.

Figure 1-4: Societal Cost Test Ratios by Program

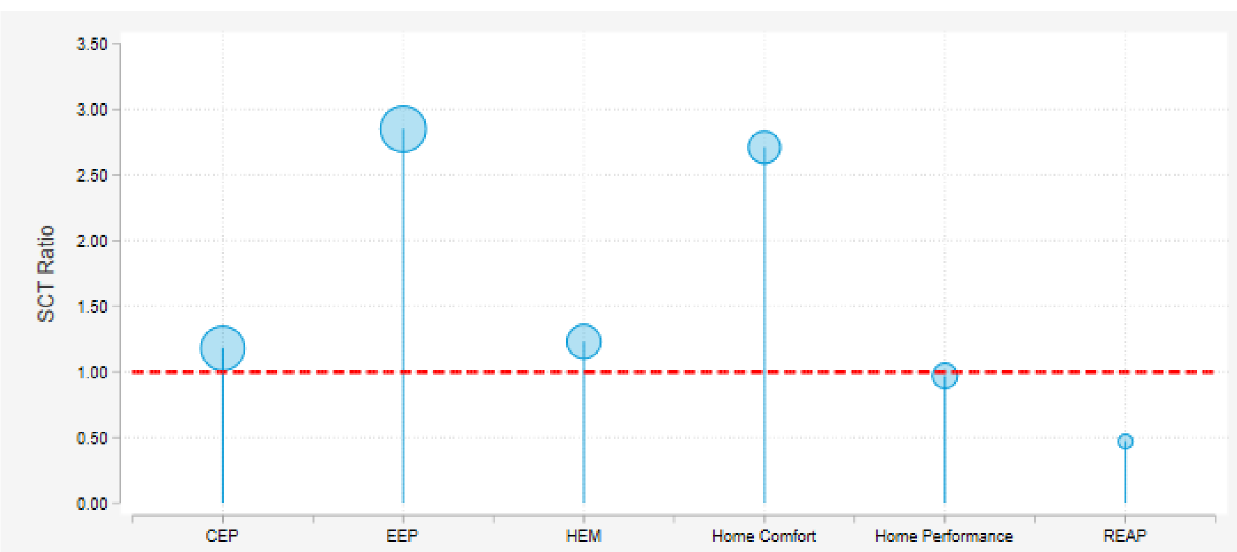
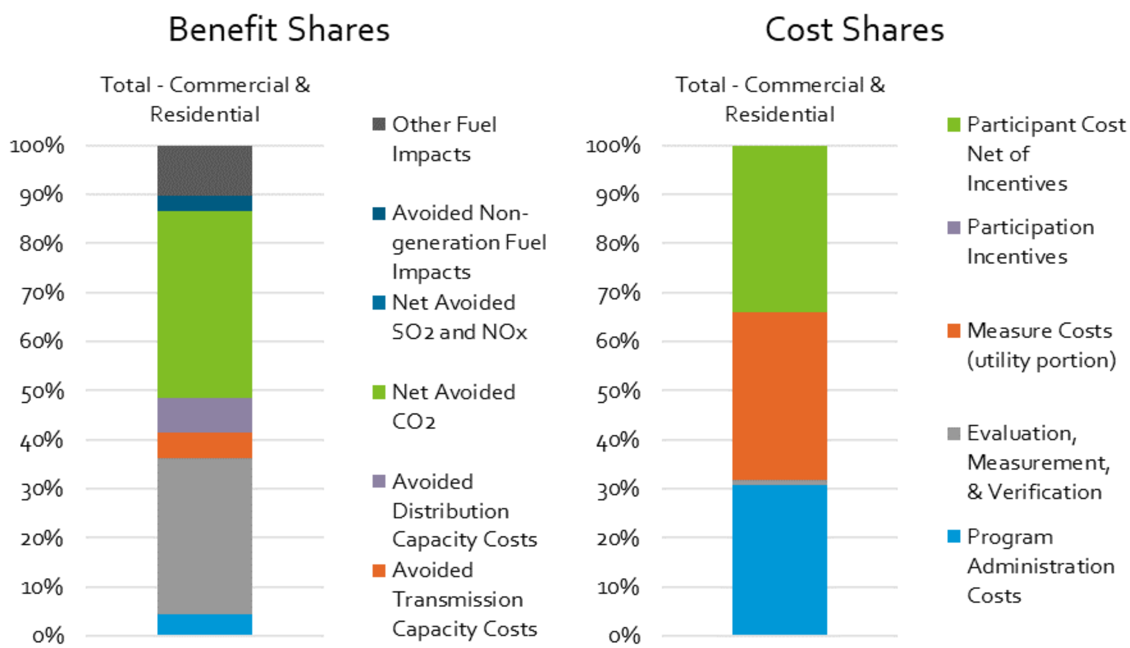


Figure 1-5 summarizes the benefit and cost categories analyzed and the share each contributed to the SCT. The primary two benefits for the SCT are avoided electric energy (LBMP) at 32% of benefits and avoided carbon emissions at 38% of benefits[4][5]. The combined benefits for capacity (generation, transmission, distribution) together comprise about 19% of societal benefits. From a societal perspective, the largest cost category is the measure costs borne by participants, followed by the measure costs borne by the utility in the form of customer rebates and contractor incentives. Together these two categories comprise the full incremental cost of efficiency measures over baseline measures. Program administration costs, including utility labor, advertising, and implementation vendor fees, comprise about 31% of societal costs.

Figure 1-5: Portfolio Net Present Value Benefit and Cost Shares by Category



[4] Carbon emission rate for electricity based on DPS "Order Adopting a Clean Energy Standard". http://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterCaseNo=15-e-0302
[5] Carbon and particulate emission rates for fuels based on EPA AP-42 Quantification. https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors

2 COMMERCIAL EFFICIENCY PROGRAM

2.1 COMMERCIAL EFFICIENCY PROGRAM DESCRIPTION

PSEG Long Island's Commercial Efficiency Program (CEP) is intended to assist non-residential customers in saving energy by offering rebates and incentives for the installation of energy conservation measures. In addition to rebates for energy savings measures, Technical Assistance rebates are available under CEP to offset the cost of engineering and design services for qualifying projects. CEP sponsors a broad array of measures among a variety of business types through the program components identified in Table 2-1.

Table 2-1: Summary of CEP Measure Catalog

Category and Measure		Description
Lighting	Comprehensive Lighting	CEP continued to offer the performance-based interior lighting program that incentivizes customers and contractors to install the most energy efficient equipment available. Rebates are paid to customers on a $/kWh basis.
	Fast-Track Lighting	The prescriptive alternative to Comprehensive Lighting allows business customers and their Prime Efficiency Partners (PEPs) to submit streamlined applications for lighting upgrades associated with fixed rebates.
	Outdoor Lighting	CEP offers per-unit incentives for the upgrade of exterior lighting fixtures and controls among all business types.
HVAC		CEP's HVAC offerings have expanded over time and now include high-efficiency unitary and split-system air conditioners, air-source heat pumps, and geothermal heat pumps.
Custom		The Custom program sponsors projects that are not conducive to the prescriptive path, providing business customers support for complex, interactive, or unique efficiency measures.
Distributed Generation		Over the years, CEP has sponsored a variety of combined heat and power (CHP) projects that result in a significant source MMBtu savings. In PY2020, CEP sponsored a fuel cell project that comprised 13% of the program's claimed kWh savings.
Standard Measures		The Standard category includes commercial measures that do not fall into the above categories and includes compressed air, variable frequency drives (VFDs), battery operated lawn equipment, non-road electric vehicles, and pool equipment.

The CEP implementation contractor instituted notable changes in 2020 that are expected to become more prominent in future program years. These changes include:

- CEP's savings goals now reflect MMBtu savings. As a result, the program will continue to introduce new offerings to promote beneficial electrification and achieve the MMBtu savings goal.
- Reflecting the uptick in multifamily building development on Long Island, CEP will serve as a basis for a new Multifamily Program that offers similar measures to CEP, including interior and exterior lighting and HVAC.
- The energy assessment procedure has been modified from the year prior to better meet needs of the customers. Depending on business size and customer interest, business owners can receive any or all of: support from an Energy Consultant or Inspector, a benchmark or ASHREA Level I audit of the facility, ENERGY STAR® benchmark score, or a more rigorous audit by approved Technical Assistant partners.

2.1.1 Program Design and Implementation

CEP participation is driven through partnerships with installation contractors, or Lead Partners, through whom customers may apply directly without an installation contractor. Engaging the implementation contractors to deliver the program has improved program performance and market impacts. As such, Lead Partner relationship management is an integral part of the program. The program recognizes, and promotes, the importance of open communication between the contractors and the program.

The introduction of the Prime Efficiency Partner network in 2017 has enabled the program to touch more small business customers and has led to an increase in project submittals. Contractors wishing to participate in the Fast Track program and be designated "Prime" must meet specific business criteria, complete trainings, and meet the strict program requirements. The launch of the Prime Efficiency Partner program has also played a crucial role in maintaining customer satisfaction. Program administrators offer weekly trainings and Quality Control Evaluation procedures to ensure continued quality installations for commercial customers.

2.1.2 Program Participation and Performance

PSEG Long Island's CEP exceeded MMBtu goals by 15% in 2020, as shown in Table 2-2.

Table 2-2: 2020 CEP Verified Ex-Ante Gross Program Performance vs. Goals

Metric	MMBtu
Goal	329,232
Verified Ex-Ante Gross Savings	378,438
% of Goal	115%

Comprehensive Lighting projects accounted for the largest share of CEP ex-ante gross energy savings in 2020. As shown in Table 2-3, Comprehensive Lighting projects accounted for 65% of ex-ante gross

MMBtu savings, outpacing Fast Track (11%) and Outdoor Lighting (2%) measure groups within the lighting category.

Table 2-3. 2020 CEP Percent of Total Ex-Ante Gross Savings by Program Component

Program Component		Ex-Ante Gross Savings		
		% MMBtu	% MWh	% kW
Lighting	Comprehensive Lighting	65%	67%	73%
	Fast Track Lighting	11%	12%	12%
	Refrigerated Case Lighting	2%	2%	1%
	Lighting Subtotal	78%	80%	86%
Distributed Generation	Fuel Cells	13%	13%	9%
Standard	Refrigeration	2%	2%	1%
	Motors & VFDs	1%	1%	0%
	Compressed Air	1%	1%	0%
	Building Envelope	0%	0%	1%
	Other Commercial Equipment	1%	0%	0%
	Standard Subtotal	5%	4%	1%
Custom	Custom	3%	2%	2%
HVAC	HVAC	1%	1%	2%

The lighting category's share of CEP ex ante gross savings has gradually decreased in recent years, from 94% of CEP kWh savings in 2016, to 77% of claimed kWh savings in 2019, and now 78% of MMBtu in 2020.

The program sponsored a lone Fuel Cell project in 2020 that accounted for 13% of the claimed MMBtu savings. This project was a carryover from the 2019 program year, during which distributed generation projects were still eligible for CEP funding. PSEG Long Island has since stopped supporting new fossil fuel DG offerings, as they do not align with New York's and PSEG Long Island's electrification goals.

2.2 COMMERCIAL EFFICIENCY PROGRAM IMPACTS

2.2.1 OVERVIEW OF IMPACTS BY RESOURCE TYPE

Table 2-4, Table 2-5, and Table 2-6 compare ex-post gross savings to ex-ante gross savings and show the associated realization rates by program component for MMBtu, MWh, and kW, respectively. The evaluation team calculated realization rates by dividing ex-post gross savings values by ex-ante gross savings values. Overall, CEP realized 79% of its ex-ante gross MMBtu energy savings claims, 89% of MWh savings claims, and 95% of kW savings claims. As evidenced by high RRs for MWh and kW savings, CEP's electric savings claims were reasonable and generally aligned with the savings algorithms recommended in PSEG Long Island and New York State TRMs. The 79% RR for MMBtu savings is driven primarily by the evaluation team's inclusion of waste heat penalties for lighting. Switching to MMBtu-based goals, as part of New York's aggressive decarbonization targets, requires more complete fuel accounting than in prior years. Opportunities to refine MMBtu savings claims are further addressed in Table 2-8.

Table 2-4: 2020 CEP Ex-Post Gross MMBtu Impacts by Program Component

	Program Component	N	Ex-Ante Gross Savings (Claimed) MMBtu	Ex-Post Gross Savings MMBtu	Realization Rate %
Lighting	Comprehensive Lighting	427,829	254,893	183,880	72%
	Fast Track Lighting	58,337	42,071	25,613	61%
	Refrigerated Case Lighting	6,765	7,991	6,649	83%
	Lighting Subtotal	492,931	304,956	216,142	71%
Distributed Generation	Fuel Cells[1]	1	49,031	55,732	114%
Standard	Refrigeration	6,319	7,581	7,327	97%
	Motors & VFDs	33	3,413	3,437	101%
	Compressed Air	64	3,587	3,236	90%
	Cool Roof	24	-226	-314	139%
	Other Comm. Equipment	55	4,957	6,022	121%
	Standard Subtotal	6,495	19,313	19,708	102%
Custom	Custom	155	12,297	11,682	95%
HVAC	HVAC	468	4,463	3,079	69%
Grand Total[2]		**500,050**	**390,069**	**306,343**	**79%**

[1] The ex-post gross MMBtu savings shown for the Fuel Cell Project is savings "at source". For all other measures, the MMBtu savings are "at site".
[2] One project adjustment of 10 MMBtu is included in ex-ante total gross savings and overall realization rates, but not shown as a separate line item in this table.

Table 2-5: 2020 CEP Ex-Post Gross MWh Impacts by Program Component

	Program Component	N	Ex-Ante Gross Savings (Claimed)[1] MWh	Ex-Post Gross Savings MWh	Realization Rate %
Lighting	Comprehensive Lighting	427,829	74,302	64,771	87%
	Fast Track Lighting	58,337	13,011	9,523	73%
	Refrigerated Case Lighting	6,765	2,342	1,949	83%
	Lighting Subtotal	492,931	89,654	76,243	85%
Distributed Generation	Fuel Cells	1	14,370	15,925	111%
Standard	Refrigeration	6,319	2,148	2,160	101%
	Motors & VFDs	33	1,000	1,007	101%
	Compressed Air	64	895	949	106%
	Cool Roof	24	255	255	100%
	Other Comm. Equipment	55	-34	-58	169%

	Program Component	N	Ex-Ante Gross Savings (Claimed)[1] MWh	Ex-Post Gross Savings MWh	Realization Rate %
	Standard Subtotal	6,495	4,264	4,313	101%
Custom	Custom	155	2,459	2,336	95%
HVAC	HVAC	468	830	695	84%
Grand Total[2]		**500,050**	**111,580**	**99,512**	**89%**

[1] MWh Ex-Ante Gross Savings (Claimed) in table might not match KPI scorecard values. Table values include all Energy Efficiency Savings as well as negative MWh savings from Beneficial Electrification, while KPI scorecard reports Energy Efficiency Savings only.
[2] One project adjustment of 2,943 kWh is included in ex-ante gross savings and overall realization rates, but not shown as a separate line item in this table

Table 2-6: 2020 CEP Ex-Post Gross kW Impacts by Program Component

	Program Component	N	Ex-Ante Gross Savings (Claimed)[1] kW	Ex-Post Gross Savings kW	Realization Rate kW
Lighting	Comprehensive Lighting	427,829	14,919	13,518	91%
	Fast Track Lighting	58,337	2,338	2,133	91%
	Refrigerated Case Lighting	6,765	195	472	242%
	Lighting Subtotal	492,931	17,452	16,123	92%
Distributed Generation	Fuel Cells	1	1,823	1,818	100%
Standard	Refrigeration	6,319	115	197	172%
	Motors & VFDs	33	44	35	81%
	Compressed Air	64	70	185	265%
	Cool Roof	24	105	103	98%
	Other Comm. Equipment	55	-1	-11	1,134%
	Standard Subtotal	6,495	332	508	153%
Custom	Custom	155	366	293	80%
HVAC	HVAC	468	337	461	137%
Grand Total[2]		**500,050**	**20,313**	**19,203**	**95%**

[1] kW Ex-Ante Gross Savings (Claimed) in table might not match KPI scorecard values. Table values include all Energy Efficiency Savings as well as Beneficial Electrification, while KPI scorecard reports Energy Efficiency Savings only.
[2] One project adjustment of 3.1 kW is included in ex-ante gross savings and overall realization rates, but not shown as a separate line item in this table

2.2.1.1 Fuel Cell Project Impacts

2020 program activity included a fuel cell project at an office building with an associated data center. This project was initiated in 2019 and carried over into 2020, during which the program wholly claimed its impacts. PSEG Long Island dropped fossil fuel distributed generation from CEP in 2020 because of state policy. PSEG Long Island and LIPA negotiated how to handle DG projects that were pre-approved prior to change under the new fuel neutral accounting framework and decided to simply convert the electricity generated on-site at 0.003412 MMBtu per kWh. The evaluation team's ex post impacts consider the additional natural gas consumed on-site to power the fuel cell, line losses, and the thermal efficiency of the grid to estimate an "MMBtu at source" metric that takes into account the total impact of the project on Long Island. Table 2-7 summarizes the "at site" and "at source[6]" impacts and interim calculations for the participating facility. Our alternative calculation approach returns MMBtu savings 14% higher than the methodology established by PSEG Long Island and LIPA.

Table 2-7: 2020 CEP Fuel Cell Project Summary

Reporting Basis	Parameter of Interest	Value	Units
Ex-Ante Gross Savings	Annual Energy Savings	14,370	MWh
	Peak Demand Reduction	1,823	kW
	Total MMBtu Savings (kWh generation * 0.003412)	49,031	MMBtu
Ex-Post Gross Impacts	Electricity Generation at Site (Reduction in Grid Supplied Power)	15,925	MWh
	Gross MMBtu Associated with Reduction in Grid-Supplied Electricity (kWh generation * 0.003412)	54,337	MMBtu
	Summer Peak Generation at Site (Reduction in Participant's Peak Load)	1,818	kW
	Additional Annual Natural Gas Consumption at Site to Power Fuel Cell	103,733	MMBtu
	Total Fuel Impact at Site (MMBtu of electricity generated – MMBtu of gas input)	-49,396	MMBtu
	Assumed Heat Rate of Marginal Generating Unit	9,413	Btu/kWh
	Fuel Required for Grid-Supplied Electricity Offset by Fuel Cell	159,465	MMBtu
	Overall Energy Reduction at Source	55,732	MMBtu
	MMBtu Realization Rate (55,732 / 49,031)	114%	Ratio

2.2.2 Key Drivers for Differences in Impacts

As the lighting program components comprised the majority of CEP savings in 2020, their performance greatly influenced the overall RRs. Table 2-8 summarizes the major differences that contributed to the MMBtu RRs, along with the evaluation team's recommendations to improve savings claims moving forward.

[6] Source MMBtu savings take into account generation, transmission and distribution losses for electricity, and the heat rate of the source/power plant to estimate fossil fuel impacts at source, providing an equitable quantification of savings among both electricity and fossil fuel sources. The evaluation team used a grid heat rate of 9,413 Btu/kWh based on average of 2019 EIA heat rates for combined cycle and combustion turbines. https://www.eia.gov/electricity/annual/html/epa_08_02.html

Table 2-8: Key Contributors to CEP MMBtu RR and Proposed Solutions

Component	Summary of Savings Difference	Recommendation
Comprehensive Lighting	▪ Heating system impacts from reduced waste heat were not considered in ex-ante MMBtu savings calculations. ▪ Operating hours by building type differed from values in 2020 PSEG-LI TRM	▪ Similar to HVAC interactive savings during cooling season, include MMBtu impacts to heating system during heating season ▪ Align savings assumptions with PSEG-LI TRM
Fast Track Lighting	▪ Heating system impacts from reduced waste heat were not considered in ex-ante MMBtu savings calculations. ▪ Claimed energy savings included both demand and energy waste heat factors	▪ Similar to HVAC interactive savings during cooling season, include MMBtu impacts to heating system during heating season. ▪ Ensure only energy or demand waste heat factors are applied to kWh and kW savings, respectively
Fuel Cell	▪ The ex-ante and ex-post calculations were fundamentally different. Ex-ante claimed savings convert kWh production to MMBtu at site while the ex-post evaluation considers increased fuel consumption, line losses, and the heat rate of the grid to estimate MMBtu impacts at source. ▪ This fuel cell project was initiated in 2019 and closed in 2020.	▪ While the CEP no longer sponsors new DG measures, we recommend applying an "at source" calculation approach to any remaining DG projects claimed in 2021. ▪ MMBtu-at-source calculations require an assumption about the heat rate of the downstate New York electric grid. We recommend a value in the 9,000-9,500 range to account for mix of combined cycle and combustion turbines on the margin.
Custom Measures	▪ Program applied RRs of 95% for MMBTU and kWh savings and 80% for kW savings per a 2012 evaluation of custom projects cited in the 2020 PSEG-LI TRM.	▪ The custom RRs are outdated and should be revisited in the context of the program's MMBtu-based goals.
HVAC	▪ Many projects closed in 2020 were carryover from 2019, and implementers calculated claimed savings using from 2019 application assumptions. ▪ Evaluators reduced the cooling equivalent full load hours for packaged air conditioning units to align with cooling EFLH values	▪ Ensure that ex-ante EFLH values align with PSEG Long Island TRM recommendations by building type.

Component	Summary of Savings Difference	Recommendation
	stipulated in Version 7 of the New York TRM.	

2.3 CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this evaluation, our key findings and recommendations for the Commercial Efficiency Program are presented in Table 2-9.

Table 2-9: Commercial Efficiency Findings and Recommendations

Finding	Recommendation
▪ We commend PSEG Long Island and CEP for shifting to MMBtu-based goals, as a reflection of New York's decarbonization initiatives. This transition to fuel agnostic conservation requires a more complete accounting of resource impacts than prior years when the portfolio was organized around electric savings. For commercial lighting measures, we determined that ex-ante savings did not include the interactive heating penalty due to reduced waste heat from the lighting wattage reduction.	▪ As PSEG Long Island has shifted to MMBtu-based goals, the accounting of fuel-specific impacts is critical to accurate program reporting and measurement of performance versus goal. Evaluators recommend that the CEP consider MMBtu impacts from all energy sources at site in the calculation of reported savings. Given the contribution of LED lighting to CEP, we developed Long Island-specific waste heat factors for use in the 2020 evaluation and 2022 PSEG Long Island TRM.
▪ CEP's non-lighting measures have become increasingly prominent. On the other hand, lighting's share of savings has gradually decreased year to year, now accounting for 78% of ex-ante gross MMBtu savings and 71% of ex-post gross MMBtu savings.	▪ PSEG Long Island should continue to expand program offerings to make up for lighting's continually decreasing share of program savings. Such offerings include non-lighting segments such as refrigeration and HVAC, as well as lighting controls, for which the market is rapidly evolving.

Finding	Recommendation
▪ For some CEP components, such as refrigeration and compressed air, program savings algorithms and input assumptions continue to reference the 2010 LIPA Technical Manual.	▪ CEP program planners should reference the PSEG Long Island TRM whenever possible, as it represents the most accurate source of assumptions and includes Long Island-specific research where available. Evaluators look forward to sharing the latest PSEG Long Island TRM in May 2021 to inform the implementation team's planning for the 2022 program year.
▪ For select measures, critical project-level details are excluded from Captures tracking data. As a result, we could not conduct measure-level engineering analysis of the population of projects but rather relied on desk reviews among a sample of comprehensive lighting and refrigeration measures. ▪ Most of these project-level details were incorporated in tracking activities for the 2020 program year. Limitations in evaluation mostly resulted from 2019 carryover projects where these project-level details were not yet tracked.	▪ CEP administrators should continue to collect and track relevant measure- and project-specific data in Captures, most notably for the following: ▪ Existing fixture wattage and quantity (Comprehensive Lighting program component) ▪ 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)

3 ENERGY EFFICIENCY PRODUCTS PROGRAM

3.1 ENERGY EFFICIENCY PRODUCTS PROGRAM DESCRIPTION

The following sections detail the program design, implementation strategies, and PY2020's participation and performance for the Energy Efficiency program.

3.1.1 PROGRAM DESIGN AND IMPLEMENTATION

The objective of the Energy Efficient Products (EEP) program is to increase the purchase and use of energy efficient appliances and lighting among PSEG Long Island residential customers. The program provides rebates or incentives for ENERGY STAR certified lighting and appliances through upstream, online, and downstream promotions. These products meet the energy efficiency standards set by the Environmental Protection Agency (EPA) and the Department of Energy (DOE). Key measures in the EEP program for 2020 include LED lighting, heat pump pool heaters (HPPH), pool pumps, ENERGY STAR appliances, appliance recycling, battery operated lawn equipment, and heat pump water heaters (HPWH).

In 2020 the EEP program introduced several measures aimed at beneficial electrification, namely heat pump pool heaters and battery-operated lawn maintenance equipment. Beneficial electrification measures increase electricity consumption (negative kWh savings) but reduce total energy consumption (MMBtu) and emissions. Some beneficial electrification measures, like heat pump water heaters, have a composite baseline of electric and fossil fuel units. This leads to both electricity savings and increases in electricity consumption. We include supplemental tables for these dynamic measures in Section 4.2.1.1 to illustrate the more complex fuel accounting.

3.1.2 PROGRAM PARTICIPATION AND PERFORMANCE

The EEP program achieved 142% of 2020 program MMBtu goals, saving 460,988 MMBtu on a verified ex-ante basis. Ninety-four percent of EEP savings are attributable to three measure categories: LED lighting (61%), pool heaters (28%), and pool pumps (5%). No other measure category contributes more than 2% of overall EEP ex-ante gross savings. Table 3-1 shows 2020 EEP program performance compared to goals.

Table 3-1: EEP Verified Ex-Ante Gross Program Performance vs. Goals

Metric	MMBtu
Goal	324,990
Verified Ex-Ante Gross Savings	460,988
% of Goal	142%

In 2020, the EEP program incentivized more than 3.6 million energy efficient products to PSEG Long Island residential customers. PSEG Long Island rebated more than 6,300 major appliances (washers, dryers, refrigerators, freezers, and dishwashers) through EEP in 2020 and incentivized 1,636 heat pump pool heaters and 2,627 pool pumps. The program provided point-of-sale discounts on more than 3.5 million LED lamps at Long Island retailers. Table 3-2 summarizes participation for each program measure compared to the planning goal. PSEG Long Island initially planned not to support standard general service LED A-lamps in 2020, so the planned units for EEP-1200 is zero. In spring 2020, PSEG Long Island revisited this decision due to rescinded standards at the federal level and continued support of A-lamps by other New York utilities. The EEP program ended up incentivizing nearly 846,000 standard A-lamps in 2020.

Table 3-2. 2020 EEP Program Participation vs. Goals, by Measure

Measure	Number of Units	Planned Units (Goal)	Percentage of Goal Achieved
EEP-100 EEP ES Room Air Purifier	271	-	-
EEP-105 EEP ES Room Air Purifier (<200 CADR)	395	350	113%
EEP-110 EEP ES Room Air Purifier (>200 CADR)	373	250	149%
EEP-200 EEP Advanced Power Strip Tier 1	30	-	-
EEP-210 EEP Advanced Power Strip Tier 2	112	100	112%
EEP-300 EEP Clothes Dryer - Electric Resistance	2,814	2,500	113%
EEP-310 EEP Clothes Dryer - Most Efficient	57	50	114%
EEP-400 EEP ME Clothes Washer	2,796	2,500	112%
EEP-500 EEP ES Dehumidifier	2,521	3,000	83%
EEP-600 EEP Heat Pump Water Heater - Small	154	200	77%
EEP-610 EEP Heat Pump Water Heater - Large	75	100	75%
EEP-700 & EEP-701 EEP Pool Pump Two Speed	3	300	1%
EEP-710 & EEP-711 EEP Pool Pump Variable Speed	2,624	2,750	95%
EEP-720 Heat Pump Pool Heater	1,636	100	1,636%
EEP-900 EEP Refrigerator Recycle- Pre 2001	575	800	72%
EEP-910 EEP Refrigerator Recycle- Post 2001 & Pre 2010	1,536	2,000	77%
EEP-920 EEP RAC Recycle	284	400	71%
EEP-930 EEP Dehumidifier Recycle	63	150	42%
EEP-1000 EEP Most Efficient Refrigerator	227	1,000	23%
EEP-1200 LED Standard	845,908	-	-
EEP-1210 Connected Lighting Bulbs	3,761	6,400	59%
EEP-1250 LED Specialty	2,434,728	2,400,000	101%
LED-S In-storage LEDs	303,612	303,612	100%
EEP-1415 Connected Thermostat	762	3,750	20%
EEP-1420 Learning Thermostat	1,252	3,750	33%
EEP-1500 EEP Most Efficient Dishwasher	168	450	37%
EEP-1700 EEP ES Bathroom Exhaust Fans	108	250	43%
EEP-1710 EEP Most Efficient Bathroom Exhaust Fans	20	75	27%
EEP-1800 EEP ES Freezer	247	250	99%
EEP-1900 EEP Electric Lawn Mower <4aH	25	150	17%
EEP-1905 EEP Electric Lawn Mower 4-5aH	329	150	219%
EEP-1910 EEP Electric Lawn Mower >5aH	695	200	348%

Measure	Number of Units	Planned Units (Goal)	Percentage of Goal Achieved
EEP-1920 EEP Electric Weed Trimmer	1,357	500	271%
EEP-1930 EEP Electric Leaf Blower	1,448	500	290%
EEP-2000 Connected Lighting Kits	555	-	-
Total	**3,611,521**	**2,432,976**	**148%**

Figure 3-1 shows the distribution of ex-ante gross energy and demand savings across the EEP program. Lighting measures (LED Standard/Specialty, Connected Lighting, and In-storage LEDs) account for most of the ex-ante gross savings across all resources. Heat pump pool heaters, pool pumps, and Wi-Fi connected thermostats are other top measures; along with LED lighting, these account for 97% of ex-ante gross MMBtu savings.

Figure 3-1: EEP Program Ex-Ante Gross Savings by Resource and Measure Category

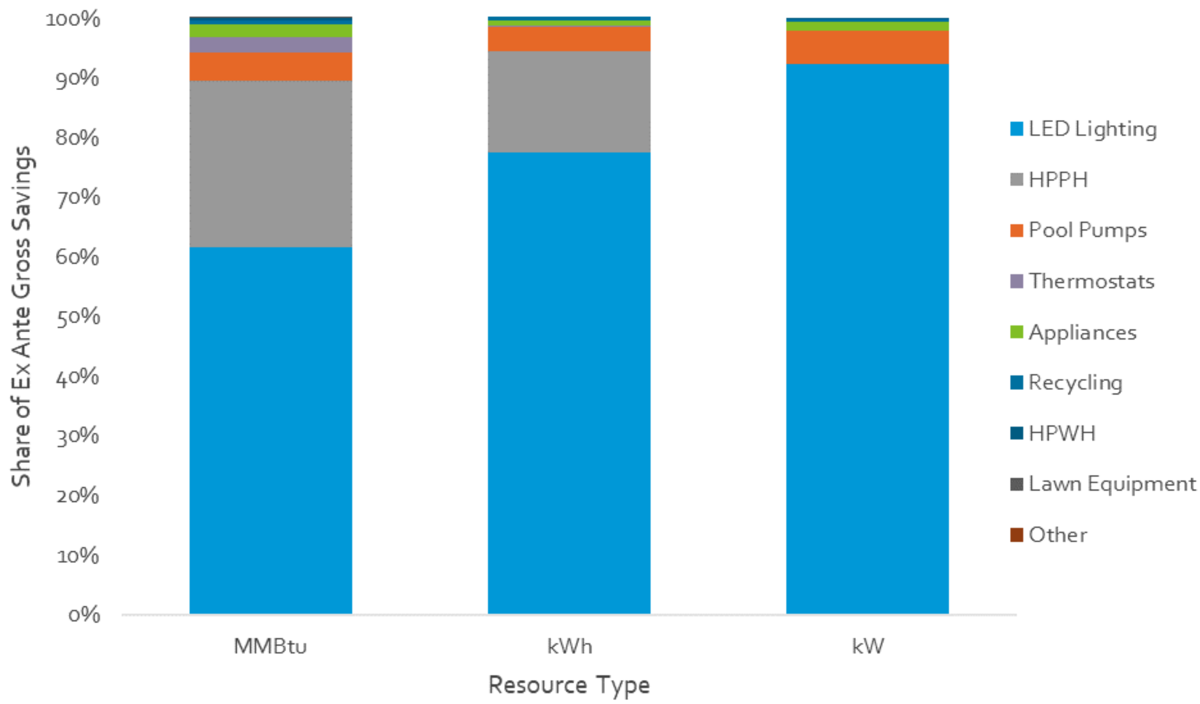
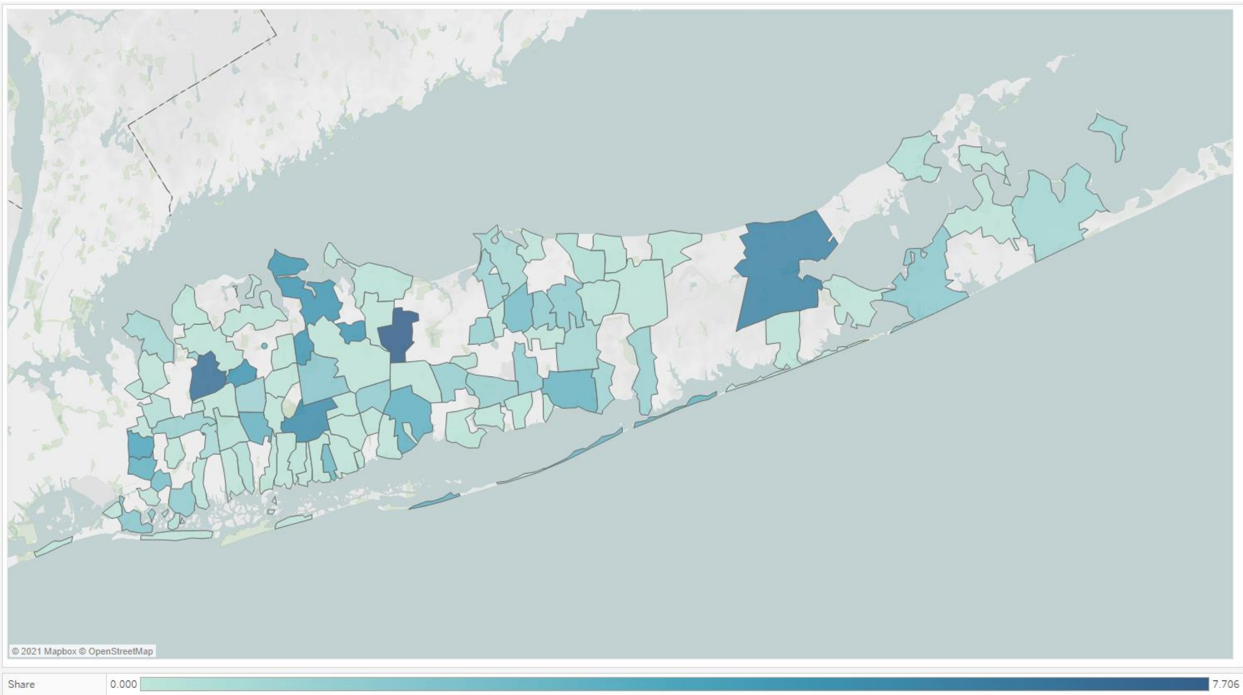


Table 3-3 shows the distribution of incented LED bulbs (excluding connected lighting and in-storage lighting) by retailer and bulb style. LED fixtures like the recessed downlight retrofit kit shown to the right were very popular in 2020. The "Other" row in Table 3-3 aggregates several small retail partners with limited 2020 program volume. Over 60% of bulbs went through Home Depot or Lowe's, and another 15% went through electric supply stores. Costco was also well-represented with approximately 14% of the incented bulbs. Figure 3-2 shows how the incented bulbs were dispersed geographically using retailer zip codes. Each polygon represents a different zip code. The shade of the polygons represents the share of 2020 LED bulbs incented in that zip code (where a darker shade means more). Note the figure is not normalized to the population.

Table 3-3: Distribution of Standard and Specialty LED Bulbs by Retailer and Bulb Type

Retailer	General Service	Reflectors	Globes and Candelabras	Fixtures	Total
Ace Hardware	37,536	28,732	25,493	2,764	94,525
Brinkmann's Hardware	4,411	2,823	2,226	187	9,647
Costco	196,872	131,486	93,990	50,790	473,138
Dollar Tree	4,918	7,810	3,460	---	16,188
Electric Supply Stores	7,933	78,557	6,936	398,646	492,072
Home Depot	376,019	403,379	337,589	606,840	1,723,827
Lowe's	72,984	97,828	79,715	12,878	263,405
Other	63,417	9,555	4,648	1,156	78,776
Sam's Club	2,022	792	---	---	2,814
Stop & Shop	1,527	249	652	---	2,428
Target	6,297	4,851	412	---	11,560
True Value	3,602	3,546	2,037	62	9,247
Walmart	68,561	13,271	21,177	---	103,009
Total	**846,099**	**782,879**	**578,335**	**1,073,323**	**3,280,636**

Figure 3-2: Geographic Distribution of Incented LED Bulbs



3.2 ENERGY EFFICIENT PRODUCTS PROGRAM IMPACTS

The following sections provide the results of the impact analysis for the EEP program.

3.2.1 OVERVIEW OF IMPACTS BY RESOURCE TYPE

Table 3-4 shows ex-post gross MMBtu impacts by measure category along with the net-to-gross ratios (NTGR) used to calculated net impacts for cost effectiveness. Table 3-5 and Table 3-6 show the ex-post gross MWh and kW impacts, respectively, along with their net-to-gross ratios.

Table 3-4 2020 EEP MMBtu Impacts by Measure Category

Measure Category	Ex-Ante Gross Savings (Claimed) MMBtu	Ex-Post Gross Savings MMBtu	Realization Rate %
Lighting	283,377	262,903	93%
Heat Pump Pool Heaters	128,366	48,030	37%
Pool Pumps	21,680	21,804	101%
Thermostats	12,464	12,140	97%
Appliances	9,693	6,830	70%
Recycling	3,116	7,863	252%
Heat Pump Water Heaters	1,480	3,094	209%
Lawn Equipment	730	778	107%
Other (APS, Exhaust Fans)	82	79	97%
Total	**460,988**	**363,522**	**79%**

Table 3-5 2020 EEP MWh Impacts by Measure Category

Measure Category	Ex-Ante Gross Savings (Claimed[1]) MWh	Ex-Post Gross Savings MWh	Realization Rate %
Lighting	120,689	116,892	97%
Heat Pump Pool Heaters	26,510	2,078	8%
Pool Pumps	6,354	6,391	101%
Thermostats	268	279	104%
Appliances	1,273	1,447	114%
Recycling	913	2,304	252%
Heat Pump Water Heaters	30	-121	-403%
Lawn Equipment	-49	-49	100%
Other (APS, Exhaust Fans)	24	23	97%
Total	**156,012**	**129,245**	**83%**

[1] MWh Ex-Ante Gross Savings (Claimed) in table might not match KPI scorecard values. Table values include all Energy Efficiency Savings as well as Beneficial Electrification, while KPI scorecard reports Energy Efficiency Savings only.

Table 3-6 2020 EEP kW Impacts by Measure Category

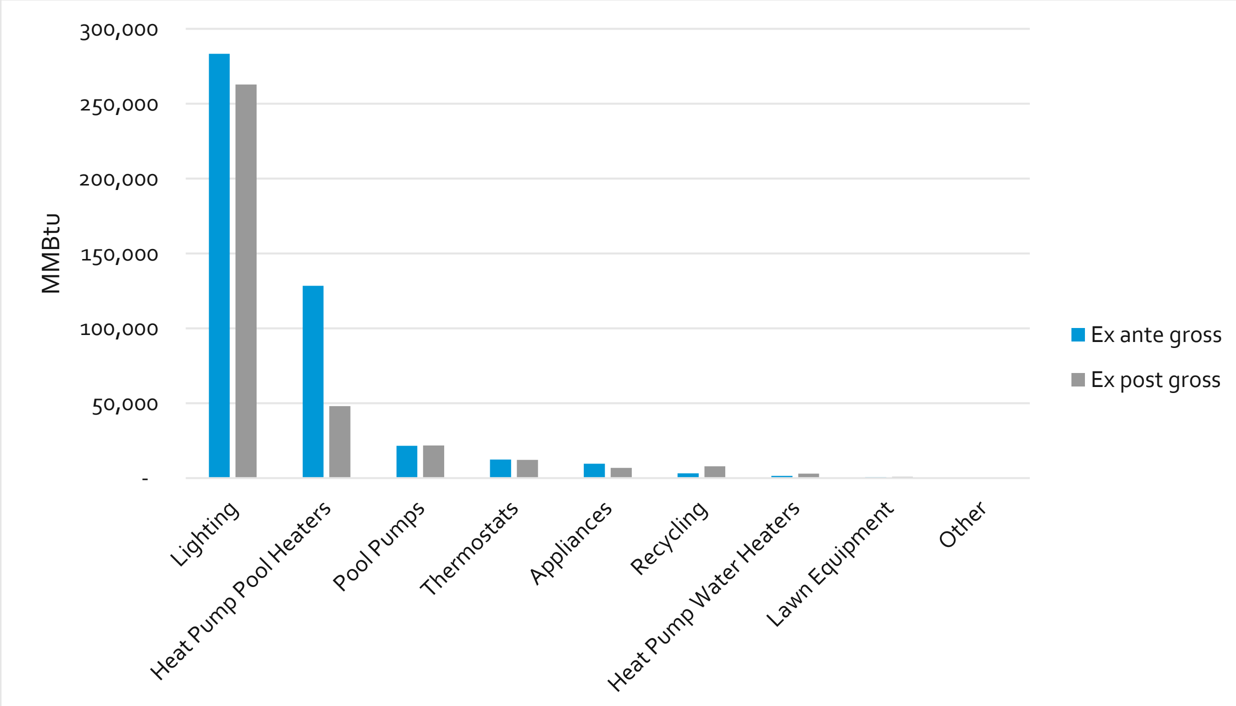
Measure Category	Ex-Ante Gross Savings (Claimed[1]) kW	Ex-Post Gross Savings kW	Realization Rate %
Lighting	30,729	17,040	55%
Heat Pump Pool Heaters	-	-	-
Pool Pumps	1,873	1,580	84%
Thermostats	-	-	-
Appliances	505	266	53%
Recycling	137	388	283%
Heat Pump Water Heaters	39	39	100%
Lawn Equipment	-	-	-
Other (APS, Exhaust Fans)	3	2	96%
Total	**33,286**	**19,315**	**58%**

[1] kW Ex-Ante Gross Savings (Claimed) in table might not match KPI scorecard values. Table values include all Energy Efficiency Savings as well as Beneficial Electrification, while KPI scorecard reports Energy Efficiency Savings only.

3.2.1.1 Ex-Post Findings

The overall EEP program MMBtu realization rate, calculated as the ratio of ex-post gross savings to ex-ante gross savings, is 79%. The heat pump pool heater measures account for 66% of the overall program ex-post gross MMBtu variance. Lighting measures contribute the second-most (37%) to overall MMBtu variance. Notably, the EEP program still achieved over 104% of the 2020 MMBtu goal on an ex-post gross basis. Figure 3-3 compares ex-ante gross and ex-post gross MMBtu savings by measure category.

Figure 3-3 EEP Ex-Ante Gross and Ex-Post Gross MMBtu Savings by Measure Category



Overall, 23 out of 37 EEP measures have MMBtu realization rates of greater than 100%, and 14 measures have realization rates of less than 100%. The highest realization rate is for Room AC Recycling (2,407%). The lowest realization rate is for Heat Pump Pool Heaters (37%). The biggest positive ex-post gross MMBtu variances are in Recycling measures, which exceed ex-ante values by 4,746 MMBtu (RR = 252%), and Heat Pump Water Heaters, which exceed ex-ante estimates with a combined RR of 209% and ex-post gross savings 1,614 MMBtu greater than ex-ante gross.

3.2.1.2 Beneficial Electrification Impacts

Table 3-7 shows the breakdown of Energy Efficiency (EE) and Beneficial Electrification (BE) MMBtu and kWh for measures where a BE component exists. The clothes dryer, heat pump water heater, and heat pump pool heater measures include a mixture of electric efficiency and beneficial electrification impacts. Lawn equipment measures assume a purely gasoline-powered baseline.

Table 3-7: Breakdown of Ex-Post Gross MMBtu Per-Unit Impacts by EE and BE Components

Measure	$MMBtu_{ee}$	$MMBtu_{be}$	$MMBtu_{total}$	kWh_{ee}	kWh_{be}	ΔkWh
EEP-300 EEP Clothes Dryer - Electric Resist.	0.0	0.1	**0.1**	8	72	**(64)**
EEP-310 EEP Clothes Dryer - Most Efficient	0.5	0.4	**0.9**	161	132	**29**
EEP-600 EEP Heat Pump Water Heater - Small	1.3	13.8	**15.1**	386	852	**(466)**
EEP-610 EEP Heat Pump Water Heater - Large	0.6	9.6	**10.2**	190	842	**(652)**
EEP-720 Heat Pump Pool Heater	7.8	21.6	**29.4**	2,276	1,006	**1,270**
EEP-1900 EEP Electric Lawn Mower <4aH	-	0.5	**0.5**	-	13	**(13)**
EEP-1905 EEP Electric Lawn Mower 4-5aH	-	0.5	**0.5**	-	20	**(20)**

Measure	$MMBtu_{ee}$	$MMBtu_{be}$	$MMBtu_{total}$	kWh_{ee}	kWh_{be}	ΔkWh
EEP-1910 EEP Electric Lawn Mower >5aH	-	0.4	**0.4**	-	30	**(30)**
EEP-1920 EEP Electric Weed Trimmer	-	0.1	**0.1**	-	5	**(5)**
EEP-1930 EEP Electric Leaf Blower	-	0.1	**0.1**	-	11	**(11)**

3.2.2 Key Drivers for Differences in Impacts

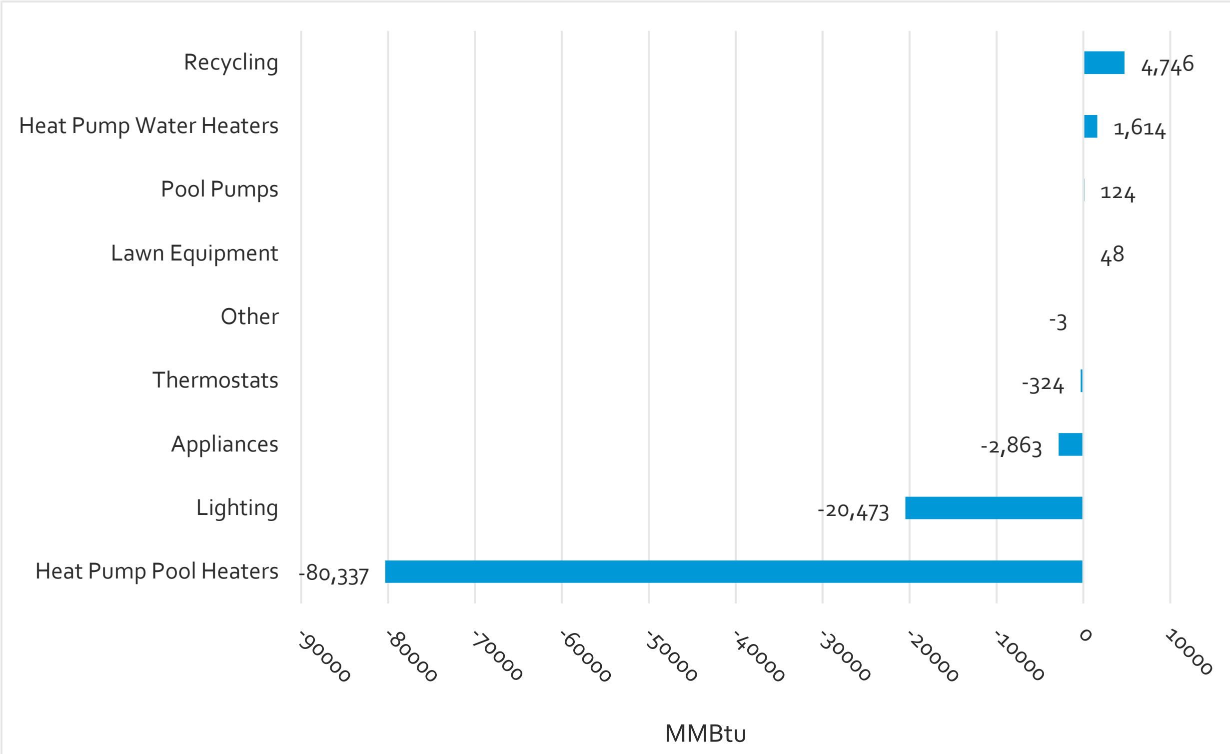
This section describes key drivers of the overall gross realization rates, with an emphasis on MMBtu savings. Most variance between ex-ante gross and ex-post gross savings is due to one or more of the following evaluation activities:

- **Use of 2020 equipment characteristics to inform and refine per-unit savings assumptions.** For example, by cross-referencing model numbers from the 1,039 Air Purifiers rebated in PY2020, we were able to use actual manufacturer specifications for size and efficiency. For this measure, the actual program-supported units were, on average, more efficient than the 2020 planning assumptions used to claim ex-ante gross savings.
- **Refinement to other algorithm inputs, such as a baseline efficiency standard or coincidence factor (CF), based on an improved source or revised assumption.** This is evident for Heat Pump Pool Heaters where the baseline efficiency of fossil fuel units was revised to match the federal standard, and for Lighting, where we added a missing in-service rate parameter and updated the coincidence factor and waste heat factor assumptions. These types of findings translate particularly easily into simple TRM updates.
- **Improvement of the calculation method/algorithm itself, often enabled by install data.** For example, the 2020 Refrigerator Recycling tracking data contains model specifications like volume, age, and configuration for all recycled units. This enabled the evaluation team to replace deemed savings values with unit-specific annual consumption estimates derived using the Uniform Methods Project regression model for Refrigerator Recycling.[7]

The sub-sections below summarize the key drivers in order of measure contribution to the overall EEP MMBtu realization rates. The measure categories detailed in this section (Heat Pump Pool Heaters, Lighting, Recycling, Appliances, Heat Pump Water Heaters, and Thermostats) account for nearly all of the overall EEP MMBtu variance. Measures *not* covered in detail (Lawn Equipment, Bathroom Exhaust Fans and Power Strips) are summarized in Table 3-13 at the end of this section.

[7] UMP Refrigerator Recycling, https://www.nrel.gov/docs/fy17osti/68563.pdf

Figure 3-4 MMBtu Variance by Measure Category (Ex-Post Gross minus Ex-Ante Gross)



3.2.2.1 Heat Pump Pool Heaters

HPPH realization rates are 37% for MMBtu and 8% for MWh. Demand (kW) savings are assumed to be zero because we assume limited pool heating is required on system peak day when temperatures are in the 90s on Long Island. This measure is a new addition to EEP in 2020 and was first characterized in 2020 planning assumptions. Heat pump pool heaters are included in the 2021 PSEG LI TRM, but the measure is not currently included in the New York TRM.

Table 3-8 Key Contributors to RR Variance and Recommendations: Heat Pump Pool Heaters

Component	Summary of Contributing Factors	Recommendations
Heat Pump Pool Heaters	▪ **2020 Planning Assumptions Rely on Inconsistent Heating Loads between Baseline and Efficient Case:** In 2020 planning assumptions based on the 2020 PSEG-LI TRM, electric baseline pool heaters are assumed to deliver ten times more heat to the pool water than the HPPH. Standardizing the algorithm assumptions about heat load lowers to baseline electric use significantly. ▪ **Evaluation Results Assume Federal Code as the Baseline:** This key assumption about the baseline thermal efficiency of a fossil fuel pool heater was updated to the Department of Energy Federal code of 82%. For end of life replacement measures, code minimum efficiency is the appropriate baseline for gross savings. ▪ **HPPH COP and Baseline Energy Use:** The actual average coefficient of performance (COP) of all HPPH units incentivized according to AHRI model lookups in 2020 was 5.98, higher than the planning assumption of 5.0.	▪ **Revise TRM and planning assumptions** around fossil fuel baseline efficiency. Consider update to the COP assumption based on 2020 install data and normalizing the measure by size so that a large unit saves more than a small unit. ▪ **Invest in more HPPH research.** Previous HPPH research has already positioned this measure well to help customers save a lot of energy. Heat Pump Pool Heaters are responsible for 13% of Ex-Post gross MMBtu savings in 2020. Section 3.2.2.1.1 discusses our suggested research questions in more detail. ▪ **Future Implications:** Unless there is a mid-year correction, we expect the 2021 evaluation will show the same variance between ex-ante and ex-post as the 2020 evaluation. The realization rate volatility from this evaluation should lessen considerably in 2022 once planning assumptions are aligned with the PSEG Long Island TRM.

Table 3-9 compares per-unit HPPH resource impacts across 2020 planning assumptions, 2020 evaluation, and the 2021 PSEG Long Island TRM. We anticipate the 2022 PSEG Long Island TRM measure characterization to mirror 2020 evaluation results.

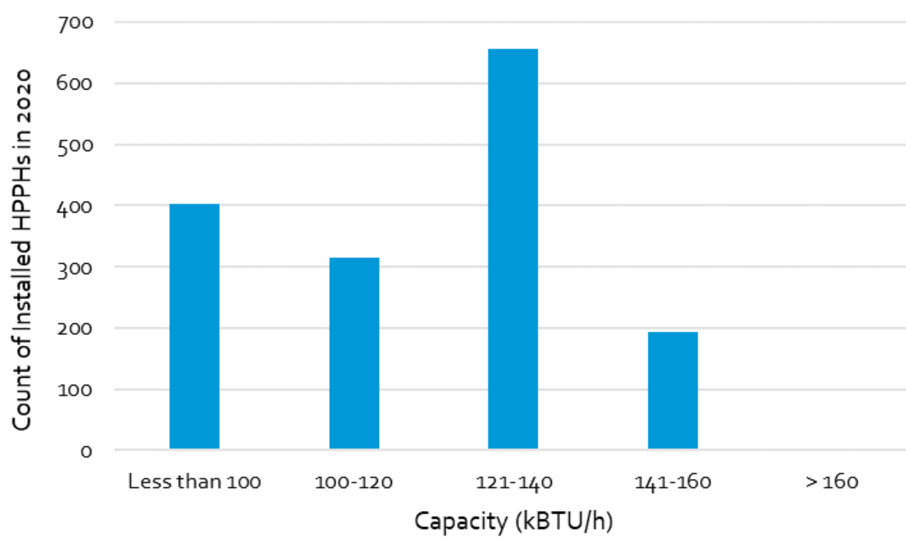
Table 3-9: HPPH Assumptions and Resource Savings by Source

Resource	2020 Planning	2021 PSEG LI TRM	2020 Evaluation
kW	0	0	0
kWh_{ee}	17,392	2,117	2,276
kWh_{be}	1,164	1,164	1,006
ΔkWh	16,225	953	1,270
$MMBtu_{ee}$	59	7	8
$MMBtu_{be}$	19	19	22
$MMBtu_{total}$	79	26	29

3.2.2.1.1 OPPORTUNITIES TO FURTHER REFINE HEAT PUMP POOL HEATERS RESEARCH

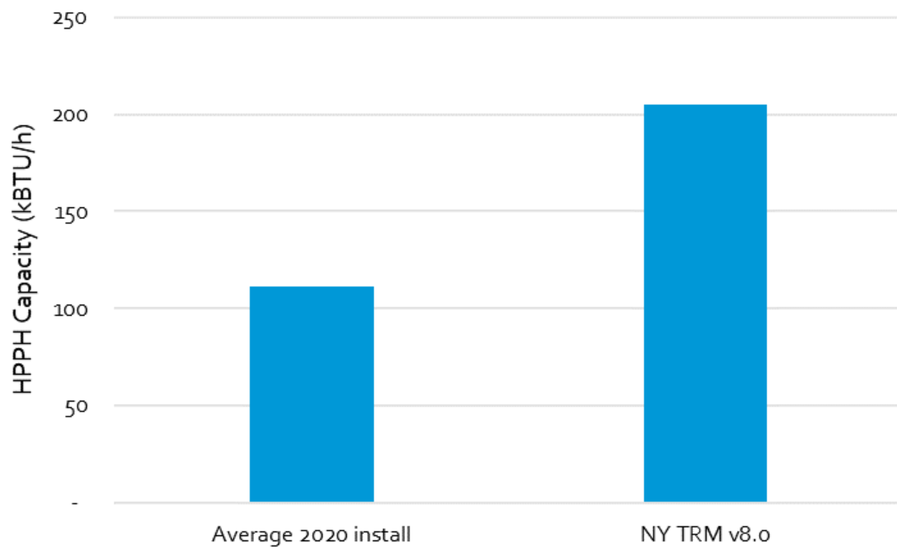
Despite low realization rates in 2020, heat pump pool heaters remain an appealing measure in terms of overall MMBtu savings and acquisition cost. PSEG-LI expertise around this measure has improved extensively since PY2020 thanks to research from program implementation and planning teams. Because of the expected contribution going forward, opportunities to further refine planning assumptions could include gathering more data about the average pool size in the PSEG-LI service area, frequency of pool covers, water temperature, operating seasons and hours, pump sizing, and bill impacts. The current measure characterization assumes that 69% of pool heaters are fossil fuel and the other 31% are electric based on RECS 2015[8] data for the Northeastern United States. The economics and beneficial electrification impacts of the measure are sensitive to this input so we recommend Long Island-specific research. Based on 2020 install data, the average heating capacity of all units rebated in 2020 is 111 kBtu/hour (See Figure 3-6 below), which is smaller than the NY TRM v7 assumption of 205 kBtu/hour output for a fossil fuel pool heater.[9] This suggests that heat pump pool heaters are sized smaller, but run more hours than baseline pool heaters. We recommend interviews with contractors to discuss sizing practices.

Figure 3-5 Installed HPPH Capacity in 2020



[8] 2015 RECS Survey Data. https://www.eia.gov/consumption/residential/data/2015/
[9] Heat pump pool heaters are rated in terms of heat output. The New York TRM assumption of 250 kBtu/hour input capacity at 82% thermal efficiency corresponds to 205 kBtu/hour of heat output.

Figure 3-6: Comparison of Heat Output Capacity (HPPH vs. TRM Baseline)



3.2.2.2 Lighting

As shown in Table 3-10, the gross realization rates (ratio of Ex-Post Gross to Claimed savings) for lighting measures combined are 93% for MMBtu savings, 97% for kWh savings, and 55% for kW.

Table 3-10: EEP Lighting Realization Rates by Measure

Measure	N	MMBtu RR	kWh RR	kW RR
EEP-1200 LED Standard	845,908	104%	104%	59%
EEP-1250 LED Specialty	2,434,728	93%	94%	53%
EEP-1210 Connected Lighting Bulbs	3,761	152%	127%	687%
EEP-2000 Connected Lighting Kits	555	27%	12%	69%
LED-S In-storage LEDs	303,612	73%	110%	62%
Total (Weighted Average)	**3,588,564**	**93%**	**97%**	**55%**

Outside of minor adjustments to wattages based on lookups against the ENERGY STAR Qualified Products List, lighting realization rates are largely explained by omission of the TRM in-service rate from MMBtu planning assumptions, along with an updated coincidence factor. Table 3-11 lists the key drivers of differences between ex-ante gross and ex-post gross impacts for EEP lighting measures along with our recommendations for better aligning ex-ante and ex-post savings going forward.

Table 3-11 Key Contributors to RR Variance and Recommendations: Lighting

Component	Summary of Contributing Factors	Recommendations
Standard & Specialty Bulbs	▪ **EEP tracking data shows installed and baseline wattages** of standard & specialty LEDs that are lower than planning assumptions. ▪ **MMBtu ex-post calculations include the in-service rate:** the TRM year-one ISR of 89% was applied to kWh planning calculations but not carried through to MMBtu planning calculations. ▪ **Coincidence Factor Updated from 2016 Assumptions:** The 23% CF used for planning was based on "LED-only" metering results from 2016 when LEDs were still relatively expensive and mostly installed in high-use sockets. ▪ **Updated HVAC interactive effect assumptions**: based on concerns regarding the vintage and methodology used in the NYS TRM, the evaluation team developed new residential and commercial factors using Long Island-specific inputs and a transparent calculation method.	▪ **Revise TRM and planning assumptions** around coincidence factor, waste heat factors, in-storage LEDs, and Connected Kits unit counts. ▪ **Split Specialty LEDs into more specific product tiers** and track installs and savings accordingly. This change will provide PSEG Long Island flexibility and improved accuracy if the mix of specialty lamps changes in future years.
In-storage LEDs[10]	▪ In-storage LEDs were approximately 51% Standard and 49% Specialty Bulbs. Ex-Post savings calculations include a waste heat penalty and apply a 100% ISR.	
Connected Lighting	▪ All connected lighting projects were carryover from 2019 and were not planned for in 2020. ▪ **The average baseline wattage was 131% of the planning value** due to the inclusion of some reflectors and standard A-lamps. ▪ **For Kits, an errant multiplier** (presumably intended to account for multiple bulbs per kit) effectively triple-counted total bulb quantities.	

3.2.2.3 Other EEP Measures

Table 3-12 presents a summary for other EEP program components where ex-post gross savings differed materially from ex-ante gross savings.

Table 3-12 Key Contributors to RR Variance and Recommendations: Other EEP Measures

Component	Summary of Contributing Factors	Recommendations
Recycling	Combined realization rates for recycling measures (refrigerators, room air conditioners, and dehumidifiers) are 252% for MMBtu, 252% for kWh, and 283% for kW.	
	Recycling realization rates are driven by the removal of the replacement equipment energy consumption from the energy usage differential. Ex-Post savings are based on the removed unit only, in accordance with the industry standard practice, the NY TRM, and the Uniform Methods Project protocol.	▪ **Consolidate refrigerator recycling into a single measure**. The program tracking database includes a rich set of characteristics that can be used to calculate annual energy consumption using the regression model from the DOE's Uniform Methods Project protocol. [11]
Appliances	Combined Appliance RRs are 70% for MMBtu, 79% for kWh, and 53% for kW. The biggest measure in this category is Clothes Washers.	

[10] DSA applied the second-year and third-year carryover in-service rates of 5% and 3%, respectively, to 2019 and 2018 LEDs supported via EEP. The delayed savings claim accounts for 303,612 LEDs or about 8% of total bulbs verified for 2020.

[11] Universal Methods Project Chapter 7: Refrigerator Recycling Evaluation Protocol. National Renewable Energy Lab, 2017. https://www.nrel.gov/docs/fy17osti/68563.pdf

Component	Summary of Contributing Factors	Recommendations
	Weighted average fossil fuel water heating energy savings are lower when derived using model data and the NYS TRM v7 rather than the planning value from the Massachusetts TRM, which could be confusing this end of life baseline with an early retirement measure. While approximately one-fourth of the dehumidifiers incentivized through EEP in 2020 were not on the version 5.0 ENERGY STAR qualified products list effective 10/2019, all units were included in ex-post gross calculations. [12,13]	▪ **Anchor program eligibility requirements in current codes and standards.** Continue to align eligibility with the most current ENERGY STAR qualified product lists and have clear business rules around changes to codes and standards. ▪ After a "sell-through" period to address known changes, only rebate units that comply with current ENERGY STAR standards.
Heat Pump Water Heaters	Combined HPWH realization rates across the two measures are 209% for MMBtu, 108% for kWh, and 100% for kW. Install data was used to derive uniform energy factors (UEFs) for baseline and efficient cases based on model numbers and ENERGY STAR standards for tank capacity.	
	The use of a Uniform Energy Factor (UEF) for a code minimum baseline fossil fuel water heater instead of the baseline UEF of an electric water heater use for planning (which is much higher) explains higher ex-post beneficial electrification MMBtu savings. The participating household is assumed to purchase a new water heater because their old heater has reached the end of its useful life. An 85/15 fossil fuel/electric split is assumed in baseline water heating fuel based on the 2018 PSEG Long Island Baseline study. For the 85% of participants assumed to have a fossil fuel baseline, the baseline thermal efficiency is that of a code-minimum fossil fuel unit.	▪ **Revise TRM and planning assumptions** around fossil fuel baseline efficiency. ▪ **Update the peak demand algorithms in the TRM to reflect increase in peak load from kW_{be} units where applicable.** This measure adds electric load to the grid, some amount of which will be coincident with the system peak. The additional peak load from fuel conversions will offset the peak demand reduction from homes that convert from an electric resistance unit to a heat pump water heater.
Learning & Connected Thermostats	Combined realization rates for Thermostats are 97% for MMBtu and 104% for kWh. The premise behind having two Wi-Fi thermostat measures is that thermostats with learning capabilities save more energy than those without. However, the MMBtu planning assumptions for thermostats without learning capabilities were larger than their supposedly more efficient counterpart.	

[12] https://www.regulations.gov/document/EERE-2012-BT-STD-0027-0045

[13] https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Dehumidifiers%20Version%205.0%20Program%20Requirements.pdf

Component	Summary of Contributing Factors	Recommendations
	We calculated savings for both types of thermostats using the PSEG Long Island TRM savings algorithm of the Learning Thermostat and the ENERGY STAR product specifications for Connected Thermostats.	▪ **Standardize the Wi-Fi thermostat savings algorithms.** Rather than using deemed per-unit savings for Connected Thermostats and a savings-factor-based algorithm for Learning Thermostats, combine these measures and apply different savings factor(s) to each. ▪ **Segment thermostats into those with and without free opt-in optimization features** rather than the current learning vs. connected distinction.[14]

Table 3-13 shows the realization rates for EEP program components not detailed above, comprising the *Lawn Equipment* and *Other* categories in the preceding tables.

Table 3-13 Realization Rates for Remaining Program Components

Measure	N	MMBtu RR	kWh RR	kW RR
Power Strip	142	98%	98%	98%
Bathroom Exhaust Fan[a]	128	91%	91%	91%
Lawn Mower	1,049	112%	100%	-
Weed Trimmer	1,357	100%	100%	-
Leaf Blower	1,448	100%	100%	-

[a]Bathroom Exhaust Fan measure removed in program year 2020. All completed projects are carryover from 2019.

[14] Nest Seasonal Savings (https://nest.com/energy-solutions/) and ecobee's eco+ (https://www.ecobee.com/en-us/eco-plus/) are both free to thermostat owners on an opt-in basis.

4 HOME COMFORT PROGRAM

PSEG Long Island's Residential Home Comfort program aims to reduce the energy usage of residential customers with central air conditioning systems or heat pumps. The primary objective of the program is to influence PSEG Long Island customers to make high efficiency choices when purchasing and installing ENERGY STAR® ducted split air-source heat pumps (ASHP), ductless mini split heat pumps (HP), and ground source heat pumps (GSHP). In the spring of 2019, PSEG Long Island rebranded the Cool Homes Program to the Home Comfort Program. In 2020, to align with NYSERDA's plans to promote the installation of more air-source heat pumps, the Home Comfort program offered higher rebates for air-source heat pumps.

4.1 HOME COMFORT PROGRAM DESIGN AND PARTICIPATION

The following sections detail the program design, implementation strategies, and PY2020's participation and performance for the Home Comfort program.

4.1.1 PROGRAM DESIGN AND IMPLEMENTATION

The Home Comfort program offers customer rebates and contractor incentives for heating and cooling system upgrades. Program participation is primarily driven through partnerships with installation contractors, also called Home Comfort Participating Contractors. In 2020, split central air conditioner (CAC) systems and ductless mini split ACs were not eligible for rebates through the Home Comfort program. However, rebates were paid in 2020 to those units which were part of a backlog of 2019 applications and hence were claimed towards savings in 2020.

Engaging the installation contractors to deliver the program has improved program performance and market impacts by ensuring the Quality Installation Verification of HVAC equipment, which includes right-sizing of the equipment, refrigerant charge correction, and airflow testing. All whole-house heat pumps[15] in 2020 required a Quality Installation Verification installation.

4.1.2 PROGRAM PARTICIPATION AND PERFORMANCE

Based on verified ex-ante estimates, the Home Comfort program reached 73% of its energy savings goal in 2020. Table 4-1 presents 2020 Home Comfort programs verified ex-ante gross MMBtu savings compared to goal.

[15] A whole-house heat pump system is sized and installed to provide between 90% and 125% of the design heating load per Manual J calculations.

Table 4-1: Home Comfort Program Verified Ex-Ante Gross MMBtu Savings versus Goals

Metric	MMBtu
Goal	111,021
Verified Ex-Ante Gross Savings	81,266
% of Goal	73%

In 2020, there was a significant increase in the installation of ducted ASHPs and ductless mini split heat pumps through the Home Comfort program, consistent with PSEG Long Island MMBtu-based savings goals and New York State Clean Heat initiatives. The split CAC measures were phased out in 2020, although incentives were paid for 1,304 CACs carried over from 2019 with savings claimed in 2020.

Table 4-2: Comparison of Home Comfort Program Measures Installed – 2018 to 2020

Measure	2018	2019	2020	Percent Difference 2019 to 2020
Split CAC	3,415	2,315	1,304	-44%
Smart Thermostats	155	162	227	40%
ASHP	346	385	822	114%
Ductless Mini Split Heat Pumps	1,884	2,045	2,837	39%
GSHP	151	142	132	-7%
Total	**5,951**	**5,049**	**5,322**	**5%**

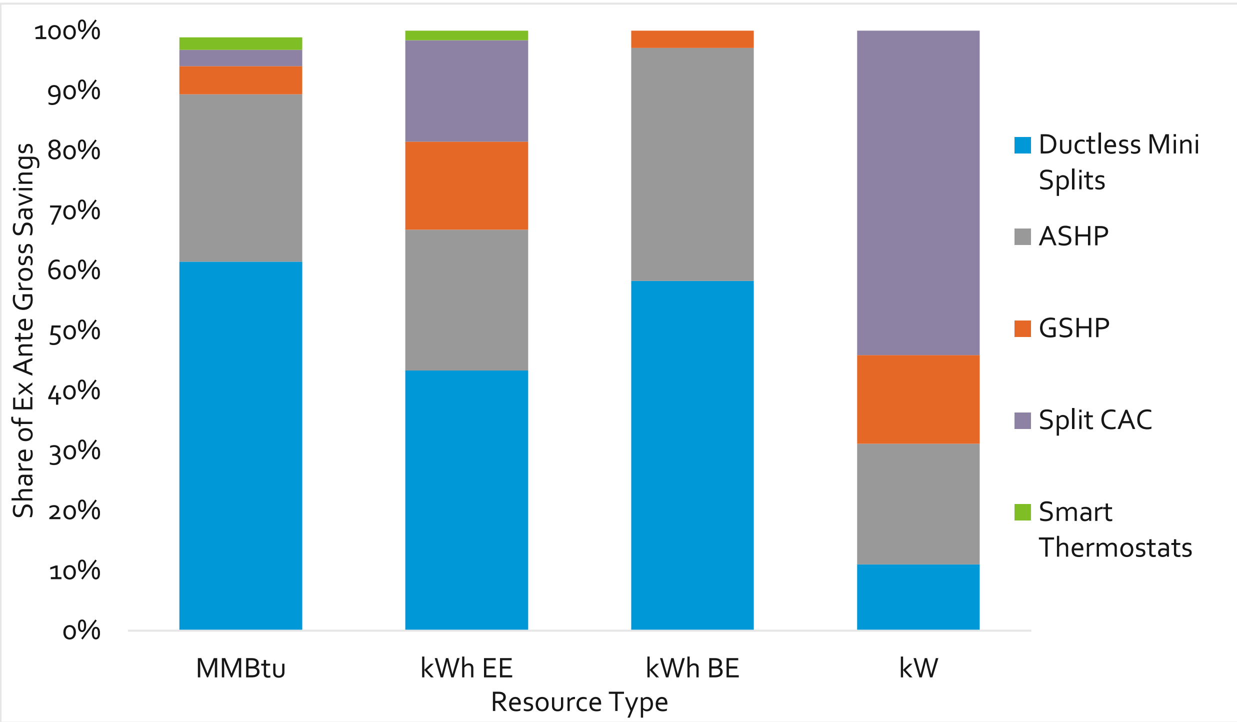
Figure 4-1 shows the distribution of ex-ante gross energy and demand savings across the Home Comfort program. ASHPs and ductless mini splits accounted for a combined 89% of the ex-ante gross MMBtu savings in 2020. These installations also resulted in beneficial electrification impacts for which a baseline heating load supplied by a fossil fuel source was displaced by the incented heat pump. When planning for the 2020 program year, program implementers identified the cooling and heating baseline scenarios for heat pump installations shown in Table 4-3. Evaluators reviewed and agreed with these baseline assumptions during the program planning phase and have therefore incorporated them in the calculation of ex-post impacts.

Table 4-3: Cooling and Heating Baseline Scenarios for Heat Pump Installations

Scenario	Preexisting Cooling Equipment	Preexisting Heating Equipment	Cooling Baseline	Heating Baseline
New Construction	N/A	N/A	Code Compliant HP	Code compliant fossil fuel furnace
Retrofit	AC or Heat Pump	Fossil Fuel	Preexisting AC or HP	Preexisting fossil fuel furnace/boiler
Retrofit	AC or Heat Pump	Electric Resistance or Heat Pump	Preexisting AC or HP	Preexisting electric heating system

Beneficial electrification measures increase electricity consumption, resulting in negative kWh impacts, but reduce total energy consumption (MMBtu) and emissions from the displacement of fossil fuels. Scenarios 1 and 2 above result in beneficial electrification impacts, shown as kWh BE in Figure 4-1. The electric savings resulting from the installation of efficient heating and cooling equipment is shown as kWh EE.

Figure 4-1: Home Comfort Program Ex-ante Gross Impacts by Resource and Measure Category



4.2 HOME COMFORT IMPACTS

The following sections provide the results of the impact analysis for the Home Comfort program.

4.2.1 OVERVIEW OF IMPACTS BY RESOURCE TYPE

Table 4-4 shows ex-post gross and MMBtu impacts by measure category and the net-to-gross ratios used to estimate ex-post net impacts for benefit-cost analysis. Table 4-5 and Table 4-6 show the ex-post MWh and kW impacts, respectively. The evaluation team calculated realization rates by dividing ex-post gross savings values by ex-ante gross savings values. Overall, the Home Comfort program realized 103% of its ex-ante gross MMBtu energy savings claims, 187% of MWh impacts claims, and 78% of kW savings claims. Note that the overall gross MWh impacts are negative for the Home Comfort program due to significant increase in site-level electric consumption from beneficial electrification measures (e.g., heat pumps). We expand on the impacts of beneficial electrification for Home Comfort measures in Section 4.2.1.1.

Table 4-4: 2020 Home Comfort Program Ex-Post Gross MMBtu Impacts

Measure	N	Ex-Ante Gross Savings (Claimed) MMBtu	Ex-Post Gross Savings MMBtu	Realization Rate %
Split CAC (QI installs)	1,073	1,516	1,517	100%
Split CAC (Non-QI installs)	231	283	283	100%
Smart Thermostats with CAC	135	64	22	35%
Smart Thermostats with HP	87	101	194	191%
Wifi Thermostats with HP	5	2	2	94%
ASHP	822	28,015	23,828	85%
Ductless Mini Splits	2,837	46,830	50,229	107%
GSHP	132	4,446	7,412	167%
Totals[1]	**5,322**	**81,264**	**83,487**	**103%**

Note: Totals may not sum due to rounding.

[1] Six project adjustments of 8 MMBtu are included in ex-ante total gross savings and overall realization rates, but not shown as a separate line item in this table.

Table 4-5: 2020 Home Comfort Program Ex-Post Gross MWh Impacts

Measure	N	Ex-Ante Gross Savings[2] (MWh)	Ex-Post Gross Savings[2] (MWh)	Realization Rate (MWh)
Split CAC (QI installs)	1,073	444.3	444.5	100%
Split CAC (Non-QI installs)	231	83.7	82.9	99%
Smart Thermostats with CAC	135	18.8	6.5	35%
Smart Thermostats with HP	87	29.7	56.7	191%
Wifi Thermostats with HP	5	0.6	0.5	94%
ASHP	822	-1,445.1	-2,125.8	147%
Ductless Mini Splits	2,837	-1,912.2	-3,221.9	168%
GSHP	132	295.9	-169.9	-57%
Totals[1]	**5,322**	**-2,638.0**	**-4,926.4**	**187%**

Note: Totals may not sum due to rounding.

[1] Six project adjustments of -153.6 MWh are included in ex-ante total gross savings and overall realization rates, but not shown as a separate line item in this table.

[2] MWh impacts include both energy efficiency (EE) and beneficial electrification (BE) components. MWh impacts are negative for heat pump measures (ASHP, GSHP, and Ductless Mini Splits) due to the displacement of preexisting fossil fuel heating with electricity. The forthcoming section separates the EE and BE components for all measure groups and further explains the reasons for negative impacts.

Table 4-6: 2020 Home Comfort Program Ex-Post Gross kW Impacts

Measure	N	Ex-Ante Gross Savings (kW)	Ex-Post Gross Savings (kW)	Realization Rate (kW)
Split CAC (QI installs)	1,073	497	428	86%
Split CAC (Non-QI installs)	231	79	63	80%
Smart Thermostats with CAC	135	0	0	N/A
Smart Thermostats with HP	87	0	0	N/A
Wifi Thermostats with HP	5	0	1	N/A
ASHP	822	214	180	84%
Ductless Mini Splits	2,837	118	105	89%
GSHP	132	157	59	38%
Totals[1]	**5,322**	**1,063**	**836**	**78%**

Note: Totals may not sum due to rounding.

[1] Six project adjustments of -2kW are included in ex-ante total gross savings and overall realization rates, but not shown as a separate line item in this table.

4.2.1.1 Beneficial Electrification Impacts

Table 4-7 shows the breakdown of Energy Efficiency (EE) and Beneficial Electrification (BE) components of MMBtu and kWh savings for measures where a BE component exists. The ASHP, ductless mini split heat pumps, and GSHP measures include a mixture of electric energy efficiency and beneficial electrification impacts.

Table 4-7: Breakdown of Ex-Post Gross Impacts by EE and BE Components

Measure	MWh_{ee}	MWh_{be}	MWh Total (EE - BE)	$MMBtu_{ee}$	$MMBtu_{be}$	MMBtu Total (EE + BE)
ASHP	546	2,671	-2,126	1,714	22,114	23,828
Ductless Mini Splits	1,097	4,319	-3,222	3,448	46,781	50,229
GSHP	134	304	-170	457	6,955	7,412
Total	**1,777**	**7,295**	**-5,518**	**5,620**	**75,850**	**81,470**

We estimate that 2020 program-supported heat pump measures added 7,295 MWh/year of additional electrical sales by displacing preexisting fossil fuel-fired systems. The program incented customers and contractors to install high-efficiency heat pumps that, when compared with code-compliant heat pumps or pre-existing electric heating equipment, led to 1,777 MWh of energy savings. The overall electric consumption therefore increased by 5,518 MWh. However, accounting for the consumption of displaced fossil fuels in the $MMBtu_{be}$ column, Home Comfort heat pumps led to 81,740 MMBtu savings.

4.2.2 Key Drivers for Differences in Impacts

To estimate ex-post gross energy and demand savings, we used installed sizes and efficiencies of rebated equipment, as determined through examination of the 2020 program tracking data. We relied on the 2020 PSEG Long Island TRM, which references the 2015 International Energy Conservation Code and NY TRMv7, for baseline efficiencies. We 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 savings algorithms and assumptions, including, but not limited to, baseline efficiencies and full load operating hours of equipment. In 2020, there was an increased emphasis on electrification of fossil fuel systems, for the purpose of meeting decarbonization goals. This resulted in an overall increase of electric equipment load on the grid due to the displacement of fossil fuel heating loads by heat pumps.

Below we describe the reasons for discrepancies between gross ex-ante savings and ex-post savings for each measure.

Table 4-8: Key Contributors to Home Comfort MMBtu RR and Recommended Adjustments

Component	Summary of Contributing Factors	Recommendation
Air-Source & Ductless Heat Pumps	▪ Quality Install (QI) savings algorithms differed from those prescribed in the 2020 PSEG-LI TRM. ▪ Full load heating and cooling hours differed from 2020 PSEG-LI TRM recommendations, specifically for ductless mini split heat pumps. The 2020 PSEG-LI TRM recommendations align with NE NY's	▪ Align QI savings algorithms with PSEG-LI TRM. ▪ Align the full load heating and cooling hours with PSEG-LI TRM for ductless mini split units.

Component	Summary of Contributing Factors	Recommendation
	"Analysis of Residential Heat Pump Potential and Economics-May 2019" (NYSERDA HP study).	
Geothermal Heat Pumps	▪ Implementer applied savings algorithms that differed from 2020 PSEG-LI TRM algorithms (equipment capacity-based algorithms vs. Manual J based algorithms in the PSEG-LI TRM).	▪ Align savings algorithms with PSEG-LI TRM.
Smart Thermostats	▪ Implementers applied deemed savings values for 2019 carryover measures utilizing the 2019 planning assumptions instead of using algorithms in 2020 PSEG-LI TRM. ▪ Full load heating and cooling hours differed from 2020 PSEG-LI TRM recommendations, specifically for thermostats installed with heat pumps.	▪ Align savings estimation methods with PSEG-LI TRM. ▪ Align the full load heating and cooling hours with PSEG-LI TRM.

4.3 CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this evaluation, our key findings and recommendations for the Home Comfort Program are presented in Table 4-9.

Table 4-9: Home Comfort Findings and Recommendations

Finding	Recommendation
▪ The measure-specific savings algorithms and assumptions used by the implementers varied from the 2020 PSEG Long Island TRM for various measures as shown in Table 4-8.	▪ Home Comfort program implementers should apply most up to date PSEG Long Island TRM algorithms and assumptions to improve the alignment of ex-ante and ex-post demand and energy impacts.
▪ For beneficial electrification measures (ASHP, GSHP, and ductless mini splits), the program tracking database contained limited data on the preexisting fossil fuel fired heating system. Additionally, project documentation on AHRI equipment capacities and efficiencies for GSHP installations did not completely match values listed in the program tracking database.	▪ To improve the accuracy of ex-ante savings estimation of beneficial electrification measures, we recommend collecting and tracking the quantity, capacity, total heating load share, and thermal efficiency of the preexisting boiler or furnace heating system, and utilizing these data points in the ex-ante savings calculations for heat pumps. For GSHP installations, consider aligning tracked values for equipment capacity and efficiencies with those listed on unit specifications and AHRI certificates.

Finding	Recommendation
▪ For 2019 carryover projects involving smart thermostats, program administrators applied a deemed, cooling-only savings value for smart thermostat savings that does not consider HVAC system type.	▪ As recommended in the PSEG Long Island TRM, adopt deemed savings values that vary based on the HVAC equipment controlled by the thermostat.

5 RESIDENTIAL ENERGY AFFORDABILITY PARTNERSHIP PROGRAM

5.1 PROGRAM DESCRIPTION

The Residential Energy Affordability Partnership (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 (general service, globes, reflectors, candelabras, and night lights), domestic hot water (DHW) measures, thermostatic valves, exterior lighting, Tier II smart power strips, room air conditioners (RACs), dehumidifiers, refrigerators. In 2020, the program administrators added room air purifiers 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

Based on verified ex-ante estimates, the REAP program reached 91.7% of its energy savings goal in 2020. Table 5-1 presents verified ex-ante gross MMBtu savings compared to goals for the 2020 REAP program.

Table 5-1. 2020 REAP Program Verified Ex-ante Gross Program Performance against Goals

Metric	MMBtu
Goal	3,903
Verified Ex-ante Gross Savings	3,048
% of Goal	78.1%

Table 5-2 shows the distribution of savings by program component. Lighting continues to account for the largest share of gross REAP program savings, accounting for 29.7% of ex-ante gross MMBtu savings, 51.58% of ex-ante gross MWh savings, and 64.76% of ex-ante gross kW savings in 2020.

Table 5-2. 2020 REAP Program Component Percent of Total Ex-Ante Gross Savings

Program Component	Ex-Ante Utility Gross Savings		
	MMBtu (%)	MWh (%)	kW (%)
Lighting	29.68%	51.58%	64.76%
Night Lights	1.37%	2.56%	-
Room AC	2.74%	2.50%	14.50%
Dehumidifiers	2.73%	2.50%	1.93%
DHW – Pipe Insulation	2.17%	0.24%	0.02%
DHW – Temperature Turndown	0.13%	0.01%	0.01%
DHW – Thermostatic Shower Valve	3.58%	0.33%	-
DHW – Low Flow Showerheads	13.47%	1.23%	-
DHW – Aerators	2.85%	0.26%	-
Room Air Purifiers	20.10%	18.40%	9.08%
Power Strips	20.42%	18.66%	8.83%
Refrigerators	0.77%	1.73%	0.88%

The REAP program treated 1,175 unique participants in 2020 compared to 2,155 customers in 2019 for a decrease of 45%. 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

Category	Percent Receiving
Lighting	95.8%
Night Lights	96.6%
Room AC	28.5%
Dehumidifiers	11.9%
DHW – Pipe Insulation	3.7%
DHW – Temperature Turndown	1.1%
DHW – Thermostatic Shower Valve	10.4%

Category	Percent Receiving
DHW – Low Flow Showerheads	12.3%
DHW – Aerators	12.4%
Room Air Purifiers	20.0%
Power Strips	98.8%
Refrigerators	5.4%

5.2 REAP PROGRAM IMPACTS

5.2.1 Overview of Impacts by Resource

As in previous years, we used both engineering and consumption analysis to estimate savings for the REAP program in 2020. Ex-post gross MMBtu savings (Table 5-4) and ex-post gross kW savings (Table 5-6) rely on both the engineering analysis and the consumption analysis, while ex-post gross MWh savings (Table 5-5) rely exclusively on the consumption analysis[16]. The program achieved ex-post gross MMBtu savings of 2,334 MMBtu, ex-post gross MWh savings of 789 MWh, and ex-post gross kW savings of 111 kW.

Table 5-4. 2020 REAP Program MMBtu Impacts

Category	N	Ex-Ante Gross Savings (Claimed) MMBtu	Ex-Post Gross Savings MMBtu	Realization Rate %
Lighting	16,732	901.8	840.3	93.2%
Night Lights	1,481	41.6	39.5	94.9%
Room Air Conditioning	487	83.2	67.4	81.1%
Dehumidifiers	139	83.1	67.4	81.1%
DHW – Pipe Insulation	211	65.8	53.4	81.1%
DHW – Temperature Turndown	13	3.9	3.2	81.1%
DHW – Thermostatic Shower Valve	169	108.7	88.2	81.1%
DHW – Low Flow Showerheads	194	409.1	330.8	80.9%
DHW – Aerators	267	86.7	70.3	81.1%
Air Purifiers	235	610.8	495.4	81.1%
Power Strips	1,161	620.4	502.4	81.0%
Refrigerators	63	23.3	18.8	80.7%
Totals	**21,152**	**3,038**	**2,577**	**84.8%**

[16] To calculate ex-post gross kWh savings due to energy efficiency (EE kWh savings), we applied the consumption analysis realization rate (81%) to the ex-ante gross EE savings. To calculate the ex-post gross kWh impacts due to beneficial electrification measures, we utilized results from engineering analysis. To calculate ex-post gross demand and MMBtu savings, we used a kW/kWh and MMBtu/kWh ratio respectively developed from the engineering analysis and applied to the ex-post gross energy savings.

Table 5-5. 2020 REAP Program MWh Impacts

Category	N	Ex-Ante Gross Savings (Claimed[1])	Ex-Post Gross Savings	Realization Rate
		MWh	MWh	%
Lighting	16,732	501.8	407.0	81.1%
Night Lights	1,481	24.9	20.2	81.1%
Room Air Conditioning	487	24.4	19.8	81.1%
Dehumidifiers	139	24.3	19.7	81.1%
DHW – Pipe Insulation	211	2.3	1.9	81.1%
DHW – Temperature Turndown	13	0.1	0.1	81.1%
DHW – Thermostatic Shower Valve	169	3.2	2.6	81.1%
DHW – Low Flow Showerheads	194	12.0	9.7	81.1%
DHW – Aerators	267	2.5	2.1	81.1%
Air Purifiers	235	179.0	145.2	81.1%
Power Strips	1,161	181.6	147.2	81.1%
Refrigerators	63	16.8	13.6	81.1%
Totals	**21,152**	**972.9**	**789.0**	**81.1%**

[1] MWh Ex-Ante Gross Savings (Claimed) in table might not match KPI scorecard values. Table values include all Energy Efficiency Savings as well as Beneficial Electrification, while KPI scorecard reports Energy Efficiency Savings only.

Table 5-6. 2020 REAP Program kW Impacts

Category	N	Ex-Ante Gross Savings (Claimed)	Ex-Post Gross Savings	Realization Rate
		kW	kW	kW
Lighting	16,732	146.6	67.5	46.1%
Night Lights	1,481	--	--	--
Room Air Conditioning	487	32.8	16.3	49.7%
Dehumidifiers	139	4.4	3.5	80.9%
DHW – Pipe Insulation	211	0.0	0.2	548.0%
DHW – Temperature Turndown	13	0.0	0.0	64.9%
DHW – Thermostatic Shower Valve	169	--	--	--
DHW – Low Flow Showerheads	194	--	--	--
DHW – Aerators	267	--	--	--
Air Purifiers	235	20.5	16.7	81.1%
Power Strips	1,161	20.0	14.6	73.3%
Refrigerators	63	2.0	1.6	81.3%
Totals	**21,152**	**226.3**	**120.5**	**53.2%**

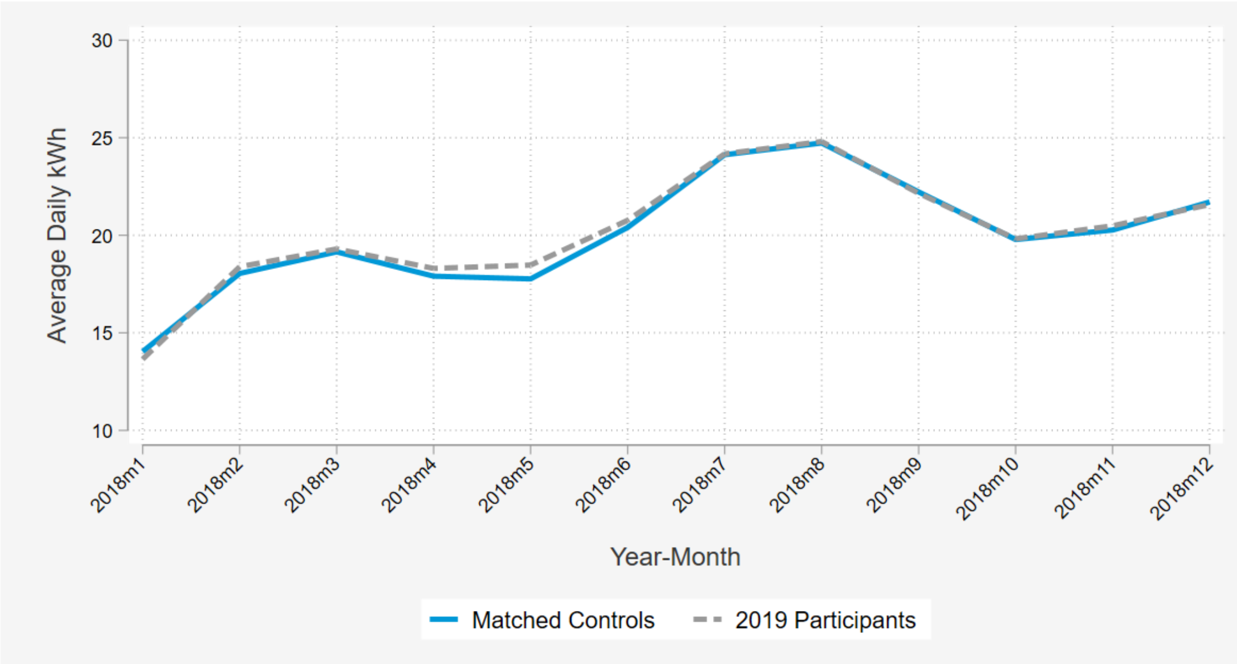
5.2.2 ANALYSIS APPROACH AND DETAILED RESULTS

As noted, we used both engineering and consumption analysis to estimate savings for the REAP program in 2020. 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, we based the program ex-post kWh savings on the results of the consumption analysis. We used the engineering analysis to calculate MMBtu to kWh and kW to kWh ratios at the measure level and utilize these ratios to estimate ex-post gross MMBtu and kW impacts. 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.

5.2.2.1 Consumption Analysis – Approach

Because the consumption analysis requires post-installation electricity usage data for approximately one year after treatment, our analysis uses 2019 participants as the treatment group. We used the pre-participation period of the 2020 participants as a basis for comparison, 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 (2019 participants) in their post-installation period. One difference between the 2020 evaluation and prior evaluations, however, is that we used a matched control design in 2020. In this framework, each treatment group home is matched with exactly one comparison group home based on weather-normalized annual consumption (prior to the energy upgrades) and the weather sensitivity of their consumption. Figure 5-1 compares average daily consumption between treatment group homes and their matched comparison homes. Usage between the two groups shows good alignment. Another benefit to using 2020 participants as a comparison group is that this accounts for the self-selection of program participation.

Figure 5-1: Average Daily Usage of Treatment and Comparison Groups (kWh), Pre-Installation



The consumption analysis model uses monthly billing data to quantify post-participation changes in energy use. The matched controls inherit a pseudo pre-post transition date from their participant match and any billing records after they actually participated (in 2020) are excluded from the analysis. The transition from the pre-period to post-period is based on the project completion date so over the course of 2019, the status the participant group is in aggregate gradually shifts.

The consumption analysis model is a linear fixed effects panel regression model. A fixed effects model absorbs time-invariant household characteristics via inclusion of separate intercept terms for each account in the treatment and comparison group. Additional details regarding the consumption analysis model, including the model specification and model parameter definitions, is presented in Appendix 0. A number of different model specifications were tested to assess the robustness of the results, and the results were indeed consistent across models.

5.2.2.2 Consumption Analysis – Results

In Table 5-7, we use the results of the REAP consumption model to estimate average savings for 2019 participants and compare the estimated impact to the ex-ante gross kWh savings claimed by the implementer. Across the 1,402 Long Island homes included in the regression model, the average annualized savings was 563 kWh.[17] This equals 81.1% of the average ex-ante gross kWh savings claim

[17] There were more than 1,402 REAP participants in 2019. However, only participants with at least one year of pre-participation data and one year of post-participation data were included in the modeling.

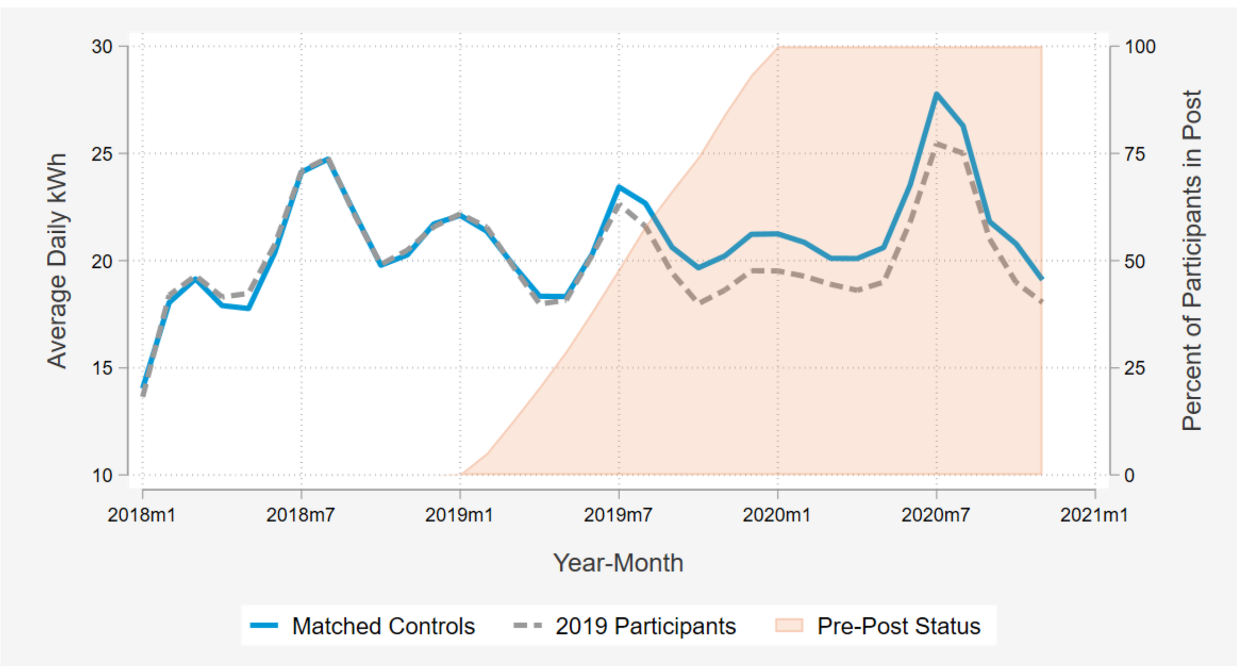
for the same homes. We applied this 81.1% realization rate to the ex-ante gross kWh savings claim of 2020 participants to estimate ex-post gross kWh savings for REAP.

Figure 5-2 visualizes consumption analysis results. As more participants move into the post period, the average daily electric usage for the treatment group begins to depart from the matched control group. This is the effect of interest.

Table 5-7: REAP Consumption Analysis Results (n=1,402)

Parameter	Estimate	Lower Bound of 95% CI	Upper Bound of 95% CI
Daily Treatment Effect (kWh Saved)	1.542	1.175	1.909
Daily Treatment Effect (% Savings)	7.4%	5.6%	9.1%
Annual Savings	563	429	697
Ex-Ante Gross kWh		694	
Realization Rate	81.1%	61.8%	100.4%

Figure 5-2: REAP Consumption Analysis Results Visualized



5.2.2.3 Engineering Analysis

The evaluation team used program tracking data and engineering analysis to estimate gross kWh and kW savings achieved by each measure installed through the 2020 REAP program. As described above, the results of the engineering impacts analysis provide us with (1) the demand to energy ratio needed to develop demand savings from the energy consumption analysis, (2) an MMBtu to kWh ratio needed to develop MMBtu savings from the energy consumption analysis, and (3) 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 5-8, Table 5-9, and Table 5-10 show the ex-post gross MMBtu, MWh, and kW savings as determined by the engineering analysis for each measure category. The sum of measure-level energy savings in the engineering analysis exceed the total gross ex-post energy savings determined through the consumption analysis (see Table 5-5). 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 5-8. 2020 REAP Program Measure-Specific MMBtu Gross Impacts: Engineering Analysis

Category	N	Ex-Ante Gross Savings (Claimed)	Engineering Analysis Ex-Post Gross Savings	Engineering Analysis Realization Rate
		MMBtu	MMBtu	
Lighting	16,732	901.8	1355.8	150.3%
Night Lights	1,481	41.6	60.6	145.6%
Room AC	487	83.2	83.2	100.0%
Dehumidifiers	139	83.1	83.1	100.0%
DHW – Pipe Insulation	211	65.8	65.8	100.0%
DHW – Temperature Turndown	13	3.9	4.6	117.2%
DHW – Thermostatic Shower Valve	169	108.7	108.7	100.0%
DHW – Low Flow Showerheads	194	409.1	475.6	116.2%
DHW – Aerators	267	86.7	86.7	100.0%
Room Air Purifiers	235	610.8	610.8	100.0%
Power Strips	1,161	620.4	620.0	99.9%
Refrigerators	63	23.3	23.0	99.0%
Totals	**21,152**	**3,038**	**3,578**	**117.8%**

Table 5-9. 2020 REAP Program Measure-Specific MWh Gross Impacts: Engineering Analysis

Category	N	Ex-Ante Gross Savings (Claimed)	Engineering Analysis Ex-Post Gross Savings	Engineering Analysis Realization Rate
		MWh	MWh	
Lighting	16,732	501.8	656.6	130.8%
Night Lights	1,481	24.9	31.0	124.4%

Category	N	Ex-Ante Gross Savings (Claimed) MWh	Engineering Analysis Ex-Post Gross Savings MWh	Engineering Analysis Realization Rate
Room AC	487	24.4	24.4	100.0%
Dehumidifiers	139	24.3	24.3	100.0%
DHW – Pipe Insulation	211	2.3	2.3	100.0%
DHW – Temperature Turndown	13	0.1	0.2	117.2%
DHW – Thermostatic Shower Valve	169	3.2	3.2	100.0%
DHW – Low Flow Showerheads	194	12	13.9	116.6%
DHW – Aerators	267	2.5	2.5	100.0%
Room Air Purifiers	235	179	179.0	100.0%
Power Strips	1,161	181.6	181.7	100.1%
Refrigerators	63	16.8	16.7	99.5%
Totals	**21,152**	**973**	**1136**	**116.7%**

Table 5-10. 2020 REAP Program Measure-Specific kW Gross Impacts: Engineering Analysis

Category	N	Ex-Ante Gross Savings (Claimed) kW	Engineering Analysis Ex-Post Gross Savings kW	Engineering Analysis Realization Rate
Lighting	16,732	146.6	109.0	74.3%
Night Lights	1,481	--	--	--
Room AC	487	32.8	20.1	61.2%
Dehumidifiers	139	4.4	4.4	99.7%
DHW – Pipe Insulation	211	0.0	0.3	675.7%
DHW – Temperature Turndown	13	0.0	0.0	93.7%
DHW – Thermostatic Shower Valve	169	--	--	--
DHW – Low Flow Showerheads	194	--	--	--
DHW – Aerators	267	--	--	--
Room Air Purifiers	235	20.5	20.5	100.0%
Power Strips	1,161	20.0	18.1	90.5%
Refrigerators	63	2.0	2.0	99.7%
Totals	**21,152**	**226.3**	**174**	**77.0%**

5.2.3 Key Drivers for Differences in Impacts

5.2.3.1 Reasons for Differences in Engineering Impacts

For MMBtu and MWh savings, the sum of the measure-level savings estimates from our engineering analysis exceeded ex-ante gross savings (see Table 5-8 and Table 5-9). For kW savings, the sum of the measure-level savings estimates from our engineering analysis was less than ex-ante gross demand savings (Table 5-10). Reasons for discrepancies between the ex-ante assumptions and measure-level engineering results are shown in Table 5-11.

Table 5-11: Realization Rate Drivers

Component	Summary of Contributing Factors	Recommendation
Lighting	▪ MMBtu and MWh realization rates both exceeded 100%. The assumptions that were used for the ex-ante savings in 2020 program tracking database were based on a stipulated mix of lamp types and baseline wattages. A different mix of lamps was actually installed and the baseline wattages in the 2020 program tracking database were also different from those used for the per lamp ex-ante savings. ▪ The kW realization rate was 74.3%. This was driven by the coincidence factor. We used a coincidence factor of 12%, which is lower than the value used for ex-ante kW savings (23%). The 23% CF used for planning was based on "LED-only" metering results from 2016 when LEDs were still relatively expensive and mostly installed in high-use sockets. ▪ HVAC interactive effect assumptions were updated based on modeling completed by the evaluation team (Appendix XXX)	▪ Where possible, use actual values rather than TRM assumptions. ▪ Update the lighting coincidence factor to reflect the "All Bulbs" category from the same study (12%).
Night Lights	▪ The MMBtu realization rate was 145.6% and the MWh realization rate was 124.4%. Night lights do not produce peak demand savings, so there was no kW realization rate. The driver for MMBtu and kWh realization rates was the hours of use assumption. We assumed 12 hours per day, which produced per-unit MMBtu and kWh savings of 0.033 MMBtu and 20.82 kWh, respectively. Per-unit savings under ex-ante were 0.028 MMBtu and 16.82 kWh.	▪ Increase the HOU assumption for LED night lights in ex-ante calculations.
Room AC	▪ The kW realization rate was 61.2%. Ex-ante savings calculations used a coincidence factor of 80% for some records and 30% for others. We applied a coincidence factor of 30% (per the PSEG-LI TRM) to all records.	▪ Align coincidence factor with the PSEG-LI TRM.

Component	Summary of Contributing Factors	Recommendation
DHW – Pipe Insulation	▪ The kW realization rate is quite large – 675.7%. We used a CF of 100% rather than 80% as the annual hours of use assumption for this measure is 8,760 hours (or 24 hours per day). This resulted in a modest boost in kW savings. The larger driver was a correction in the formula. The electric water heating factor (0.148) was being applied twice for ex-ante savings.	▪ Align savings algorithms with PSEG-LI TRM.
DHW – Temperature Turndown	▪ MMBtu and kWh realization rates were 117%. We incorporated actual baseline and post water temperatures from the 2020 tracking data rather than values from the PSEG-LI TRM. This resulted in a slightly larger delta temperature value than what was used in the ex-ante calculations.	▪ Where possible, use actual values rather than TRM assumptions.
DHW – Low Flow Showerheads	▪ MMBtu and kWh realization rates were 116.2% and 116.6% respectively. Like with the Temperature Turndown measures, we incorporated actual delta flow rate (GPM, gallons per minute) from the 2020 tracking data. The actual delta flow rate was slightly larger than the assumed value in the ex-ante calculations.	▪ Where possible, use actual values rather than TRM assumptions.
Power Strips	▪ The kW realization rate was 90.5%. Some ex-ante records used a coincidence factor of 80% and others used 100%. In our analysis, we used an 80% CF for all records (per the PSEG-LI TRM), leading to a modest reduction in kW savings.	▪ Align coincidence factor with the PSEG-LI TRM.

5.2.3.2 Reasons for Differences between Consumption Analysis and Ex-ante Savings

The 2020 consumption analysis resulted in slightly lower overall ex-post gross savings than ex-ante gross savings, as shown by the 81% realization rate. The results were stable across multiple model specifications but have a relatively wide margin of error. The 95% confidence interval of the realization rate ranges from 62% to 100%. One potential explanation for the results is that low-income homes typically use less energy than non-low-income homes. Our consumption analysis for REAP showed lower average kWh usage than the Home Performance consumption analysis.

5.3 CONCLUSIONS AND RECOMMENDATIONS

Our key findings and recommendations based on this evaluation are shown in Table 5-12.

Table 5-12: REAP Findings and Recommendations

Finding	Recommendation
▪ REAP savings continue to be dominated by lighting measures. In 2019 and 2020, lighting accounted for approximately half of the REAP kWh savings. In 2020, lighting accounted for nearly one third of REAP MMBtu savings.	▪ Continue monitoring the lighting market. As market transformation continues, LEDs will represent a greater share of residential sockets. Planning assumptions will need to reflect fewer LEDs as these bulbs become more prevalent in low-income homes.
▪ Our consumption analysis results fell more in line with planning assumptions than in prior evaluations. This is partially due to PSEG Long Island's lighting per-unit savings assumption, revised in 2019, which reflects 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.	▪ 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.
▪ The low realization rate for demand (77%) was largely driven by a low realization rate for lighting, which itself was driven by the coincidence factor assumption. The value used for ex-ante savings (23%) is based on "LED-only" metering results from a 2016 study when LEDs were still relatively expensive and mostly installed in high-use sockets.	▪ We recommend aligning with CF assumption with the "All Light Bulbs" metering results from the same study – 12%. LEDs are approaching price parity with inefficient lamps and now represent a majority of lamp sales. The CF for "All Light Bulbs" is likely more reflective of the true CF for LEDs is today.
▪ For a number of measures, the key driver of the realization rate was the same: In our engineering analysis, we used actual values from the program tracking database rather than TRM assumptions.	▪ When actual values are known (for example, baseline and post water temperatures for the Temperature Turndown measure), use them rather than TRM assumptions.

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). The primary objective of the Home Performance suite of programs is to make high efficiency choices part of the decision-making process for PSEG Long Island customers when upgrading their home. The goal of the Home Performance programs is to reduce the carbon foot print of customers who utilize electric, oil or propane as a primary heat source.

6.1 HOME PERFORMANCE PROGRAM DESIGN AND PARTICIPATION

6.1.1 PROGRAM DESIGN AND IMPLEMENTATION

The Home Performance portfolio offers customer rebates and contractor incentives for heating and cooling system upgrades, weatherization, and building shell upgrades like insulation, air sealing, and duct sealing. Certain minimum efficiency requirements must be met to receive HP incentives and all projects must be pre-approved by the program team contractor. In accordance with New York State's Reforming the Energy Vision (REV), PSEG Long Island discontinued rebates for fossil fuel measures for the 2020 Home Performance programs. Program design in 2020 encouraged contractors to recommend whole house decarbonization solutions, such as weatherization projects coupled with HVAC upgrades, including enhanced rebates for air source heat pumps, geothermal systems, and integrated controls. Home Performance offerings are available to all single-family homes in PSEG Long Island, including both market-rate and Low-Moderate Income (LMI) demographics.

As part of the HPwES Program, **Home Energy Assessments (HEA)** are free energy audits available to any single-family homeowner in PSEG Long Island service territory. The program is administered by TRC and involves a qualified contractor conducting a Home Energy Assessment in order to make the homeowner aware of energy savings opportunities. In March 2020, PSEG Long Island and TRC introduced a new energy audit tool compatible with the Captures database; these new systems replaced the EnergySavvy tools that had been used in prior program years. Program offerings include "Thank You" Kits that contain three 9-Watt LED bulbs, mailed to all HEA recipients.

Eligible customers with electric heat can participate in the **Home Performance Direct Install (HPDI)** program, which includes select free efficiency upgrades and an energy assessment by a certified contractor. Once the free direct install measures are completed (LEDs, duct sealing, low flow DHW devices, smart strips), the customer receives their free HEA and is eligible for HPwES rebates.

6.1.2 PROGRAM PARTICIPATION AND PERFORMANCE

Based on verified ex-ante estimates, the Home Performance program reached 107% of its energy savings goal in 2020. Table 6-1 presents 2020 Home Performance programs verified ex-ante gross MMBtu savings compared to goal.

Table 6-1: Home Performance Programs Verified Ex-Ante Gross MMBtu Savings Versus Goals

Metric	MMBtu
Goal	28,387
Verified Ex-Ante Net Savings	30,260
% of Goal	107%

In 2020, the HPDI program completed projects with 100 customers, while the HPwES program treated 1,135 customers. A total of 40 customers participated in both programs. The HEA program delivered thank you kits to 2,551 customers. Of the HEA recipients, 611 customers also participated in the HPDI or HPwES programs. Overall, 3,133 unique customers were treated by the Home Performance programs in 2020.[18]

6.2 HOME PERFORMANCE PROGRAMS IMPACTS

The following sections provide the results of the impact analysis for the Home Performance program.

6.2.1 Overview of Impacts by Resource Type

For the ex-post evaluation, we used both engineering and consumption analysis to estimate savings for the Home Performance programs in 2020.[19] The combined consumption and engineering analyses found that the programs generated approximately 28,329 MMBtu in ex-post gross energy savings in 2020, or approximately 93% of the ex-ante gross MMBtu savings. Table 6-2 shows ex-post gross and net MMBtu impacts by measure category. Table 6-3 and Table 6-4 show the ex-post gross MWh and kW impacts respectively.

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

[19] To calculate ex-post gross kWh savings due to energy efficiency (EE kWh savings), we applied the consumption analysis realization rate (78%) to the ex-ante gross EE savings. To calculate the ex-post gross kWh impacts due to beneficial electrification measures, we utilized results from engineering analysis. To calculate ex-post gross demand and MMBtu savings, we used a kW/kWh and MMBtu/kWh ratio respectively developed from the engineering analysis and applied to the ex-post gross energy savings.

Table 6-2: 2020 Home Performance Program Ex-Post MMBtu Impacts

	Category	N	Ex-Ante Gross Savings (Claimed)	Ex-Post Gross Savings	Realization Rate
			MMBtu	MMBtu	%
Home Performance Direct Install	LED Bulbs	1,529	140	109	78%
	Domestic Hot Water	129	53	41	78%
	Duct Sealing	70	23	18	78%
	Advanced Power Strips	99	54	42	78%
	HPDI Subtotal	**1,827**	**269**	**211**	**78%**
Home Performance with ENERGY STAR	Duct Sealing	700	3,270	2,588	79%
	Air Sealing	974	6,486	4,838	75%
	Envelope	1,387	10,305	15,043	146%
	Heat Pumps	121	6,113	4,157	68%
	Lighting	16	18	16	92%
	HVAC (Non heat pumps)	40	1,475	595	40%
	DHW	103	1,930	230	12%
	HPwES Subtotal	**3,341**	**29,597**	27,468	93%
Home Energy Audits	Thank You Kits (HEA)	2,558	560	651	116%
	HEA Subtotal	**2,558**	**560**	651	116%
Overall	**Measure Level Total**	**7,726**	**30,426**	28,329	93%

Table 6-3: 2020 Home Performance Program Ex-Post MWh Impacts

	Category	N	Ex-Ante Gross Savings (Claimed[1])	Ex-Post Gross Savings	Realization Rate
			MWh	MWh	%
Home Performance Direct Install	LED Bulbs	1,529	40.9	32.0	78%
	Domestic Hot Water	129	15.5	12.1	78%
	Duct Sealing	70	6.7	5.2	78%
	Advanced Power Strips	99	15.7	12.3	78%
	HPDI Subtotal	**1,827**	**78.8**	**61.7**	**78%**
Home Performance with ENERGY STAR	Duct Sealing	700	230.8	180.7	78%
	Air Sealing	974	231.3	181.1	78%
	Envelope	1,387	389.4	304.9	78%
	Heat Pumps	121	-386.7	-398.3	103%
	Lighting	16	10.6	8.3	78%
	HVAC (Non heat pumps)	40	24.1	18.9	78%
	DHW	103	102.5	95.1	93%

Category		N	Ex-Ante Gross Savings (Claimed[1]) MWh	Ex-Post Gross Savings MWh	Realization Rate %
	HPwES Subtotal	**3,341**	601.9	390.7	**65%**
Home Energy Audits	Thank You Kits (HEA)	2,558	278.9	218.4	78%
	HEA Subtotal	**2,558**	**278.9**	**218.4**	**78%**
Overall	**Measure-Level Total**	**7,726**	**959.7**	**670.9**	**70%**

[1] MWh Ex-Ante Gross Savings (Claimed) in table might not match KPI scorecard values. Table values include all Energy Efficiency Savings as well as Beneficial Electrification, while KPI scorecard reports Energy Efficiency Savings only.

Table 6-4: 2020 Home Performance Program Ex-Post kW Impacts

Category		N	Ex-Ante Gross Savings (Claimed[1]) kW	Ex-Post Gross Savings kW	Realization Rate %
Home Performance Direct Install	LED Bulbs	1,529	11.3	5.8	51%
	Domestic Hot Water	129	0.2	0.2	100%
	Duct Sealing	70	6.3	7.8	125%
	Advanced Power Strips	99	1.9	1.6	86%
	HPDI Subtotal	**1,827**	19.6	15.4	78%
Home Performance with ENERGY STAR	Duct Sealing	700	314.1	152.6	49%
	Air Sealing	974	85.5	33.0	39%
	Envelope	1,387	83.0	111.5	134%
	Heat Pumps	121	37.4	64.6	173%
	Lighting	16	N.R.	0.0	N/A
	HVAC (Non heat pumps)	40	N.R.	1.3	N/A
	DHW	103	N.R.	5.6	N/A
	HPwES Subtotal	**3,341**	520.0	368.6	71%
Home Energy Audits	Thank You Kits (HEA)	2,558	71.0	31.4	44%
	HEA Subtotal	**2,558**	**71.0**	**31.4**	**44%**
Overall	**Measure-Level Total**	**7,726**	**610.6**	**415.4**	**68%**

[1] MW Ex-Ante Gross Savings (Claimed) in table might not match KPI scorecard values. Table values include all Energy Efficiency Savings as well as Beneficial Electrification, while KPI scorecard reports Energy Efficiency Savings only.

6.2.2 Analysis Approach and Detailed Results

Our ex-post gross savings estimates are anchored in the analysis of billed kWh and supplemented by engineering calculations to estimate total MMBtu conservation and peak demand savings. We use the engineering analysis to calculate MMBtu to kWh and kW to kWh ratios at the measure level and utilize these ratios to estimate ex-post gross MMBtu and kW impacts. 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.

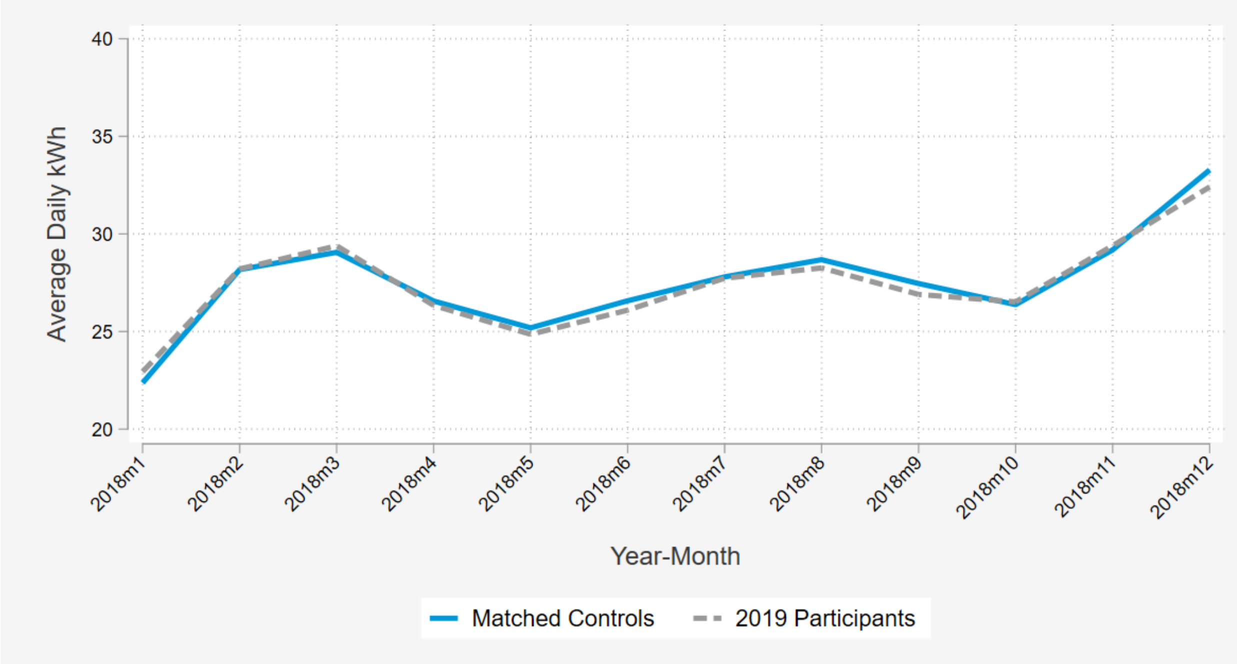
6.2.2.1 Consumption Analysis – Approach

The Home Performance programs are well-suited to consumption analysis for several reasons.

- **The measures are retrofit rather than replace-on-burnout**. This means that the equipment installed and condition of the home prior to program participation are the appropriate baseline to use in the savings calculation.
- **Savings are large on a percent basis**. On average, the ex-ante gross claimed kWh savings represented 10.6% of pre-retrofit annual billed electricity usage.
- **We have a large pool of homes to analyze**. With over 1,000 participating households per year in 2019 and 2020, the Home Performance billing analysis are stable across model specification and robust to changes idiosyncratic changes in behavior at the household level.
- **Participating households tend to adopt multiple measures**. These measures can interact with one another in ways that are difficult to captures in engineering equations.

Because the consumption analysis requires post-installation electricity usage data for approximately one year after treatment, we use 2019 participants as the treatment group and construct a matched comparison group from the 2020 participants. The use of future participants controls for selection effects. In other words, we know that the matched comparison group is composed of the type of homes that participate in the Home Performance programs because they participated in the following year. We further refine the comparison groups through the use propensity score matching with replacement. Figure 6-1 shows compares the average monthly billing analysis of the 'treatment group' and matched control group during 2018, which is the year prior to the treated homes' participation. Although the matches are quite good, we employ a difference-in-differences regression model that nets out pre-period differences from the impact estimates.

Figure 6-1: Comparison of Pre-Treatment Consumption for Home Performance Consumption Analysis

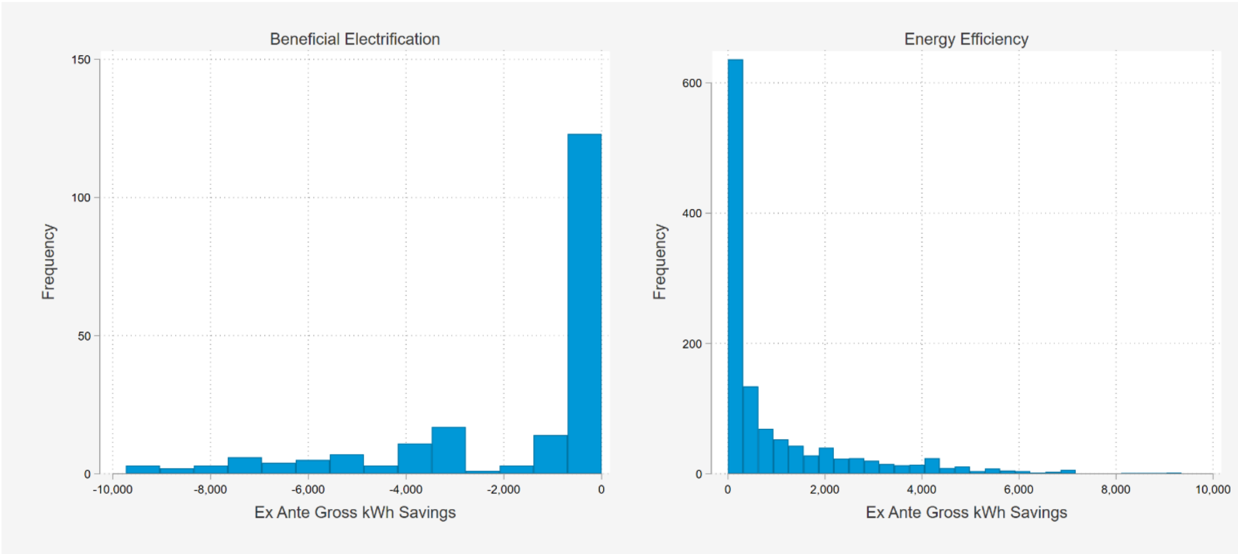


The consumption analysis model uses monthly billing data to quantify post-participation changes in energy use. The matched controls inherit a pseudo pre-post transition date from their participant match and any billing records after they actually participated (in 2020) are excluded from the analysis. The transition from the pre-period to post-period is based on the project completion date so over the course of 2019, the status the participant group is in aggregate gradually shifts.

The consumption analysis model is a linear fixed effects panel regression model. A fixed effects model absorbs time-invariant household characteristics via inclusion of separate intercept terms for each account in the treatment and comparison group. Additional details regarding the consumption analysis model, including the model specification and model parameter definitions, is presented in Appendix B. Several different model specifications were tested to assess the robustness of the results, and the results were indeed consistent across models.

The participant group in the consumption analysis includes homes that participated in HPwES, homes that participated in HPDI, and few homes that participated in both. During 2019 and 2020 the HPwES program included a mix of electric conservation and beneficial electrification measures. This means that some participants had negative ex-ante gross kWh savings and other participants had positive ex-ante gross kWh savings. We use this distinction to split the 2019 participants into "Beneficial Electrification" and "Energy Efficiency" groups. Figure 6-2 shows the distribution of per-household savings, by group.

Figure 6-2: Segmentation of 2019 Participants into Energy Efficiency and Beneficial Electrification



The consumption analysis method is indifferent to the direction of the savings. However, including a mix of homes with positive and negative savings pulls the average towards zero and makes it more difficult to precisely estimate the impacts. Since the 2019 beneficial electrification measures were mostly heat pumps, we elected to use consumption analysis for the energy efficiency group and analyze beneficial electrification measures using the same methods as the Home Comfort program.

A key assumption with this model framework is that our estimates of 2019 performance and realization rates are applicable to 2020 measures and projects. Although the program audit tool changed in 2020, the measure mix and ex-ante savings assumptions were generally consistent across years so we are comfortable applying the realization rate determined using 2019 participants to 2020.

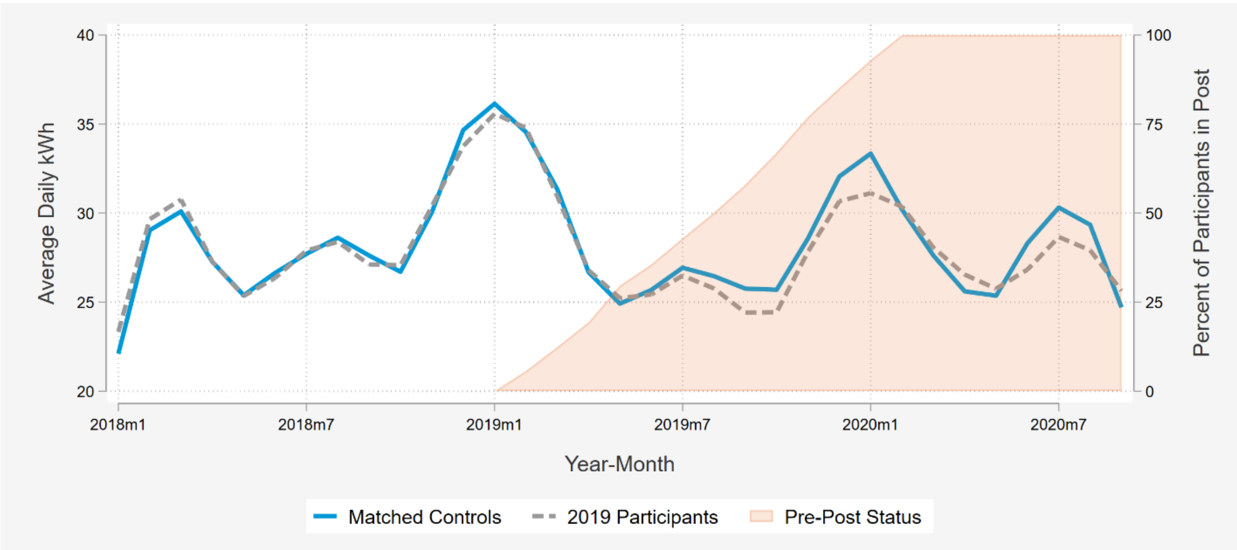
6.2.2.2 Consumption Analysis – Results

In Table 5-7, we use the results of the combined Home Performance programs model to estimate average savings for 2019 participants and compare the estimated impact to the ex-ante gross kWh savings claimed by the implementer. Across the 1,197 Long Island homes included in the regression model, the average annualized savings was 816 kWh. This equals 78.3% of the average ex-ante gross kWh savings claim for the same homes. We applied the 78.3% realization rate to the ex-ante gross kWh savings claim of 2020 participants to estimate ex-post gross kWh savings for efficiency measures. (Beneficial electrification measures are evaluated using an approach that mirrors the Home Comfort program.) Figure 6-3 visualizes the consumption analysis results. As more participants move into the post period, the average daily electric usage for the treatment group begins to depart from the matched control group. This is the effect of interest. The savings are largest during the winter and summer months, which is expected given the focus on HVAC and envelope improvement measures.

Table 6-5: Home Performance Consumption Analysis Results (n=1,197)

Parameter	Estimate	Lower Bound of 95% CI	Upper Bound of 95% CI
Daily Treatment Effect (kWh Saved)	2.236	1.563	-2.909
Daily Treatment Effect (% Savings)	9.2%	6.8%	11.5%
Annual Savings	816.1	570.5	1,061.8
Ex-Ante Gross kWh		1,042.3	
Realization Rate	78.3%	54.7%	101.9%

Figure 6-3: Home Performance Consumption Analysis Results Visualized



Because the consumption analysis relies on monthly billing data rather than hourly AMI data, it does not produce estimates of peak demand savings. PSEG Long Island does not sell natural gas or delivered fuel so fossil fuels consumption records are not available for analysis. To estimate MMBtu and peak demand savings for the Home Performance programs, we first calculated MMBtu to kWh and kW to kWh ratios between the engineering-based estimates 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.

6.2.2.3 Reasons for Differences between Consumption Analysis and Ex-Ante Savings

The 2020 consumption analysis resulted in lower ex-post gross savings compared to ex-ante gross savings, as shown by the 78.3% realization rate. The results were stable across multiple model specifications, but have a relatively wide margin of error. The 95% confidence interval of the realization rate ranges from 55% to 102%. One potential explanation for the results is the average customer size. The group of 2019 participants analyzed had an average pre-retrofit consumption of 28.65 kWh per day, or 10,457 kWh per year. While higher than the average PSEG-LI residential consumption of ~9,000 kWh/year, these are not extremely high usage homes on average. In general, high-usage homes will save more on an absolute and percent basis so the programs are not serving what we would classify as high usage homes.

6.2.2.4 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 2020 HPDI program. As described above, the results of the engineering impacts analysis provide us with the demand-to-energy ratio needed to quantify demand savings from the energy consumption analysis, as well as an understanding of individual measure savings variations between consumption analysis results and planning assumptions.

Table 6-6,

Table 6-7, and Table 6-8 show the engineering analysis gross savings for each HPDI measure category in MMBtu, kWh, and kW, respectively.

Table 6-6: 2020 HPDI Engineering Analysis Gross MMBtu Impacts

Category	N[1]	Ex-Ante Gross Savings (MMBtu)	Engineering Analysis Ex-Post Gross Savings (MMBtu)	Engineering Analysis Realization Rate (MMBtu)
LED Bulbs	1,529	139.6	115.9	83%
Domestic Hot Water	129	52.9	46.3	88%
Duct Sealing	70	22.9	22.9	100%
Advanced Power Strips	99	53.7	53.7	100%
Measure-Level Total	**1,827**	**269.0**	**238.8**	**89%**

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

Table 6-7: 2020 HPDI Engineering Analysis Gross MWh Impacts

Category	N[1]	Ex-Ante Gross Savings (MWh)	Engineering Analysis Ex-Post Gross Savings (MWh)	Engineering Analysis Realization Rate (MWh)
LED Bulbs	1,529	40.9	33.8	83%
Domestic Hot Water	129	15.5	13.6	88%
Duct Sealing	70	6.7	6.7	100%
Advanced Power Strips	99	15.7	15.7	100%
Measure-Level Total	**1,827**	**78.8**	**69.8**	**89%**

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

Table 6-8: 2020 HPDI Engineering Analysis Gross kW Impacts

Category	N[1]	Ex-Ante Gross Savings (kW)	Engineering Analysis Gross Savings (kW)	Engineering Analysis Realization Rate (kW)
LED Bulbs	1,529	11.3	6.4	57%
Domestic Hot Water	129	0.18	0.18	100%
Duct Sealing	70	6.3	7.8	125%
Advanced Power Strips	99	1.9	1.6	86%
Measure-Level Total	**1,827**	**19.6**	**16.0**	**82%**

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

6.2.2.5 Reasons for Differences in Engineering Impacts: HPDI

The engineering analysis found variance between ex-post and ex-ante measure-level gross savings among the HPDI measure categories. Key reasons for differences are summarized in Table 6-9 below.

Table 6-9: Key Contributors to HPDI Engineering Analysis MMBtu RR and Proposed Solutions

Component	Summary of Savings Difference	Proposed Solution
Lighting	▪ Tracked lamp types and pre-installation wattages in Captures did not appear to be reflected within ex-ante savings estimates.	▪ Ensure that contractors collect pre-installation quantities and wattages, and that those values are migrated into Captures and reflected in ex-ante savings.
DHW Fixtures	▪ Faucet aerator and thermostatic valve flow rates in Captures frequently did not reflect the recommended values in the 2020 PSEG-LI TRM. ▪ Some fixture projects were carryover from 2019 meaning the implementer used 2019 assumptions to calculate savings for those projects rather than the most up-to-date TRM.	▪ Consistently apply the parameters provided in the PSEG-LI TRM in ex-ante savings estimates.
Duct Sealing	▪ The ex-ante demand savings reflect a coincidence factor of 0.8 when no coincidence factor is explicitly stipulated for this measure in the PSEG-LI TRM.	

6.2.2.6 Engineering Analysis: HPwES

The evaluation team used program tracking data and engineering analysis to estimate gross MMBtu, kWh, and kW demand savings achieved by each HPwES measure. Evaluators conducted this analysis for the same purpose as detailed in the HPDI engineering analysis above. Table 6-10, Table 6-11, and

Table 6-12 compare gross engineering analysis savings to ex-ante gross savings by HPwES measure category for MMBtu, kWh, and kW savings, respectively.

Table 6-10: 2020 HPwES Engineering Analysis Gross MMBtu Impacts

Category	N[1]	Ex-Ante Gross Savings[2] (MMBtu)	Engineering Analysis Gross Savings (MMBtu)	Engineering Analysis Realization Rate (MMBtu)
Duct Sealing	700	3,270	4,215	129%
Air Sealing	974	6,486	5,871	91%
Envelope	1,387	10,305	11,470	111%
Heat Pumps	121	6,113	4,078	67%
Lighting	16	18	1	6%
HVAC (Non heat pumps)	40	1,475	469	32%
DHW	103	1,930	191	10%
Measure-Level Total[3]	**3,341**	**29,597**	**26,295**	**89%**

[1] Count of measures installed through the HPwES program.
[2] Reported ex-ante gross savings include measure-level electricity savings and interactive electricity impacts from incentivized measures but exclude impacts from beneficial electrification measures.
[3] Measure-level savings are obtained through contractor reports and are used in evaluating measure category ex-ante savings to elucidate measure performance. These measure-level savings do not account for interactivity and are therefore not the official project-level savings claimed by the program administrators.

Table 6-11: 2020 HPwES Engineering Analysis Gross MWh Impacts

Category	N[1]	Ex-Ante Gross Savings[2] (MWh)	Engineering Analysis Gross Savings (MWh)	Engineering Analysis Realization Rate (MWh)
Duct Sealing	700	230.8	283.2	123%
Air Sealing	974	231.3	243.9	105%
Envelope	1,387	389.4	272.5	70%
Heat Pumps[3]	121	-386.7	-421.5	109%
Lighting	16	10.6	0.3	3%
HVAC (Non Heat Pumps)	40	24.1	9.4	39%
DHW	103	102.5	27.9	27%
Measure-Level Total[4]	**3,341**	**601.9**	**415.7**	**69%**

[1] Count of measures installed through the HPwES program.
[2] Reported ex-ante gross savings include measure-level electricity savings and interactive electricity impacts from incentivized measures but exclude impacts from beneficial electrification measures.
[3] Negative savings are due to beneficial electrification from displacement of fossil fuel heating systems.
[4] Measure-level savings are obtained through contractor reports and are used in evaluating measure category ex-ante savings to elucidate measure performance. These measure-level savings do not account for interactivity and are therefore not the official project-level savings claimed by the program administrators.

Table 6-12: 2020 HPwES Engineering Analysis Gross kW Impacts

Category	N[1]	Ex-Ante Gross Savings[2] (kW)	Engineering Analysis Gross Savings (kW)	Engineering Analysis Realization Rate (kW)
Duct Sealing	700	314	254	81%
Air Sealing	974	85	44	52%
Envelope	1,387	83	84	101%
Heat Pumps	121	37	42	112%
Lighting	16	N.R.c	0	N/A
HVAC (Non Heat Pumps)	40	N.R.c	3	N/A
DHW	103	N.R.c	2	N/A
Measure-Level Total[4]	3.341	520	428	82%

[1] Count of measures installed through the HPwES program.
[2] Reported ex-ante gross savings include measure-level electricity savings and interactive electricity impacts from incentivized measures but exclude impacts from beneficial electrification measures.
[3] N.R. = not reported
[4] Measure-level savings are obtained through contractor reports and are used in evaluating measure category ex-ante savings to elucidate measure performance. These measure-level savings do not account for interactivity and are therefore not the official project-level savings claimed by the program administrators.

6.2.2.7 Reasons for Differences in Engineering Impacts: HPwES

Historically, program administrators tracked HPwES measure savings in EnergySavvy, but program administrators transitioned to LM Captures beginning in 2020. Due to 2019 carryover projects finishing in 2020, a subset of evaluated measures were tracked in EnergySavvy, with other measures initiated after the transition tracked in Captures. Evaluators obtained measure-level tracking reports for both EnergySavvy and Captures but could not access the proprietary assumptions and algorithms used by EnergySavvy's energy modeling software. For this reason, evaluators cannot pinpoint the specific contributors to differences between ex-post and ex-ante savings in EnergySavvy projects. Additionally, the EnergySavvy data did not include claimed demand (kW) savings. Evaluators calculated ex-post kW savings for all measures but can only provide a demand realization rate for projects tracked in Captures.

Table 6-13 identifies the key contributors to the overall engineering analysis gross MMBtu realization rate of 89%.

Table 6-13: Key Contributors to HPwES Engineering Analysis and Proposed Rectification Steps

Component	Summary of Savings Difference	Proposed Solution
Heat Pumps	▪ Many heat pump measures involved beneficial electrification. Evaluators quantified fuel-specific impacts, but the program did not include beneficial electrification in reported kWh savings.	▪ Given that the program's savings goals are now MMBtu-based, the HPwES program administrators should track and consider all impacts by fuel in the calculation of reported MMBtu savings.
Water Heaters	▪ Many DHW system upgrades involved beneficial electrification. Evaluators quantified fuel-specific impacts, but the program did not include beneficial electrification in reported kWh savings.	
Duct Sealing	▪ Duct sealing measure data in Captures did not include pre- and post-CFM values. Evaluators could not scale a duct leakage reduction assumption to home size, because building square footage was not tracked for duct sealing projects. Evaluators used the average change in CFM from PY2019.	▪ Because duct sealing savings are driven by the change in leakage air flow, program administrators should track pre- and post-CFM values. Conditioned square footage should be recorded whenever CFM is not quantifiable.
HVAC (Non Heat Pumps)	▪ The evaluation team calculated EnergySavvy thermostat savings using the 2020 PSEG Long Island TRM algorithm, resulting in a gross engineering analysis MMBtu realization rate of 12%. Evaluators cannot pinpoint specific reasons for differences due to unknown modeling assumptions.	▪ Now that the program has fully transitioned into Captures, ensure that all algorithms and assumptions are transparent and available to the evaluation team. These algorithms and assumption should generally align with the PSEG Long Island TRM.

6.2.2.8 Engineering Analysis: HEA Thank You Kits

For each HEA audit completed by PSEG Long Island in 2020, the program mailed a Thank You Kit to the customer; each kit contained three 9-Watt LED bulbs. Table 6-14, Table 6-15, and Table 6-16 compare ex-post savings (via engineering analysis) with ex-ante gross MMBtu, MWh, and kW savings, respectively, for the Thank You Kits measure.

Table 6-14: 2020 HEA Thank You Kits Gross MMBtu Impacts

Category	N	Ex-Ante Gross Savings (MMBtu)	Engineering Analysis Gross Savings (MMBtu)	Engineering Analysis Realization Rate (MMBtu)
Thank You Kits	2,558	560	566	97%

Table 6-15: 2020 HEA Thank You Kits Gross MWh Impacts

Category	N	Ex-Ante Gross Savings (MWh)	Engineering Analysis Gross Savings (MWh)	Engineering Analysis Realization Rate (%)
Thank You Kits	2,558	278.9	189.8	68%

Table 6-16: 2020 HEA Thank You Kits Gross kW Impacts

Category	N	Ex-Ante Gross Savings (kW)	Engineering Analysis Gross Savings (kW)	Engineering Analysis Realization Rate (kW)
Thank You Kits	2,558	71	27	35%

To estimate ex-ante savings, the HEA program administrator applied the planning assumptions for EEP standard LED bulbs. Since the removed bulb wattage was unknown, evaluators applied 2020 PSEG Long Island TRM assumptions and algorithms for a 9-Watt EEP standard LED to calculate ex-post savings, resulting in a gross engineering analysis MMBtu realization rate of 97%.

6.2.2.9 Beneficial Electrification Impacts

In 2020, the HPwES program completed 139[20] beneficial electrification (BE) projects that resulted in an increase in electric consumption. These projects resulted from displacement of fossil fuel-fired HVAC or DHW systems with high-efficiency electric systems – for example, from an oil furnace to an air-source heat pump. For comparison to program tracking goals, the HP program implementers zeroed out the negative savings for these projects when reporting ex-ante savings. While BE 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 both BE and energy efficiency (EE) impacts separately through engineering analysis, as shown in Table 6-17. The energy savings of the displaced 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.

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

Table 6-17: Separation of EE and BE Impacts for HP Beneficial Electrification Measures[21]

Category	Ex-Post Gross kWh_{ee}	Ex-Post Gross kWh_{be}	Ex-Post Gross kWh Total (EE - BE)	Ex-Post Gross $MMBtu_{ee}$	Ex-Post Gross $MMBtu_{be}$	Ex-Post Gross MMBtu Total (EE + BE)
Heat Pumps	73,212	471,468	-398,256	250	3,907	4,157
DHW	109,457	14,343	95,114	63	167	230
Total	**182,668**	**485,811**	**-303,142**	**313**	**4,074**	**4,387**

6.3 CONCLUSIONS AND RECOMMENDATIONS

Our key findings and recommendations based on this evaluation are shown in Table 6-18.

Table 6-18: Home Performance Findings and Recommendations

Finding	Recommendation
▪ HPwES program administrators zeroed out the HPwES projects that resulted in negative overall kWh savings. For these projects, evaluators were unable to separate beneficial electrification impacts from other claimed electricity savings at the project level because they are not recorded separately in the program tracking data. These differences led to contradictory savings totals in measure- and program-level reports for the HPwES program.	▪ Projects that result in overall negative kWh savings should not be zeroed out at the project level. Given PSEG Long Island's shift to MMBtu-based goals, HP program administrators should accurately track impacts by fuel, both positive and negative. These changes would ensure that the HPwES program- and measure-level reports are in agreement and provide sufficient data for evaluation.
▪ The evaluation team identified several instances of relevant measure-level parameters that were unavailable in the Captures tracking database: pre- and post-project CFM values and conditioned square footage for duct sealing projects; basic HVAC information such as system type and fuel type; and pre-installation wattages and quantifies for direct-install lighting measures.	▪ Contractors and program administrators should consistently collect and track these relevant measure-level parameters for transparency and evaluability.
▪ We found that the program administrator applied baseline and installed flow rate assumptions for the REAP faucet aerator measures (via the 2019 PSEG Long Island TRM) instead of the HPDI measure assumptions as recommended in the 2020 PSEG Long Island TRM.	▪ Ensure that Captures algorithms and assumptions reflect those in the applicable PSEG Long Island TRM.

[21] Ex-post EE savings represent billing analysis results. Ex-post BE savings values from engineering analysis.

7 HOME ENERGY MANAGEMENT PROGRAM

PSEG Long Island's Home Energy Management (HEM) program currently delivers paper and electronic home energy reports (HERs) to approximately 417,000 residential customers. Residential behavioral programs, such as HEM, leverage behavioral psychology and social norms to lower residential energy usage by comparing a customer's energy consumption to similar neighboring households. 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. This report summarizes the program year 2020 (PY2020) energy savings from PSEG Long Island's Home Energy Management Program. While behavioral programs typically deliver small percentage changes in energy use, they typically yield large aggregate savings because they reach a large volume of customers and do not require rebates or installations. The primary challenge is the need to accurately detect small changes in energy consumption while systematically eliminating plausible alternative explanations for those changes, including random chance.

The evaluation had three main research questions:

- Were the participant and control groups similar in terms of energy use prior to the delivery of the HERs to participant group homes?
- What is the magnitude of annual electricity savings?
- What steps can be undertaken to improve delivery and performance?

7.1 PROGRAM OVERVIEW

The Home Energy Management program offers a set of intervention strategies to influence customers' energy use behaviors. The primary strategy is a HER engagement campaign leveraging a randomized control trial (RCT) design. 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. The specific objectives of the program are to:

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

Home energy reports are behavioral interventions designed to encourage energy conservation in both gas and electricity. The paper or electronic reports compare a customer's energy consumption to similar neighboring households, thus leveraging behavioral psychology and social norms to lower residential energy usage. Home energy reports are sent to customers in the treatment group by mail and email and contain the following information:

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

The initiation of this energy savings program occurred in September 2017 when 341,570 customers began receiving HERs. This first wave of customers is referred to as Cohort 1 for the remainder of the report. In August 2018, the program began to send HERs to an additional 159,348 customers. This second wave of customers is referred to as Cohort 2 for the remainder of the report.

The program's initial goal, set in 2017, was to achieve over 30,000 MWh of behavior-based energy savings per year over a two-year period. The new goal set for 2020 was to achieve 68,547 MWh in energy savings across both cohorts. Due to attrition, the treatment and control groups for both cohorts are smaller now compared to when the cohorts were first launched. Additional details on attrition and current treatment numbers are provided below. From 2021 onward, PSEG Long Island anticipates sending HERs to treatment customers in both Cohorts 1 and 2 and is considering launching an additional third cohort.

7.2 2020 PROGRAM ENROLLMENT AND REPORT COUNTS

Table 7-1 presents HEM program participation in Cohorts 1 and 2. Cohort 1 contained 282,061 treatment customers and Cohort 2 contained 134,731 customers, which represents an attrition rate of 10% from PY2019.

Table 7-1: 2020 HEM Program Participation Summary[22]

Cohort	Number of Treatment Customers	Number of Control Customers	Number of Customers per Cohort
Cohort 1	282,061	34,374	316,435
Cohort 2	134,732	29,577	164,309
Total	**416,793**	**63,951**	**480,744**

[22] Excludes treatment and control customers who closed their account or moved out before January 1, 2020.

Each customer is sent a total of five reports over the course of the year. Some customers who are excluded from the analysis (due to the customer moving out) still received reports from PSEG Long Island in 2020. Based on the program tracking data, the verified count of paper reports sent was 2,175,667, with each participant receiving multiple reports throughout the year. The verified number of paper reports sent each month and the total for 2020 are presented in Table 7-2.

Table 7-2: HEM Program Paper HERs Sent by Month in 2020

Month	Verified Report Count
January	198,205
February	242,982
March	78,568
April	168,029
May	158,992
June	188,006
July	213,507
August	163,858
September	264,895
October	183,150
November	208,669
December	174,638
Total	**2,243,499**

7.3 EQUIVALENCY RESULTS

Electricity use is characterized by a wide range of end uses and technologies, including lighting, cooking and cleaning appliances, entertainment, and more. But the primary driver of energy loads is the heating and cooling systems. Electric usage peaks in the summer as air conditioning systems are running and in the winter for electrically heated homes. Because of this, energy use is highly dependent on weather. The home energy reports focus on conservation through a range of electric devices. For each wave of HER distribution, pre-treatment energy consumption should be identical across the participant and control groups, on average. A good control group should behave and use energy in a similar manner to the participants before either group has received an HER. Figure 7-1 shows the distribution of annual consumption by cohort for the treatment and control groups prior to each HER cohort launch. Treatment and control groups are comparable, and the average customer size is relatively similar between cohorts.

Figure 7-1: Pre-Treatment Annual Electric Consumption by Cohort

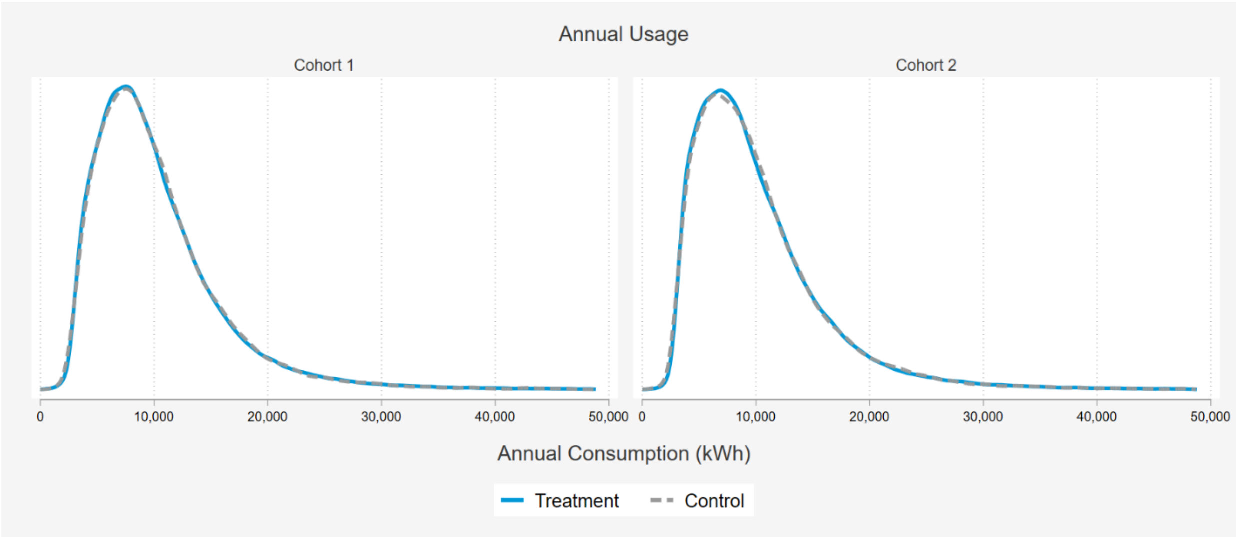


Table 7-3 shows the average annual usage between treatment and control groups by cohort. There are minor differences between the two groups for each cohort. On average, the annual usage is 0.22% different between the groups, and neither wave shows a statistically significant difference between the two groups. The minor pre-existing difference is netted out in the statistical analysis.

Table 7-3: HEM Program Pre-Participation Average Daily Consumption, Treatment vs. Control

Wave	Start Date	Number of Homes		Annual Use (kWh)		Difference in Annual Use		
		Control	Treated	Control	Treated	kWh	%	95% Conf. Interval
Cohort 1	10/1/2017	33,692	276,708	10,313.6	10,283.4	-30.1	-0.29%	(-101.4, 41.1)
Cohort 2	8/27/2018	28,802	131,391	10,250.8	10,215.9	-34.9	-0.34%	(-126.9, 57.2)
Total		**62,494**	**408,099**	**10,284.6**	**10,261.7**	**-22.9**	**-0.22%**	**(-110.8, 64.9)**

Only sites that passed data cleaning checks (98%) were included in the analysis, but the results are applied to all sites that received the treatment

7.4 ELECTRIC EX-POST SAVINGS SUMMARY

Table 7-4 depicts the ex-post savings results for HEM in MMBtu and MWh. A total of 416,793 customers participated in the program in PY2020, on average saving 74 kWh per participant annually for total annual savings of 30,834 MWh, or 105,204 MMBtu.

The HEM realization rate is the ratio between claimed ex-post savings and 2020 claimed ex-ante savings. In 2020, the realization rate for electric savings was 44.1%. The ex-post savings were 45% of the HEM goal for 2020. There are two major factors driving this relatively low realization rate. The first is higher than expected program attrition, with only 416,793 customers participating in HEM in 2020, compared to the goal of 440,000 customers. The second reason is lower per-customer annual savings than planned, with only 74 kWh saved annually compared to the planned annual savings of 156 kWh. While short of PSEG LI's goal for 2020, these savings are consistent with the savings observed in the 2019 evaluation of HEM.

Table 7-4: 2020 HEM Program Ex-Post Gross Impacts

Metric	Participation	kWh per participant	Energy Savings	
			MMBtu	MWh
Goal	440,000	156	233,883	68,547
Claimed Ex-Ante	448,700	156	238,507	69,902
Verified Ex-Ante	448,700	156	238,507	69,902
Unadjusted Ex-Post	416,793	74	105,204	30,834
Uplift Adjustment[1]	0	0	0	0
Adjusted Ex-Post After Accounting for Uplift	416,793	74	105,204	30,834
Realization Rate of Ex-Post to Claimed Ex-Ante	92.9%	47.4%	44.1%	44.1%
Ex-Post as Percent of Goal	94.7%	47.4%	45.0%	45.0%

[1] Uplift adjustment not applied because differences in participation uptake in other energy efficiency programs for treatment and control groups were not statistically different.

7.5 ELECTRIC EX-POST SAVINGS DETAIL

Table 7-5 depicts the unadjusted ex-post savings from the analysis. On average, participants saved approximately 74 kWh ± 12 kWh annually (95% confidence), or approximately 0.7% of their annual consumption. On an aggregate basis, HEM reduced electricity use by 105,204 MMBtu.

Table 7-5: 2020 HEM Unadjusted Ex-Post Per-Household and Program Energy Savings

Cohort	Number of Customers Treated in 2020	Unadjusted Savings (% per household)	Unadjusted Energy Savings (kWh per household)	Lower Bound	Upper Bound	Unadjusted Program Savings (MMBtu)
Cohort 1	282,061	0.82%	87.03	103.82	65.26	83,854
Cohort 2	134,732	0.44%	46.23	65.72	26.48	21,318
Total	**416,793**	**0.70%**	**73.86**	**86.10**	**58.21**	**105,204**

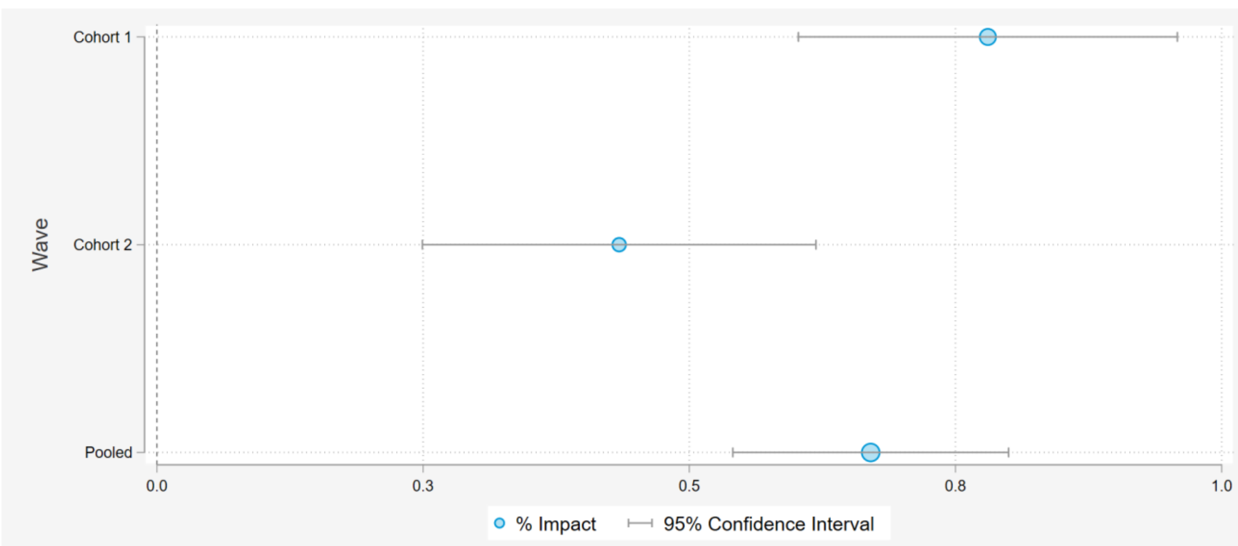
Table 7-6 depicts the percent savings for each cohort by month. We see that the highest percent savings generally occur in the winter, with Cohort 1 seeing savings over 1.1% in January.

Table 7-6: 2020 HEM Unadjusted Ex-Post Percent Savings by Month

Month	Cohort 1 Unadjusted Savings (% per household)	Cohort 2 Unadjusted Savings (% per household)	Program Unadjusted Savings (% per household)
January	1.16%	0.53%	0.96%
February	1.02%	0.23%	0.76%
March	0.74%	0.40%	0.63%
April	0.94%	0.41%	0.77%
May	0.71%	0.48%	0.63%
June	0.86%	0.41%	0.72%
July	0.79%	0.38%	0.66%
August	0.64%	0.62%	0.64%
September	0.56%	0.55%	0.56%
October	0.74%	0.51%	0.67%
November	1.02%	0.63%	0.90%
December	0.81%	0.04%	0.56%
Annual	**0.82%**	**0.44%**	**0.70%**

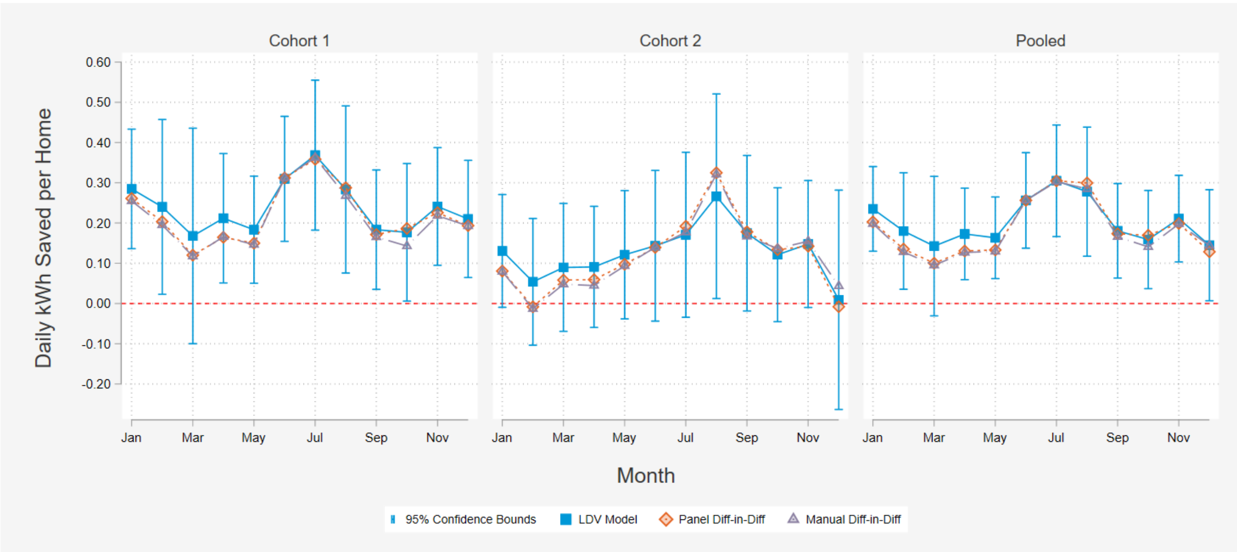
Figure 7-2 shows the percent impacts by cohort and the percent impact for all cohorts pooled. The size of the marker indicates the relative participant population size for each wave. The savings for individual cohorts are statistically significant, and there are 0.7% annual savings for the pooled analysis.

Figure 7-2: Electric Percent Impacts by Wave



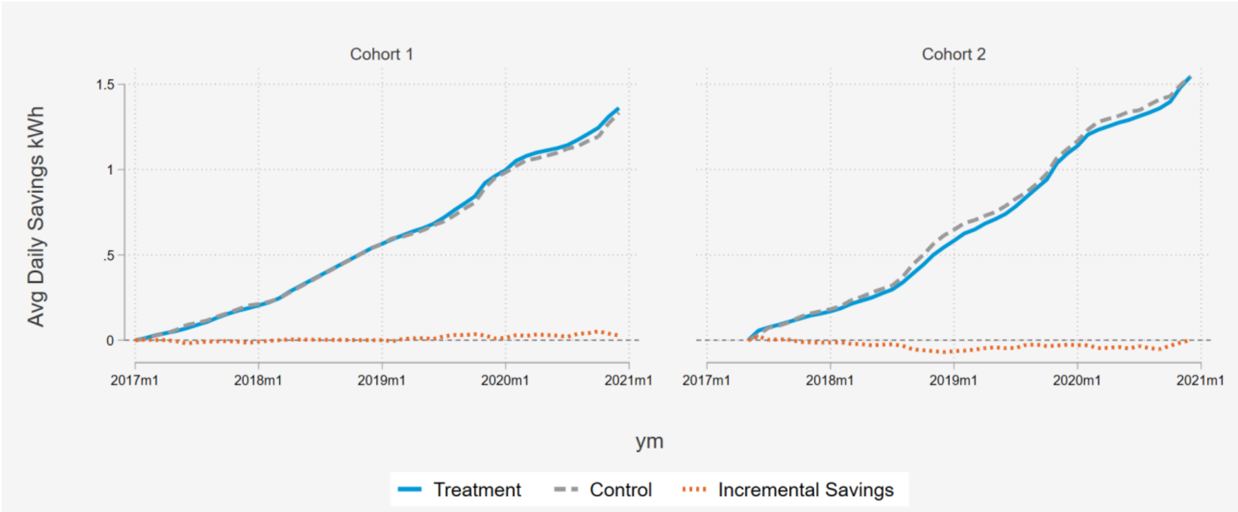
The evaluation team tested the robustness of the impacts by implementing two other common methods for estimating behavioral impacts: a panel difference-in-difference model and a manual difference-in-difference calculation. The panel difference-in-difference model uses data from both the pre and post periods. The manual difference-in-difference approach examines differences in raw averages. Monthly savings estimates were similar across the three methods. Figure 7-3 provides a comparison of the average daily savings estimates each method yields. Figure 7-3 also displays 95% confidence bounds for savings estimates from the lagged dependent variable (LDV) model, which is the primary model. The point estimate of the alternative modeling approaches is within the margin of error of the LDV model estimate each month. As anticipated, energy savings are greater in summer months when electricity usage is highest.

Figure 7-3: Unadjusted Savings by Month by Model Specification



In order to avoid double counting savings, we also conducted a dual participation analysis to see if there was significantly higher participation in other energy efficiency programs in the treatment group compared to the control group. Customers engage in energy efficiency through either rebate programs (downstream) or through in-store discounts (upstream). Figure 7-4 shows the results of the dual participation analysis for downstream customers. Both the treatment and control groups gradually accrued additional efficient installations from the start of each wave, so the average savings go up gradually over time for both groups. However, we do not see any separation between treatment and control for either wave that is statistically significant. Therefore, the results do not need to net out any savings from downstream dually-enrolled participants. The calculated adjustment for upstream savings netted out approximately 1.5% of the program savings, or 1.1 kWh per participant. This adjustment was also not statistically significant, and therefore not included in the results. For more detail on how dual participation analysis was calculated, please see Appendix F.

Figure 7-4: Downstream Dual Participation Analysis Output



7.6 COMPARISON TO PY2019

Table 7-7 compares per-customer savings from PY2019 and PY2020. In PY2020, the per-customer savings were higher for both cohorts. However, the percent savings were the same for Cohort 1 and slightly lower for Cohort 2. One potential reason for this discrepancy is the higher reference loads observed in 2020 that resulted from stay-at-home orders due to the COVID pandemic.

Table 7-7: Unadjusted Ex-Post Savings by Cohort and Evaluation Year

Cohort	2019 Energy Impact Per account (kWh/account)		2020 Energy Impact Per account (kWh/account)	
	Impact	**% Impact**	**Impact**	**% Impact**
Cohort 1	79.41	0.82%	87.03	0.82%
Cohort 2	44.32	0.47%	46.23	0.44%

7.7 CONCLUSIONS AND RECOMMENDATIONS

PSEG Long Island's HEM program remains a significant component of PSEG LI's portfolio, currently reaching over 410,000 electric accounts. While home energy reports deliver small percentage changes in energy use, they typically yield large aggregate savings because they reach a large number of customers and do not require rebates or installations. In PSEG LI, the program yielded 30.8 GWh (or 105,204 MMBtu) of electric savings. However, the realization rate is low (44%) and the ex-ante savings estimates are too high. In planning, PSEG Long Island expected an increase in the annual percent savings as the HEM cohorts matured, which did not come to fruition.

Some key findings and recommendations are provided in Table 7-8. Additionally, we'd stress the importance of analyzing the impacts of this program using an RCT. While the approach requires withholding a subset of customers to serve as controls and provide a baseline, the approach is necessary because the signal (the percent savings) is small and would be extremely difficult to detect without a control group.

Table 7-8: HEM Findings and Recommendations

Finding	Recommendation
▪ Relative to ex-ante savings, ex-post savings were low but consistent with the results from 2019.	▪ We recommend that PSEG Long Island adjusted forecasted ex-ante savings to account for the lower-than-expected percent savings in both cohorts.
▪ HEM's percent savings (0.7%) are generally lower than other HER programs.	▪ As the program continues to mature, we recommend investigating potential drivers for the lower-than-anticipated savings.
▪ One of the goals of HEM is to expand enrollment in renewable energy and/or energy storage programs.	▪ We recommend comparing treatment and control group solar and battery storage adoption over time to see if HEM has any influence on overall adoption of these technologies.

8 PROCESS EVALUATION

8.1 PROCESS EVALUATION APPROACH

This section provides details on the process evaluation objectives and methods.

8.1.1 PROCESS EVALUATIONS OBJECTIVES

The overall process evaluation objectives for this effort include the following:

- Examine and document current program processes.
- Determine whether processes are followed.
- Assess whether there are opportunities to improve programs.

In addition, the process evaluation team included the following program and sector-specific research objectives:

- Examine and document barriers to heat pump adoption in the residential sector.
- Gain insights into the future of the lighting market in the commercial sector.

8.1.2 PROCESS EVALUATION METHODOLOGY

Evaluators developed the findings in this report from the following data sources and activities:

- **Staff interviews:** The evaluation team developed and conducted interviews with the PSEG-LI program staff and the implementation contractor staff. During these interviews, we examined program processes, internal program goals, marketing and outreach strategies, inspection and/or QA/QC, and communication between the program, implementation contractor, and trade ally networks. The team conducted six interviews with the following program staff and implementers:
    - PSEG-LI and key implementation staff to document an overview of all programs that the implementer managers (group interview with both multiple team members from both PSEG-LI and the implementation contractor)
    - Implementation staff who manage the Captures platform
    - CEP program manager (implementation staff)
    - Home Comfort Program manager (implementation staff)
    - EEP program manager (implementation staff)
    - HEM program manager (implementation staff)

- **Trade ally interviews:** We also developed and fielded in-depth interviews with two groups of trade allies:
  - Home Comfort Partners and heat pump water heater installers (10 interviews completed)
  - CEP Fast-Track and Comprehensive Lighting contractors (8 interviews completed).

We asked questions regarding how these trade allies interact with the utility and program staff, their satisfaction with using the program, marketing practices, barriers to participation, and areas for market growth, such as gathering data on heat pump adoption in the residential sector and lighting market trends in the commercial sector.

8.2 PROCESS EVALUATION FINDINGS

The following sections outline process findings from the data collection activities described above.

8.2.1 PROGRAM DESIGN AND PROCESSES

The evaluation team observed program process for both residential and commercial programs overall. The following sections detail notable findings specific to a few of the programs.

8.2.1.1 Residential Energy Efficient Products Program

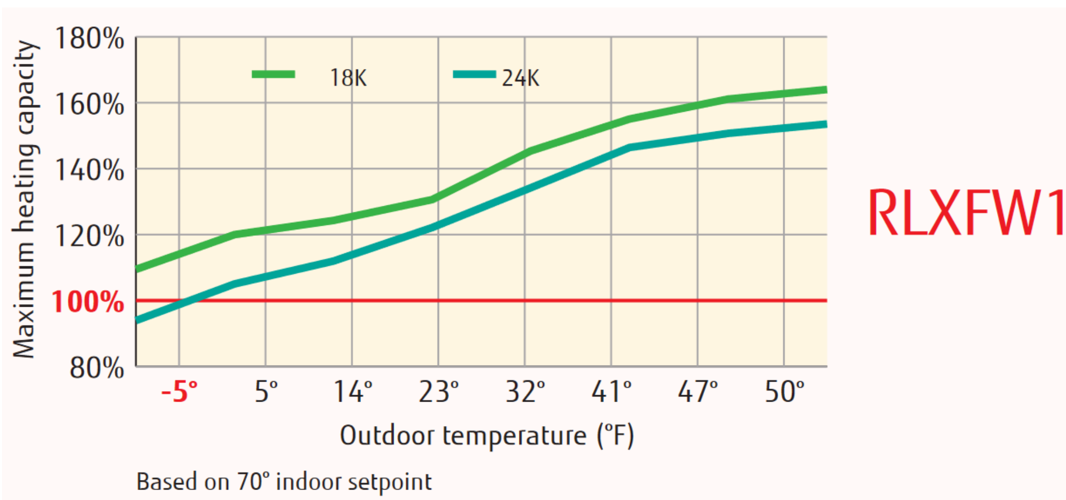
Offering multiple paths for customers to access product incentives and leveraging a standardized application process (when applicable) minimizes the steps for participating in the program. Residential customers who seek to install efficient equipment can either purchase instantly rebated items from the Online Marketplace or access rebates for larger efficient appliances through an online or paper application. Additionally, point-of-sale rebates help customers access efficient equipment. Having multiple options allows customers to access incentives in a method that they are comfortable with. Additionally, having a standard process for application data to be entered into the Captures platform ensures that customers' eligibility is verified appropriately and that all applications are processed similarly as they come in, which streamlines the application process.

8.2.1.2 Home Comfort Program

Interviewed Home Comfort Partners want the application process to be further streamlined. Several Home Comfort Partners indicated that the application process is cumbersome. Though many of them understood the need for rigor in verifying eligibility, they still indicated the process is tedious. Two contractors said that the online portal to submit applications is slow and difficult to use; they prefer using a paper version that they send to the program via email. Two contractors also indicated that they would prefer that the program remove the Manual J calculation requirements for ductless heat pumps, as this adds time and effort to the application and might not be necessary for these particular applications.

Although the program offers enhanced incentives for cold-climate heat pumps (which are typically 20-30% higher than the incentives for the traditional equipment), the rebate calculation methodology for partial-house projects promotes the installation of regular rather than cold-climate heat pumps. Rebates for all heat pump systems are calculated based on the heating capacity of the equipment. Specifically, rebates for cold-climate heat pumps are calculated based on their heating capacity at 17°F, while traditional heat pump rebates are calculated based on the heating capacity at 47°F. Several contractors stated that the heating capacity for traditional equipment at 47°F is often significantly greater than for cold-climate heat pumps at 17°F and that, as a result, traditional systems were receiving larger incentives than cold-climate heat pumps even with the enhanced rebates (approximately 25% higher per BTU compared to traditional equipment). This phenomenon is attributable to the greatly increased energy content in outside air at 47°F compared to 17°F, which impacts the ability of even cold-climate heat pumps to deliver heat into interior spaces. Figure 8-1, a capacity correction curve from a Fujitsu specifications manual, documents the difference in heating capacity at different outside air temperatures.

Figure 8-1: Maximum Heating Capacity vs. OAT for a Fujitsu RLXFW1 Cold-Climate Heat Pump



Source: Halcyon Mini-Split Heating and Cooling Systems for Residential and Light Commercial Applications Catalog, Fujitsu General America, Inc. March 2021.

This disparity impacts partial-house and electric-resistance heating replacement projects. It does not impact the whole-house portion of the Home Comfort Program, which only provides rebates for cold-climate heat pumps.

Project timelines for a Home Comfort Project range from 4 to 8 weeks. Home Comfort Partners indicate that the turnaround time from initial application to incentive payout can vary. One contractor indicated that the program staff is quick to notify them if something is missing in the application so that they can address it quickly. Though contractors would prefer a shorter turnaround time, program staff fulfills the application within the timeframe that they indicate.

While all Home Comfort Partners were aware of LMI offerings, only 30% incorporated LMI rebates as a regular part of their business. A majority of interviewed Home Comfort Partners indicated that they did not actively market to LMI customers and were not receiving calls from those customers. However, these companies indicated that they would be interested in serving more LMI customers but that most of their marketing is passive or driven by customers calling them. This indicates that very few LMI customers are requesting contractor services directly, and thus this customer segment is underserved. Specific LMI marketing and proactive outreach is an option for the program to target this segment, as are additional enhanced rebates or financing options.

Interviewed Home Comfort Partners generally do not promote on-bill recovery loans through PSEG-LI. Seven of the contractors interviewed indicated that their customers take advantage of financing through third-party lenders or NYSERDA for home upgrade projects. Most of the contractors said that they had preexisting relationships with financial institutions and, as a result, did not direct customers to PSEG-LI financing options. Two contractors indicated that they perceive the PSEG-LI loan process as too onerous and that on-bill financing creates additional burdens for the homeowners.

8.2.1.3 Commercial Efficiency Program

Trade allies and lighting contractors who make use of the CEP indicate that program application tools are relatively easy to navigate. One interviewed lighting contractor indicated that once their team members are familiar with the program application and the lighting project workbook required for comprehensive lighting projects, they are straightforward to use and submit. Another lighting contractor indicated that the online portal and access to Captures has improved and that the lighting workbook for comprehensive projects balances ease of use with level of detail.

CEP lighting project timelines vary and depend on the Efficiency Consultant. Six of the interviewed lighting contractors indicated that the timeline between project completion and incentive payout can be longer than expected or that project timelines are generally too long. When selling a project, contractors take on the risk of losing customers due to delays in scheduling pre-inspections or issuing project approval. One interviewee indicated that the length of the process seems to vary by which Efficiency Consultant gets assigned to the project; they indicated that they were satisfied with the responsiveness and rigor of a particular Energy Consultant but had less responsiveness from other Energy Consultants on different projects. This feedback suggests that there are variations in how Energy Consultants approach contractors or projects.

While the Fast-Track Lighting option serves a particular small business sector, some lighting contractors see limited value in using this option. Two of the interviewed lighting contractors who participate with both the Fast-Track Lighting option and the comprehensive lighting option indicated that they prefer the comprehensive track, since the $5,000 incentive cap for Fast-Track projects requires their team members to put in more time and effort for a smaller incentive. In some cases, they indicated that the program requirements for Fast-Track were not worth the time for the level of incentive. One contractor expressed that it was difficult to scale these projects due to the incentive cap.

8.2.2 Marketing and Customer Motivation

Program staff and the implementation contractor engage in a variety of marketing strategies, which are determined based on the target sector.

8.2.2.1 Residential Programs

Marketing for residential programs has changed due to the COVID-19 pandemic. Before COVID, residential customers would be targeted in a variety of ways including in-store signage at retailers (particularly for EEP), bill inserts, and community events where program representatives could directly talk to customers. The focus, especially for weatherization-related programs like REAP and HPwES, was to provide direct steps and actions that homeowners can take to reduce their energy usage. COVID shutdowns have prompted a rethinking of in-person marketing strategies; programs like EEP are now focusing on online channels and collateral materials to attract customers. However, sales data documents a sharp increase in revenues for home improvement stores during the pandemic, so we recommend that PSEG-LI continue to employ in-store signage as well to support any midstream rebate programs.

"Video vignettes" represent a new strategy to reach and educate residential customers on the value of energy efficiency. In response to the COVID-19 pandemic, the Company's implementer shifted their contractor training model to incorporate "video vignettes" – short training videos hosted on the internet available at any time to contractors. Although training inquiries and more nuanced topics rely upon person-to-person interaction, these vignettes were praised by residential trade allies as useful introductory and reinforcement tools. For example, the videos can assist allies answer a question about a program's application process in the field without other resources. These video vignettes are also available as a training and education tool for residential customers to increase their interest in energy efficiency.

Figure 8-2: Training Video Vignette Hosted on YouTube

Home Comfort Partners primarily rely on referrals or word-of-mouth to recruit customers. Very few of the interviewed Home Comfort Contractors indicated that they engaged in cold calls to recruit customers. Primarily, they engage customers through word-of-mouth or referrals. A few interviewed contractors indicated that they are beginning to use online platforms to advertise; this strategy includes using social media and search engine optimization. Given the need to drive beneficial electrification through increased adoption of heat pumps on Long Island, the program can consider marketing approaches that supplement HVAC contractors' traditional referral-based approach to winning work. This may include efforts such as expanding awareness of the program and the benefits offered by heat pumps or expanding the availability of co-branded marketing materials for Home Comfort Partners.

Customers who are interested in installing heat pumps through the Home Comfort Program want to enhance their cooling systems rather than look for a replacement heating system. According to Home Comfort Partners who were interviewed, most customers who they attract for heat pump jobs are interested because they are seeking a solution for central air or to get away from window unit A/Cs. They are largely unaware of the heating capabilities of these systems but see this as an added benefit. Additionally, contractors indicated that most customers who have gas heating are not looking to switch away from gas as their heat source.

8.2.2.2 Commercial Programs

Commercial sector marketing strategies are driven by direct outreach and program Energy Consultants. Marketing for commercial programs centers around direct outreach. The program makes use of Energy Consultants (implementation contractor staff) to interface with customers. These consultants manage key accounts in the small business and large business sectors. CEP staff also work closely with utility account representatives, local chambers of commerce, and the utility Economic Development Team to secure face-to-face meetings with key customers. Prior to the COVID shutdowns, conferences and networking events were another strategy to provide face-to-face contact with commercial customers. Insofar as marketing drives program participation and resultant savings, the pivot to virtual one-on-one communications (video calls/conference calls) did not seem to hinder market engagement as the program met its ex-ante gross savings goals.

Lighting contractors who submit projects to the Comprehensive and Fast-Track Lighting Programs are also a main driver for customer acquisition, and they typically engage customers through referrals and face-to-face communications. Lighting contractors indicated that their main methods of reaching customers include referrals from other strategic partners such as electricians, working with existing customer base, or word-of-mouth. Most interviewed contractors indicated that their business is driven by building connections with key customers.

Fast-Track Lighting contractors are interested in co-branded marketing materials. Fast-Track Lighting Prime Efficiency Partners (PEPs) who were aware of the ability to use co-branded marketing materials from PSEG-LI see this as important collateral material to enhance customer recognition and trust. However, one contractor indicated that the approval process for creating co-branding materials for contractor use could be made simpler to encourage use. PEPs indicated that they see a handful of leads come from the approved contractor list but not a significant volume.

8.2.3 Trade Ally Engagement and Program Rules

The following sections detail trade ally networks for residential and commercial programs.

8.2.3.1 Residential Trade Allies

The trade ally network for heat pump water heaters is underdeveloped. Heat pump water heaters, available through the Residential EEP, do not require an approved installation contractor for customers to access the rebate. Measures such as heat pumps (HVAC measures) available through the Home Comfort Program and pool pumps available through EEP do require an approved contractor. For heat pump water heaters, the program is interested in developing a contractor base for this particular measure, but there is currently no approved contractor network. Additionally, Home Comfort Partners specialize in HVAC and rarely perform water heater installations . As installations of heat pump water heaters increase through the program, implementers and program staff will be able to identify key installers and understand the viability of creating an approved contractor network.

The approved Home Comfort Partner trade ally must showcase their competency to ensure that they properly size heat pump installations and adhere to program requirements. Home Comfort Partners must install approved heat pump systems for customers to receive incentives for ASHPs or geothermal systems. The requirements to become a partner include signing a yearly participation agreement, providing insurance documentation, receiving EPA refrigerant handling certifications, and ensuring that the company is licensed to operate on Long Island. Additionally, Home Comfort Partners must attend a Quality installation verification (QIV) training to ensure correct installation practices and that Manual J calculations are being done properly. Additionally, the program provides virtual trainings as well as open house sessions for contractors to ask application questions. New Home Comfort Partners are placed on probationary status until they have successfully completed 20 applications for the program. For those initial 20 projects, the program implementer provides detailed application review and additional support to ensure contractor quality. Additionally, several Home Comfort Partners indicated that being associated with the PSEG-LI Program assures customers of their legitimacy, and that the ability to offer the rebates helps them stand out in a competitive marketplace.

The Home Comfort Program Partner Network is almost entirely composed of HVAC companies , which limits the program from strongly promoting whole house upgrades or enhanced rebate offerings beyond HVAC. Seven of the ten interviewed companies (out of approximately 100 partners) indicated that they do not participate in the Home Performance program or engage in any weatherization work. The contractors interviewed are among the most active participants in the program. None of the companies interviewed offered hot water heaters (heat pump or tankless) as a regular part of their business, though several Home Comfort Partners indicated that they will occasionally install a water heater at the customer's request, particularly if the water heater is included as part of a larger (typically whole-home) HVAC retrofit project. With regards to hot water heaters specifically, a majority of Home Comfort Partners interviewed stated that water heaters are installed by plumbers and that Partners did not have the training or licensing to make such measures a core part of their business.

8.2.3.2 Commercial Lighting Trade Allies

The Fast-Track Lighting Program has an approved contractor list of Prime Efficiency Partners (PEPs) who customers must use to secure incentives via this track. PEPs are required to sign a program agreement, provide proof of insurance, have three prior customer references, and have submitted at least five projects to the utility previously. The PEPs provide access to Fast-Track Lighting incentives for their customers, enjoy access to select pilot programs, and are invited to a variety of trainings on topics such as lighting design and business development. They also have the ability to develop marketing materials co-branded with the PSEG-LI logo. Customers who want to participate in the Comprehensive Lighting Track can select a lighting contractor of their choice (they do not have to be pre-approved).

PEPs see the major benefit of the approved trade ally network as increasing credibility and trust from the customer. Three of the lighting contractors who were interviewed indicated that the main benefit of being a PEP was that the association with the utility help customers trust them more. Being associated directly with PSEG-LI made the customer more comfortable and confident in pursuing lighting projects. However, as indicated above in the Program Design and Processes section, a number of lighting contractors prefer the Comprehensive Program Track since the smaller lighting projects require more time relative to project scope and price.

8.2.4 Inspections, QA/QC, Tracking

The Captures platform provides program staff and implementers with a central database to track projects, verify eligibility, and track customer correspondence. It has limitations. When applications come in from the online forms, Captures automatically creates a record and program staff (Specialists and Efficiency Consultants) can review applications for completeness. Paper or email applications are also uploaded to this system so that there is a single database to track projects. Captures allows for program-specific dashboards so that staff can visualize program KPIs. Captures also has the capability to automatically generate emails upon completion of certain milestones.

There are processes that could be improved in Captures. Feedback from heat pump and lighting contractors indicate that the system for submitting applications is straightforward; however, some contractors indicated that there is lag time with the platform that can make it difficult to upload application materials. Additionally, several vendors expressed that they were not aware of the current status of their applications and felt out of touch with their progress. Another potential enhancement for Captures would be the ability to generate customer reports on high users to enhance targeted outreach/marketing; this functionality is currently not available in the platform.

8.2.4.1 Home Comfort Program

For the Home Comfort Program, COVID has introduced new virtual options for pre- and post-inspections, which have received mixed responses from Home Comfort Partners. Owing to the COVID-19 pandemic, on-site inspections were replaced with a new virtual inspection process which includes submission of photographs (by Partners or customers) documenting pre- and post-installation conditions at the customer site. Two of the contractors interviewed indicated that the pre- and post-photos are more convenient than in-person inspections. However, three interviewees indicated that the photo submission process puts an additional burden on their staff as well as the customers. One contractor indicated that a key component of the residential HVAC market is the ability to provide an accurate quote to the customer and quickly close on deals (“selling at the kitchen table”). The virtual pre-inspection process created an additional hurdle to this selling strategy. The contractor highlighted the importance that approvals happen in a timely manner, otherwise customers lose interest.

8.2.4.2 Commercial Efficiency Program

PEPs perceive the Fast-Track Lighting Program process to be quick. Projects submitted under this track do not require pre-inspection for the installation to proceed. Lighting contractors, not surprisingly, reflected that this makes the process quicker.

Commercial lighting contractors indicate that pre-inspection for Comprehensive Lighting Projects have the potential to derail projects. Three of the interviewed lighting contractors indicated that if the pre-inspection scheduling takes too long, customers lose interest and contractors are at risk of losing jobs. One contractor indicated that usually pre-approval and pre-inspection would take 1 to 3 weeks at most, and now in some cases they are waiting 6 weeks to schedule a pre-inspection. Another contractor suggested that Efficiency Consultants and inspectors could be more proactive about scheduling and communication around site visit times. Finally, one contractor indicated that for the outdoor lighting track, pre-inspection does not need to be done, and that the program could be structured more like the Fast-Track Lighting Program, where pre-inspections are not required.

Lighting Contractors indicated that pre-inspectors are inconsistent about how they establish baselines. It is unclear how often this happens in practice but one contractor indicated that during pre-inspections some program staff do not count fixtures that have burned out and that the customer is looking to replace with a working lamp as part of the existing quantity of lights. For example, a customer might have 7 working fluorescent fixtures and 3 burned out ones, and they want to replace all 10 fixtures with LEDs, but the inspector only indicates that the existing quantity is 7. After the post-inspection, the savings that the customer is incentivized for becomes less than what was anticipated in the original scope due to the quantity issue. Again, it is not clear how commonplace that issue is, but one contractor indicated that this was a pain point for them and their customers.

8.2.5 Barriers and Market Opportunities

The following sections detail barriers and market opportunities for heat pump and lighting projects.

8.2.5.1 Heat Pumps and Heat Pump Water Heaters

Customer concern about switching to electric heat is a barrier to heat pump adoption. Home Comfort Partners indicated that customers are concerned that by switching to electric heat, especially if power outrages during a storm would cause them to lose heat. Additionally, customers are concerned about the cost of heating with electricity and contractors perceive that this issue is especially resonant for customers who currently use natural gas, which is more economical than fuel oil or electric resistance heating.

Home Comfort Partners perceive a lack of customer knowledge on the benefits of heat pumps. As noted in the Marketing and Customer Motivation section, many customers are not aware that heat pumps can provide heating and cooling; four contractors also specifically cited education about heat pump technology as a barrier to adoption. Additionally, one contractor indicated that there is “stigmatization” around heat pump technology (i.e. “they are expensive, and they don’t work”). Improving consumer education on the capabilities of heat pump technology and benefits represents an opportunity for the program. Six out of ten contractors interviewed said that they’d like to see PSEG-LI provide additional marketing, both about the program and about the technology in general.

Home Comfort Partners are targeting gas and oil heating customers, pointing the way to a market growth opportunity for heat pump adoption on Long Island. A majority of contractors in the Home

Comfort Program indicated that they are typically replacing gas and oil heating systems. Interviewees stated that oil heating customers are more motivated to install heat pumps since oil can be expensive. Only one contractor indicated that they are specifically targeting electric heating customers – according to this contractor, areas with abundant electric resistance heating are confined to the eastern edge of Long Island. Most of the Partners interviewed did not service Eastern Long Island. Additionally, areas without sufficient gas service to meet potential future demand on Long Island present an increased opportunity for ASHPs.

COVID-19 had both positive and negative effects on heat pump sales over the past year. Several Home Comfort Partners indicated that they had supply chain issues with sourcing equipment likely due to the COVID crisis. Supply chain issues extended project timelines, but no Partners indicated that they have lost projects owing to supply chain constraints. Several interviewees also indicated that heat pumps sales increased since residential customers were at home more often and were engaging in home improvement projects – most commonly adding additional heating and cooling capability to new home office conversions.

Home Comfort Partners perceive that younger homeowners are more motivated by electrification and environmental benefits but also may be deterred from home investments due to upfront costs. One contractor indicated that around 30–40% of their heat pump customers are interested in getting rid of fossil fuels to heat their homes. Three contractors specifically cited younger homeowners as being aware of and interested in the environmental and efficiency benefits of heat pumps, particularly when paired with solar systems and electric vehicles. This demographic represents an opportunity area; however, project costs might be a barrier for these younger homeowners.

8.2.5.2 Commercial Lighting

Demand for controls appears to be weak, except for specific segments such as warehousing. All but one of the contractors interviewed indicated that their team can specify controls systems. Three interviewees indicated that customer uptake of these options is low. One lighting contractor indicated that only around 25% of customers that are presented with a controls package opt for it, while another contractor indicated that only 3% of their customers implement controls with lighting upgrades. Several contractors stated that warehouse customers were more interested in lighting controls than commercial office space customers.

Lighting contractors are most often replacing T8s, T5s, and some first-generation LEDs for indoor applications and metal halides in outdoor applications. Contractors indicated that they sometimes see T12s in indoor settings as existing conditions, but those are more likely to be in municipal buildings or commercial tenant spaces. Two contractors interviewed indicated that they are, at times, replacing some first-generation LEDs in indoor settings.

Four of the interviewed lighting contractors see a diminishing market for LEDs on Long Island in the commercial sectors. One interviewee indicated that many customers have already made a transition to LED lighting in recent years. Those who have not transitioned to LEDs are not likely to engage in that type of project now – the interviewee stated that the benefits of LED lighting technology are well known and that commercial customers who have not yet upgraded their lights have consciously chosen to retain their original equipment in the despite clear savings opportunities with LEDs. Additionally, given the better efficiency of newer lighting technologies (e.g., T5 linear fluorescents as compared to T12), the potential savings for an LED conversion are lower, making it less appealing for the customer. Other lighting contractors reflected that the market will be decreasing due to increasing labor costs, challenges with COVID, and potential reductions in utility incentives and rebates which are perceived to drive the market.

8.3 CONCLUSIONS AND RECOMMENDATIONS

This section details the key conclusions and recommendations from the process evaluation.

8.3.1 Cross-Cutting Conclusions and Recommendations

Conclusion	Recommendation
Feedback from heat pump and lighting contractors indicate that the system for submitting applications is straightforward; however, some contractors indicated that there is lag time with the platform, which can make it difficult to upload application materials. Some contractors asked for the capability to see the status of their projects at a glance through a dashboard, indicating a lack of familiarity with the portal.	▪ The Captures portal offers value to both Program Administrators (application processing, reporting, QA/QC, and process standardization) and the contractor community. Continue to develop this platform to address contractor complaints regarding portal responsiveness. ▪ Consider developing video vignettes or other training materials specifically regarding the benefits offered to contractors by the portal, including the capability to track the progress of individual incentive or rebate applications.
Contractor communities across all programs trust PSEG-LI, its programs, and its implementation contractors, which is an achievement. Although all interviewed contractors relayed specific barriers or recommendations for program improvement, an overwhelming majority of contractors spoke about their longstanding, positive, and trusting relationships with PSEG-LI staff and their faith that PSEG-LI and its contractors have the best interest of the market and customers at heart. An overwhelming majority of contractors complimented PSEG-LI's deep relationships within the contractor communities and specifically spoke to PSEG-LI's openness and communication as key strengths in the partnership.	▪ Although PSEG-LI has built deep, trusting relationships with the contractor community, there are opportunities to improve upon this success and drive increased adoption of underserved market areas. Particularly within the residential market, the current contractor base is dominated by HVAC companies who focus on supplemental systems, which limit opportunities for whole-home programs and water heating measures. We recommend that PSEG-LI and their contractors apply the same relationship- and trust-building methodology to groom a new cadre of solution providers to deliver in these new program areas.

8.3.2 Heat Pumps/Heat Pump Water Heaters

Conclusion	Recommendation
Although the Program offers enhanced incentives for cold-climate heat pumps, the rebate calculation methodology for partial-house and electric-resistance heating replacement projects promotes the installation of regular (not cold-climate) heat pumps. Several contractors stated that the heating capacity for traditional equipment at 47°F is often significantly greater than cold-climate heat pumps at 17°F and that, as a result, traditional systems were receiving larger incentives than cold-climate heat pumps even with the enhanced rebates.	▪ The rebate calculations for Home Comfort Program partial-house and electric resistance heating replacement projects were re-visited in response to this feedback, and the rebates for ccASHPs were increased as a result. Trade allies might need some additional communication and reinforcement about this update to ensure that the rebate calculations truly align with not only higher efficiency equipment but also minimizing grid impacts.
Home Comfort Partners perceive that a lack of customer knowledge on the benefits of heat pumps is preventing increased adoption of the technology. Contractors reflected that barriers to adoption for heat pumps included that customers were unaware of their capabilities, that homeowners were concerned about costs and resiliency during a power outage, and that the reputation of older heat pump technology as ineffective is persistent.	▪ Continue to develop marketing materials for the PSEG-LI residential marketplace with a focus on expanding program awareness and explaining the benefits of heat pump systems especially compared to fossil-fuel-based technologies. Major heat pump manufacturers – Fujitsu, Mitsubishi, Carrier, and others – already have such education programs in place, and it may be beneficial to partner with these firms to deliver information cost-effectively to the Home Comfort Program's target market. ▪ Encourage further use of program-supported educational materials by Home Comfort Partners for more proactive outreach. Most contractors indicated that they receive leads through referrals or word-of-mouth. Given the need to drive beneficial electrification through increased adoption of heat pumps on Long Island, consider marketing approaches that supplement HVAC contractors' traditional referral-based approach to winning work, especially in geographies with a larger footprint of oil and electric resistance heating. This may include efforts such as expanding awareness of the program, the benefits offered by heat pumps, or expanding the availability of co-branded marketing materials for Home Comfort Partners.

Conclusion	Recommendation
A majority of the Home Comfort Partners interviewed indicated that they did not actively market to low- to moderate-income (LMI) customers and were not receiving calls from those customers – most respondents stated that their marketing is passive and driven primarily by inbound calls and customer referrals.	▪ To increase participation from LMI communities, specific LMI marketing and proactive outreach is an option to target this segment and increase participation. Also consider enhanced offerings/incentives for LMI customers or strategies to target multifamily buildings for heat pumps.
Home Comfort Partners indicate that many customers take advantage of financing through third-party lenders or NYSERDA, but typically do not engage in on-bill recovery loans through NYSERDA's Green Jobs Green New York program, which is perceived as an onerous process.	▪ Given the prevalence and widespread market adoption of existing financing solutions, the evaluation team does not recommend that PSEG-LI consider additional program-wide financing options. However, a targeted financing intervention may help increase adoption of heat pumps in under-served market segments like LMI, where Home Comfort Partners perceive the high capital cost of heat pumps is a major barrier to lower-income customers.
A majority of the Home Comfort Partners interviewed stated that the application process is burdensome – several indicated the application process was a major bottleneck to selling and delivering projects in a timely manner at scale.	▪ Invest in tool improvements for the application process to reduce the overall time required per-application. Explore options to reduce the technical literacy required to complete Manual J calculations, in particular for high-volume, relatively low-cost partial-home projects.

8.3.3 Lighting

Conclusion	Recommendation
Four of the lighting contractors interviewed see a diminishing market for LEDs on Long Island in the commercial sectors driven by increased market adoption and the recognized value offered by LEDs over outmoded lighting technologies. Those who have not already transitioned to LEDs are not likely to engage lighting retrofits until their existing equipment reaches the end of its useful life.	▪ Keep this in mind for planning, as the program starts to target the facility owners who are less inclined to engage in lighting retrofits, then cost of acquisition will start to increase with less opportunity for impacts.

Conclusion	Recommendation
Lighting contractors almost uniformly specify lighting controls in project bids, but there is little current customer demand for this type of project outside of warehouses.	▪ A lighting controls-focused program would provide an opportunity to continue to wring energy savings from an otherwise saturated market area. However, many potential customers are not aware of or are uninterested in the savings opportunity presented by controls. ▪ Develop and market educational materials targeted at specific customer segments that explain the benefits of lighting controls and provide case studies that demonstrate how those benefits may be realized at their facility.
Baselines are challenging to establish for lighting replacement projects and may be more complicated for projects that incorporate controls. Several lighting contractors indicated that pre-inspectors are inconsistent in the methodology/processes employed to set baselines across different projects. Additionally, contractors noted that miscommunication about scheduling pre-installation visits or about anticipated incentive values can derail projects eroding trust and leading to missed savings opportunities.	▪ Standardize program processes around pre-inspection scheduling and baseline determination, especially as the program pivots away from standard LED projects and into additional measures (e.g., controls). The contractor community has stated a preference for dependable, transparent processes over inconsistent timelines, even if those dependable timelines are a bit longer.

APPENDIX A: DETAILED METHODOLOGY

A. CEP METHODOLOGY

Evaluation Methodology: Commercial Efficiency Program	
Key Considerations	• Availability of project-specific inputs in Capture queries vs. supporting workbooks for Comprehensive Lighting • Perspective on total MMBtu savings for Distributed Generation • Waste Heat Factors for Commercial Lighting
General Approach (Ex-post gross)	Engineering calculations rooted in PSEG-LI TRM algorithms and informed by install tracking (Captures) database
Sampling Method(s)	• Census of all measure installs for measures where Captures data includes all parameters • Stratified random sample of projects where the parameters and calculations are housed in supporting workbooks
Primary Data	• Captures install tracking data for PY2020 CEP measures • Project specific pre- and post-inspection details • Custom measure inputs and calculations • Electrical output and fossil fuel consumption trend data in 15 minute intervals from Fuel Cell Project • Updated lighting waste heat factors developed by the evaluation team
Secondary Sources	• PSEG LI Technical Resource Manuals 2019-2021 • New York State TRM v7.0 and v8.0 • Department of Energy Codes and Standards • Lighting cut sheets and other manufacturer equipment specifications • PSEG LI Planning documents and workbooks • 2010 LIPA Technical Manual
Net-to-Gross Approach	Stipulated NTG ratios
Other Evaluation Techniques	• Engineering Calculations
Opportunities for Refinement	• **Consider MMBtu impacts at site:** for all energy sources when calculating reported savings, including distributed generation projects. • **Reference the PSEG Long Island TRM:** some program savings algorithms and input assumptions still reference the 2010 LIPA Technical Manual • **Track more project and measure level data in Captures** and make it available to be downloaded for evaluations

B. EEP METHODOLOGY

Evaluation Methodology: Energy Efficient Products	
Key Considerations	• Prescriptive measures with thorough tracking data • Low-to-moderate measure complexity • Moderate uncertainty of key savings parameters • High program contribution to portfolio savings • Program savings highly skewed to two measure categories, namely Lighting and Heat Pump Pool Heaters
General Approach (Ex-post gross)	Engineering calculations rooted in PSEG-LI TRM algorithms and informed by install tracking (Captures) database
Sampling Method(s)	Census of all measure installs
Primary Data	Captures install tracking data for PY2020 EEP measures
Secondary Sources	• PSEG LI Technical Resource Manuals 2019-2021 • New York State TRM v7.0 and v8.0 • ENERGY STAR Qualified Product Lists • Uniform Methods Project for Determining Energy Efficiency Program Savings (UMP) • Department of Energy Codes and Standards • Other manufacturer equipment specifications • PSEG LI Planning documents and workbooks
Net-to-Gross Approach	Stipulated NTG ratios
Other Evaluation Techniques	• Regression analysis, deemed savings used for certain measures • Diverged from TRM algorithm when enough data available • Assumed baseline is federal standard for end-of-life replacement measures • Updated HVAC interactive factors for LED lighting
Opportunities for Refinement	• **Inform savings estimates with supplemental research:** Research pool pumps and assumptions around baseline condition, capacity • **Use UMP regression for measures where install data permits** • **Increase focus on beneficial electrification** (data flow, rigor, and techniques)

C. HOME COMFORT METHODOLOGY

Evaluation Methodology: Home Comfort	
Key Considerations	• Beneficial Electrification measures result in an increase in site-level electric consumption by displacing fossil fuel systems sometimes resulting in negative kWh savings for those measures.
General Approach (Ex-post gross)	Engineering calculations rooted in PSEG-LI TRM algorithms and informed by install tracking (Captures) database
Sampling Method(s)	• Census of all measure installs • Stratified random sample of GSHP measures
Primary Data	• Captures install tracking data for PY2020 Home Comfort measures
Secondary Sources	• PSEG LI Technical Resource Manuals 2019-2021 • New York State TRM v7.0 and v8.0 • Department of Energy Codes and Standards • Other manufacturer equipment specifications • PSEG LI Planning documents and workbooks • Northeast/Mid-Atlantic Air-Source Heat Pump Market Strategies Report 2016 Update • NYSERDA Heat Pump Study: "Analysis of Residential Heat Pump Potential and Economics-May 2019
Net-to-Gross Approach	Stipulated NTG ratios
Other Evaluation Techniques	• Engineering Calculations
Opportunities for Refinement	• **Align with PSEG-LI TRM** on Quality Install savings algorithms, full load heating and cooling hours, savings algorithms, and savings estimation methods • **Track preexisting boiler and furnace heating system data** to improve accuracy of ex-ante savings • **Adopt deemed savings values** that vary based on the HVAC equipment controlled by the thermostats

D. REAP METHODOLOGY

Evaluation Methodology: Residential Energy Affordability Partnership Program	
Key Considerations	• REAP Evaluation was a combination of engineering calculations and consumption analysis • Consumption analysis will estimate savings that take in the interactive effects of implementing multiple measures at one location • REAP savings were dominated by lighting measures
General Approach (Ex-post gross)	• Engineering calculations rooted in PSEG-LI TRM algorithms and informed by install tracking (Captures) database. These calculations were used to calculate MMBtu to kWh and kW to kWh ratios. • Consumption analysis rooted in billing data from 2020 and 2019 customers using pre-participation data from 2020 customers as a baseline and post-participation data from 2019 customers as the treatment. Consumption analysis was used to estimate kWh realization rates. • The engineering calculation ratios and kWh realization rate from consumption were then used to estimate energy (MMBtu) and demand (kW) savings.
Sampling Method(s)	• Census of all measure installs from Captures • Matched participants provided in billing data
Primary Data	• Captures install tracking data for PY2020 EEP measures • Billing data from 2019 and 2020 REAP participants
Secondary Sources	• PSEG LI Technical Resource Manuals 2019-2021 • New York State TRM v7.0 and v8.0 • Department of Energy Codes and Standards • Other manufacturer equipment specifications • PSEG LI Planning documents and workbooks
Net-to-Gross Approach	Stipulated NTG ratios
Other Evaluation Techniques	• Engineering Analysis • Consumption Analysis using participant matching and fixed effects panel linear regression model
Opportunities for Refinement	• **Align existing and installed wattage values** with those reported in the program tracking database • **Align LED Coincidence Factor assumption with "All Light Bulbs" metering results**. This value currently relies on the "LED Only" metering results from a 2016 study when today the LED CF probably more closely reflects "All Light Bulbs". • **Use tracking data when available** rather than the TRM assumptions

E. HOME PERFORMANCE METHODOLOGY

Evaluation Methodology: Home Performance	
Key Considerations	• Beneficial Electrification measures result in an increase in site-level electric consumption by displacing fossil fuel systems sometimes resulting in negative kWh savings for those measures. • Impact Evaluation values are a combination of engineering calculations and consumption analysis
General Approach (Ex-post gross)	Engineering calculations rooted in PSEG-LI TRM algorithms and informed by install tracking (Captures) database. Consumption calculations were rooted in participant billing data and used to estimate kWh energy efficiency realization rates. Ex-post gross kWh energy efficiency savings were calculated by applying consumption analysis realization rate to EE savings. Ex-post gross kWh beneficial electrification impacts were calculated from engineering analysis. Ex-post gross kW and MMBtu savings were calculated using kW/kWh and MMBtu/kWh ratios from engineering calculations applied to ex-post gross kWh savings.
Sampling Method(s)	• Census of all measure installs from Captures • Matched participants provided in billing data
Primary Data	• Captures install tracking data for PY2020 Home Performance measures • Billing data from 2019 and 2020 Home Performance participants
Secondary Sources	• PSEG LI Technical Resource Manuals 2019-2021 • New York State TRM v7.0 and v8.0 • Department of Energy Codes and Standards • Other manufacturer equipment specifications • PSEG LI Planning documents and workbooks
Net-to-Gross Approach	Stipulated NTG ratios
Other Evaluation Techniques	• Engineering Analysis • Consumption Analysis using participant matching and fix effects panel linear regression model
Opportunities for Refinement	• **Track impacts by fuel:** (positive and negative) rather than zero out negative savings for HPwES projects • **Focused effort on tracking measure-level parameters in Captures**: specifically CFM values and conditioned square footage for duct sealing projects; HVAC system type and fuel type; pre-installation wattages and quantities for direct-install lighting

F. HOME ENERGY MANAGEMENT METHODOLOGY

The primary challenge of an impact evaluation is the need to accurately detect changes in energy consumption while systematically eliminating plausible alternative explanations for those changes, including random chance. Did the introduction of HERs cause a decrease in customer energy consumption? Or can the differences be explained by other factors? To estimate energy savings, it is necessary to estimate what these patterns would have been in the absence of treatment—this is called the counterfactual. At a fundamental level, the ability to measure energy reductions accurately depends on four key components:

- **The effect or signal size:** The effect size is most easily understood as the percent change. It is easier to detect large changes than it is to detect small ones. For most HER programs, the expected impact is between 0.5% and 2.5%, a relatively small effect.
- **Inherent data volatility or background noise:** The more volatile a customer's billing data are from month to month (or bimonthly billing period), the more difficult it is to detect small changes.
- **The ability to filter out noise or control for volatility:** At a fundamental level, statistical models, baseline techniques, and control groups—no matter how simple or complex—are tools to filter out noise (or explain variation) and allow the effect or impact to be more easily detected.
- **Population size:** It is easier to precisely estimate average impacts for a large population than a small one because individual customer behavior patterns smooth out and offset across large populations.

Approach Overview

Because the expected percent reduction from HERs is typically small (i.e., less than 5%), we followed the principles below to ensure accurate results:

1. **Verify that participant and control customers had similar usage before the introduction of HERs.** By design, randomized control trials ensure that the only systematic difference between the two groups is that one receives the HER and one does not. However, random assignment is sometimes not implemented correctly or maintained. Thus, we compare the treatment and control groups across a host of characteristics—electricity use, location, etc.—in order to ensure the implementer did indeed randomly assign customers to the treatment and control groups.
2. **Include at least one year of pre-treatment data and post-treatment data for both HER and control groups.** The pre-treatment data is useful for assessing if energy consumption changed and allows the evaluation team to use more powerful statistical techniques such as difference-in-differences and lagged dependent variable models. If HERs reduce consumption, we should observe a change in consumption for customers who received the

HER treatment but no similar change for the control group. Thus, participant and control customers that lacked pre-intervention data were not included in the analysis.

3. **Ensure sample sizes large enough to detect meaningful differences**. If sample sizes are too small, it is not possible to distinguish meaningful differences from random noise. When evaluated on their own, each wave tends to have wider confidence bands (i.e., they lack statistical power). Thus, this study's focus is on the overall program savings rather than on the savings delivered by specific waves.
4. **Apply the same data management procedures to both the HER and control groups.** Because of random assignment, data management decisions should impact the treatment and control group similarly.
5. **Pre-specify the analysis method and segmentation in advance of the study.** This required documenting the hypothesis, specifying the intervention, randomly assigning customers to treatment and control conditions, establishing the sample size and the ability to detect meaningful effects, identifying the data that will be collected and analyzed, and identifying the outcomes that will be analyzed.
6. **Ensure impacts are robust.** Impacts can be estimated using both a difference-in-difference approach and by using a post-only model. A difference-in-difference approach compares energy usage before and after the intervention for both the participant group and the control group and net out any pre-existing differences. A post-only model leverages data from the pre-treatment period as an explanatory variable, but only includes observations from the post-treatment period in the regression. In the evaluation, we estimated impacts using both approaches in order to ensure the different methods did not produce significantly different results.

MODEL SPECIFICATION

DSA used the lagged dependent variable (LDV) model to estimate ex-post impacts. The LDV model is a "post-only" model because only observations from the post-treatment period are included in the regression. However, as its name suggests, the LDV model does leverage data from the pre-treatment period as an explanatory variable.

The formal model specification is shown below with additional detail on the terms provided in Table A-1.

$$Daily\ Use_{im} = \beta_0 + \beta_{1m} * AvgPre_{im} + \beta_{2m} * CDD_m + \beta_{3m} * HDD_m + \tau_m * \mathrm{treatment}_{\mathrm{im}} + \sum_{m=1}^{12} \beta_4 * m + \varepsilon_{\mathrm{im}}$$

Table A-1: Lagged Dependent Variable Model Definition of Terms

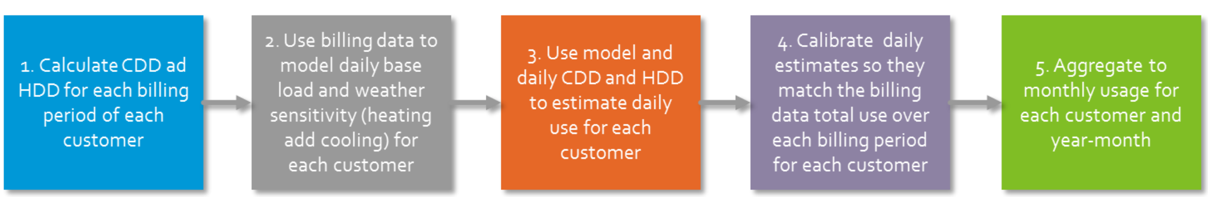
Variable	Definition
Daily Use_{im}	Customer i's average daily usage in bill month m.

Variable	Definition
β_0	Intercept of the regression equation.
β_{1m}	Coefficient explaining any variation that occurs as a result of pre-treatment usage for month m.
$AvgPre_{im}$	Average daily usage for customer i in the pre-treatment period for month m.
β_{2m}	Coefficient explaining any variation that occurs as a result of average monthly CDD for month m.
CDD_m	Difference between average temperature and 60 for month m.
β_{3m}	Coefficient explaining any variation that occurs as a result of average monthly HDD for month m.
HDD_m	Difference between 60 and average temperature for month m.
treatment_{im}	The treatment indicator variable. Equal to one when the treatment is in effect for the treatment group. Zero otherwise. Always zero for the control group.
τ_m	The estimated treatment effect in kWh per day per customer; the main parameter of interest.
β_4	Coefficient for Year Month Variable.
m	Year month indicator.
ε_{im}	The error term.

Calendarizing Billing Data

The time of the month when customer meters are read and the number of days between billing statements varies. Thus, we prorated billing data into a standard calendar month basis. The process of converting bills to usage is known as calendarization. Figure A-1 summarizes the process employed to calendarize the data.

Figure A-1: Calendarization of Billing Data



Opt Outs and Attrition

Over time, some homes assigned to the HER program will close their accounts with PSEG Long Island. The most common reason for this is that the occupant is moving, but other possibilities exist. This account churn happens at a predictable rate and can be forecasted with some degree of certainty. It is also completely external to the program, so there is no reason to suspect that it happens differently in the treatment and control when the groups were randomly assigned. The analysis includes all active accounts for a given month and all participation counts used to calculate aggregate savings. Once an account closes, there will no longer be consumption records in the billing data set, so the home is removed naturally from the analysis without requiring any special steps.

Treatment group homes are allowed to opt-out of receiving HER mailings if they choose. Typically, only a small proportion of the treatment group exercises this option. Those who opt out must not be removed from the analysis because doing so could compromise the randomization (control group homes do not opt-out).

Uplift Analysis

Exposure to behavioral program messaging often motivates participants to take advantage of other energy efficiency and beneficial electrification programs. This creates a situation where the treatment group participates in other programs at a higher rate than control group homes. To avoid double-counting these impacts, our team calculated savings from program uplift and subtracted them from the aggregate savings.

For downstream programs where participation is tracked at the account level, dual participation was calculated using the following steps:

1) Match the energy efficiency and beneficial electrification program tracking data to the treatment and control homes.
2) Assign each transaction to a month based on the participation date field in the tracking data.
3) Exclude any installations that occurred before the home was assigned to the treatment or control group.
4) Calculate the daily kWh savings of each efficient measure. This value is equal to the reported kWh savings of the measure divided by 365.
5) Sum the daily kWh impact, by account, for all measures installed prior to a given month.
6) Calculate the average kWh savings per day for the treatment and control groups by month. Multiply by the number of days in the month.
7) Calculate the incremental daily kWh from energy efficiency (treatment – control). The evaluation team subtracted this value from the treatment effect determined via regression analysis prior to calculating gross verified savings for behavioral programs.

G. CONSUMPTION ANALYSIS METHODOLOGY FOR REAP AND HOME PERFORMANCE

The consumption analysis relies on a comparison between billed consumption prior to and following the energy efficiency upgrades. In 2020, the consumption analysis leveraged a matched control design. Participants from 2019 acted as the "treatment" group and participants from 2020 were part of the control pool. Steps taken to prepare the billing data for the analysis – including the selection of a matched control group – are discussed in subsequent sections.

HANDLING ESTIMATED READS

A number of the customer bills were estimated reads, meaning the total consumption for the billing cycle is an estimate rather than the actual value. Estimated reads are not uncommon and occur for a variety of reasons. Approximately 19% of the billing records in our sample were estimated reads. Our approach to handling estimates reads was threefold:

1. For each customer, remove any billing cycles that follow the last actual read since estimated reads after the last actual read cannot be "trued" up.

2. For each customer, remove any billing cycles that precede the first actual read (including the first actual read itself).

3. For each customer, group any estimated read(s) with the first actual read that follows the estimated read(s). Sum the total consumption between the estimated read(s) and the actual read, then divide by the total number of days across the estimated read(s) and the actual read. This approach is illustrated in Table A-2 using data for a hypothetical household. The latter three bills are grouped together and an average daily kWh value is calculated across the three bills. This process removes any potential for bias if estimated reads are systematically high or low.

Table A-2: Estimated Reads

<table>
<tr><th>Meter Read Date</th><th>Days in Cycle</th><th>Estimated or Actual</th><th>Billed kWh</th><th>Average Daily kWh</th></tr>
<tr><td>2/15/2019</td><td>30</td><td>Actual</td><td>540</td><td>18.0</td></tr>
<tr><td>3/15/2019</td><td>28</td><td>Estimated</td><td>462</td><td rowspan="3">17.7</td></tr>
<tr><td>4/15/2019</td><td>31</td><td>Estimated</td><td>481</td></tr>
<tr><td>5/15/2019</td><td>30</td><td>Actual</td><td>630</td></tr>
</table>

CALENDARIZATION

Because billing cycles typically span multiple calendar months and read dates vary from customer to customer, the Evaluation Team "calendarized" the billing data as part of our analysis. In calendarizing the data, the goal is to prorate billing data into a calendar month basis shared by all participants. This process is described through example below. Table A-3 contains four months of simulated billing data. The consumption values and time periods are hypothetical and not from an actual customer.

Table A-3: Simulated Billing Data

Billing Period	Nov 12^{th} – Dec 11^{th}	Dec 12^{th} – Jan 11^{th}	Jan 12^{th} – Feb 11^{th}	Feb 12^{th} – Mar 11^{th}
Usage (kWh)	540	577	520	455

Billing Period	Nov 12th – Dec 11th	Dec 12th – Jan 11th	Jan 12th – Feb 11th	Feb 12th – Mar 11th
Average Daily	18.0	18.6	16.8	15.7

For each billing period, average daily usage can be calculated by dividing total usage by the number of days in the billing period. For example, there are thirty days in the November 12th – December 11th billing period, so the average daily usage is 540 / 30 = 18.0 kWh. This value can then be assigned to each day in the billing period. Table A-4 shows estimated daily usage for each day in December.[23] Note that the first eleven days reflect the November 12th – December 11th billing period, and the last twenty days reflect the December 12th – January 11th billing period.

Table A-4: Redistribute December Billing Data

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
		1 18.0	2 18.0	3 18.0	4 18.0	5 18.0
6 18.0	7 18.0	8 18.0	9 18.0	10 18.0	11 18.0	12 18.6
13 18.6	14 18.6	15 18.6	16 18.6	17 18.6	18 18.6	19 18.6
20 18.6	21 18.6	22 18.6	23 18.6	24 18.6	25 18.6	26 18.6
27 18.6	28 18.6	29 18.6	30 18.6	31 18.6		

To retrieve prorated billing data, simply sum up the estimated daily usage values within each month. This is illustrated in Table A-5 for December, January, and February.

Table A-5: Calendarized Billing Data

Value	December 2020	January 2021	February 2021
Estimated Usage (kWh)	11*(18.0) + 20*(18.6) = 570.0	11*(18.6) + 20*(16.8) = 540.6	11*(16.8) + 17*(15.7) = 451.7
Average Daily Usage (kWh)	570.0 / 31 = 18.4	540.6 / 31 = 17.4	451.7 / 28 = 16.1

[23] 2020 calendar is used for this example

MATCHING

In a matched control framework, each participant is matched to exactly one control home that shows a similar energy-use profile. In our 2020 analysis, this was done via propensity score matching. Steps taken to develop the matches were as follows:

1. Estimate weather-normalized annual consumption (pre-participation) for each participant.

2. Estimate the weather sensitivity of each participant's consumption. In total, three variables were estimated: (1) The expected change in average daily consumption for a one-unit increase in average daily CDD, (2) the expected change in average daily consumption for a one-unit increase in average daily HDD, and (3) the percentage of the variation in average daily consumption that can be explained by CDD and HDD. In laymen's terms, (1) represents how consumption is affected by warm weather, (2) represents how consumption is affected by cool weather, and (3) is a measure of how precisely weather data can predict consumption.

3. Using the terms estimated in (1) and (2) above, test out several different propensity score models. For each model, we produced standard metrics for bias and goodness of fit – these metrics measure the error between "nearest neighbor" loads and treatment home loads. Of the three models that produce the lowest percent bias, the model that minimizes mean absolute prediction error is selected as the best model. The control group picked by the best model is used as the control group in the consumption analysis.

Figure A-2 compares average daily consumption in the REAP treatment and control groups across 2018. There is clearly strong alignment between the two groups. Figure A-3 shows the distribution of weather-normalized consumption for the REAP treatment and matched control groups. Again, there is clearly strong alignment between the two groups. Figure A-4 and Figure A-5 are similar to Figure A-2 and Figure A-3 but represent Home Performance treatment and matched control groups rather than REAP. The takeaways for Home Performance are the same as REAP – the participant group and the matched control groups are well-aligned in their annual consumption and the seasonality of their consumption trends.

Figure A-2: Average Daily Usage of Treatment and Comparison Groups (kWh), REAP

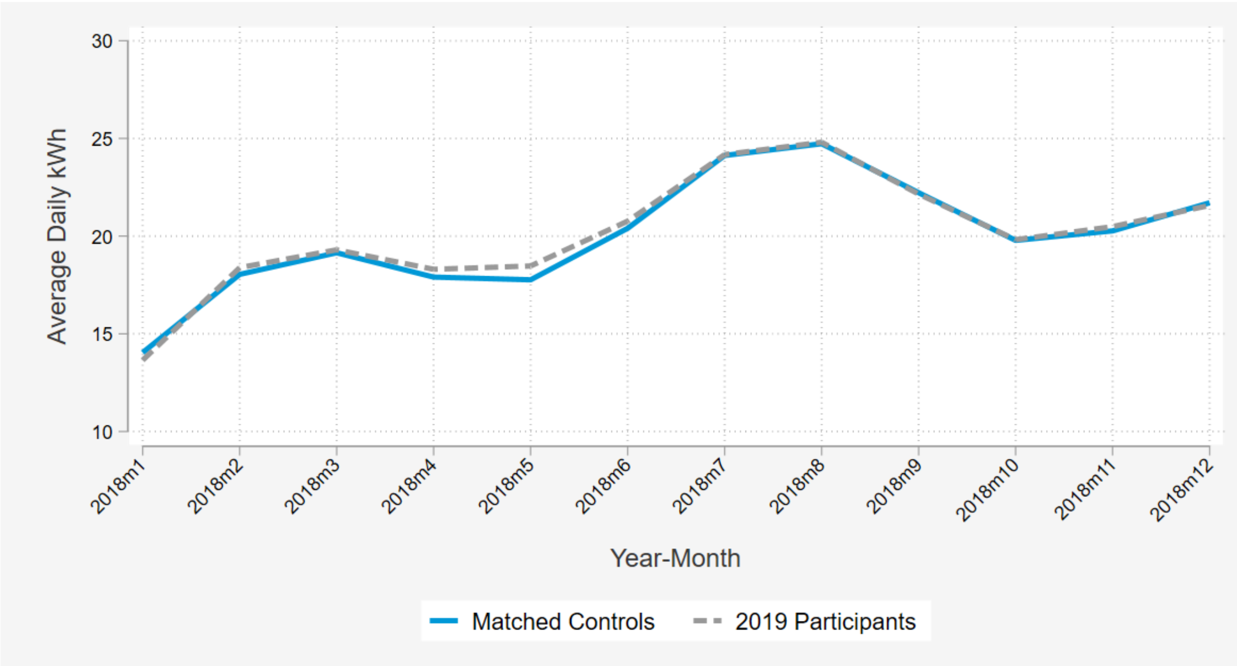


Figure A-3: Distribution of Annual Consumption, REAP

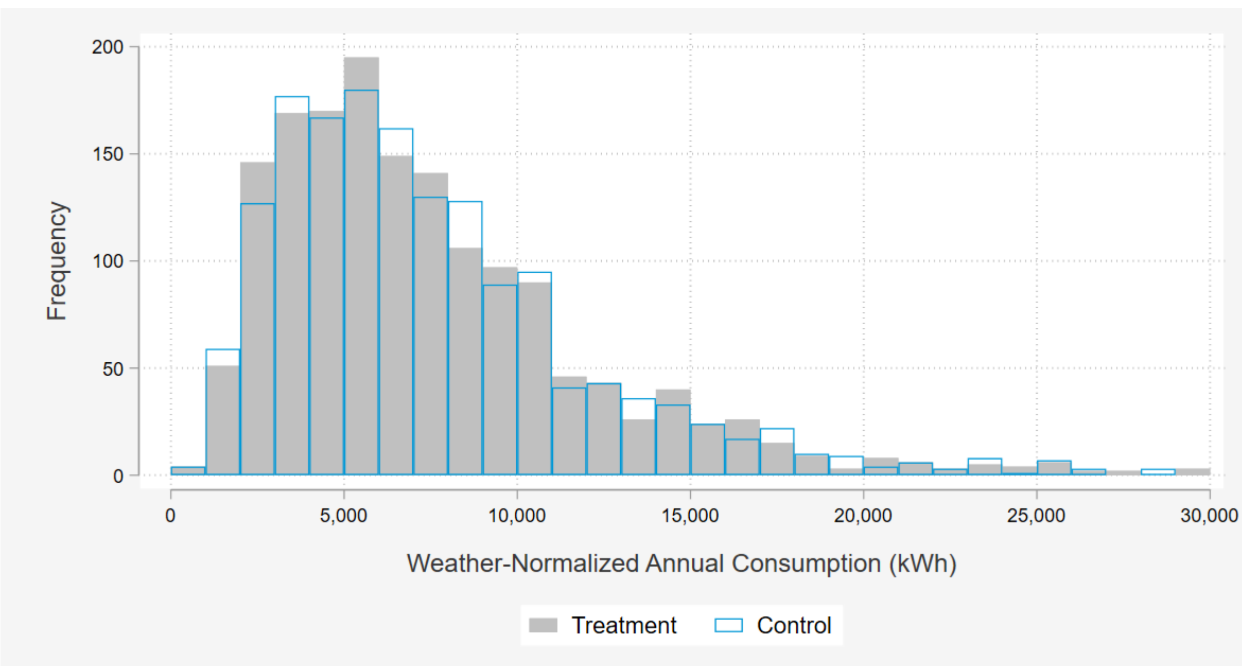


Figure A-4: Average Daily Usage of Treatment and Comparison Groups (kWh), Home Performance

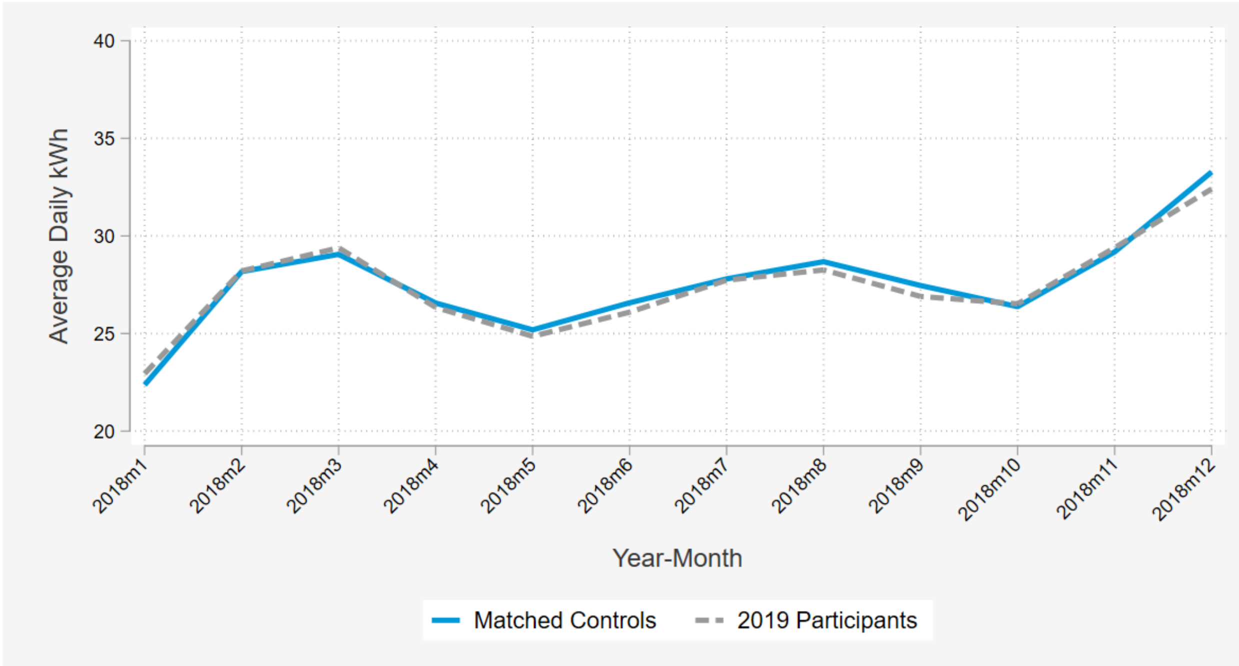
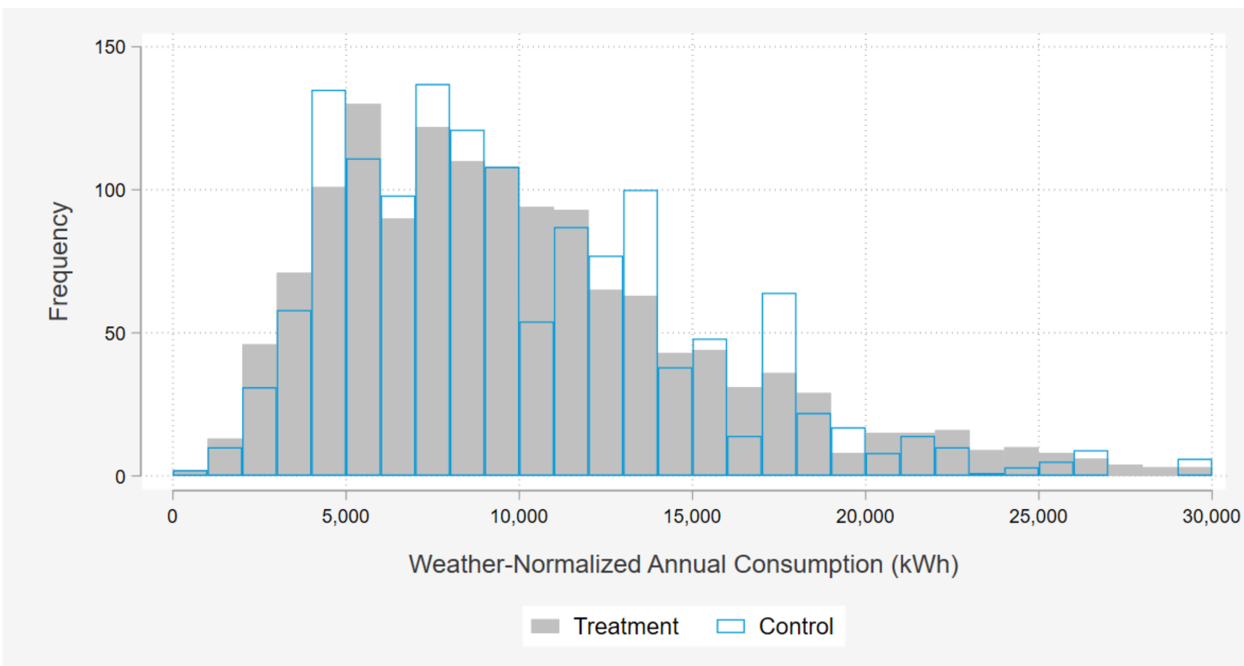


Figure A-5: Distribution of Annual Consumption, Home Performance



Impact Analysis

The consumption analysis model is a linear fixed effects panel regression model. A fixed effects model absorbs time-invariant household characteristics via inclusion of separate intercept terms for each account in the treatment and comparison group. Equation A-1 shows the full model specification.

Inclusion of monthly time effects improves the precision of the base 'difference-in-differences' calculation. We weight the regression model by the number of days of the month. The treatment effect is the difference in daily energy use that is associated with participating in the program. We multiply the treatment effect by the number of days in a year to annualize the savings.

Equation A-1: Linear Fixed Effects Regression Model Specification

$$\mathrm{kWh}_{\mathrm{imy}} = \beta_{\mathrm{i}} + \beta_p * Post_{imy} + \sum_{\mathrm{m}=1}^{12} \sum_{\mathrm{y}=2018}^{2020} \mathrm{I}_{\mathrm{my}} * \beta_{\mathrm{my}} + \tau_{my} * Post_{imy} * \mathrm{treatment}_{\mathrm{i}} + \varepsilon_{\mathrm{imy}}$$

Table A-6 defines the model terms and coefficients in Equation A-1.

Table A-6: Regression Model Parameter Definitions

Variable	Definition
$\mathrm{kWh}_{\mathrm{imy}}$	Customer i's average daily electric usage in month m of year y.
β_{i}	The intercept term for customer i, or the "fixed effect" term. Equal to the mean daily energy use for each customer.
$\mathrm{Post}_{\mathrm{imy}}$	An indicator equal to one if customer i participated in the program prior to month m of year y and zero otherwise. Coding of the post term for each member of the comparison group mirrors its matched participant.
β_p	The coefficient on the post indicator variable. The captures the change in consumption in the matched control group during the post-period due to exogenous factors such as the COVID-19 pandemic.
I_{my}	An indicator variable that equals one during month m, year y, and zero otherwise. This variable models each month's deviation from average energy.
β_{my}	The coefficient on the month-year indicator variable.
$\mathrm{treatment}_{\mathrm{imy}}$	The treatment variable. Equal to one for the participant group and zero for the matched control group.
τ_{my}	The estimated treatment effect in kWh per day; the main parameter of interest. The change in daily kWh consumption attributable to program participation.
$\varepsilon_{\mathrm{imy}}$	The error term.

The REAP consumption analysis returned an annual savings estimate of 563 kWh (95% confidence interval: 429 kWh/year, 697 kWh/year), and the Home Performance analysis returned an annual savings estimate of 816 kWh (95% confidence interval: 571 kWh/year, 1,062 kWh/year). Savings for REAP and Home Performance are visualized in Figure A-6 and Figure A-7, respectively. Statistical regression output for the REAP and Home Performance models is shown in Figure A-8 and Figure A-9, respectively. The key term in the regression output is the coefficient for the "treatpost" term, which represents the change in average daily consumption for the treatment group in the post period.

Figure A-6: REAP Consumption Analysis Results Visualized

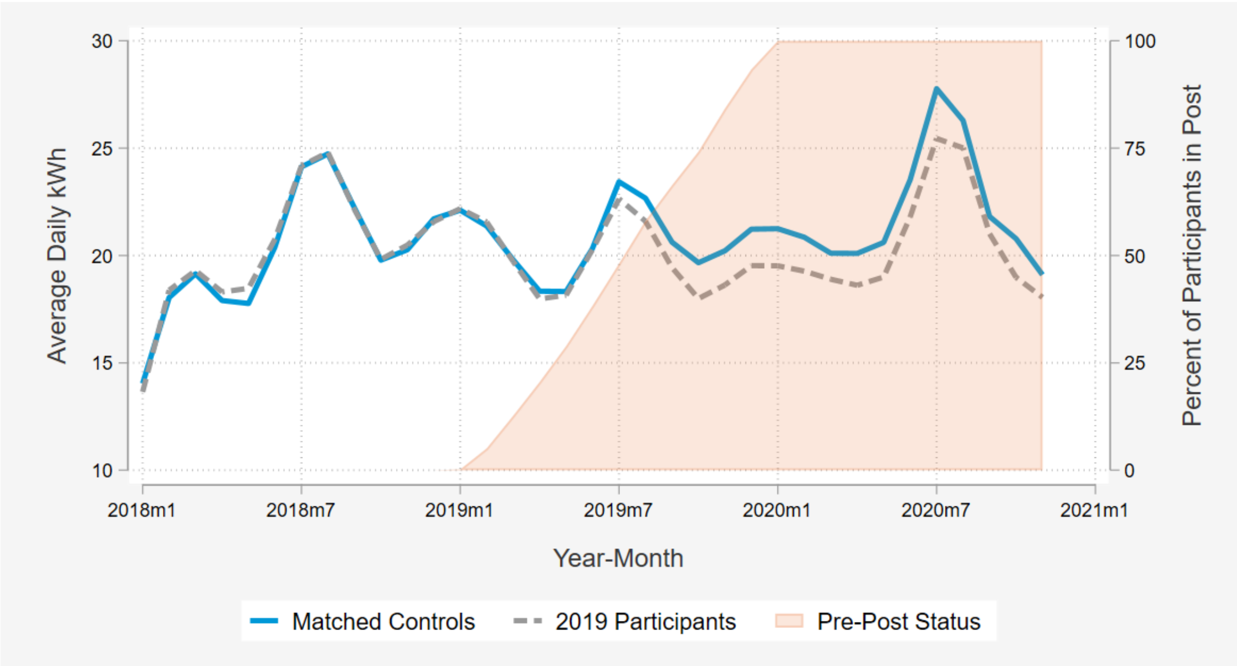


Figure A-7: Home Performance Consumption Analysis Results Visualized

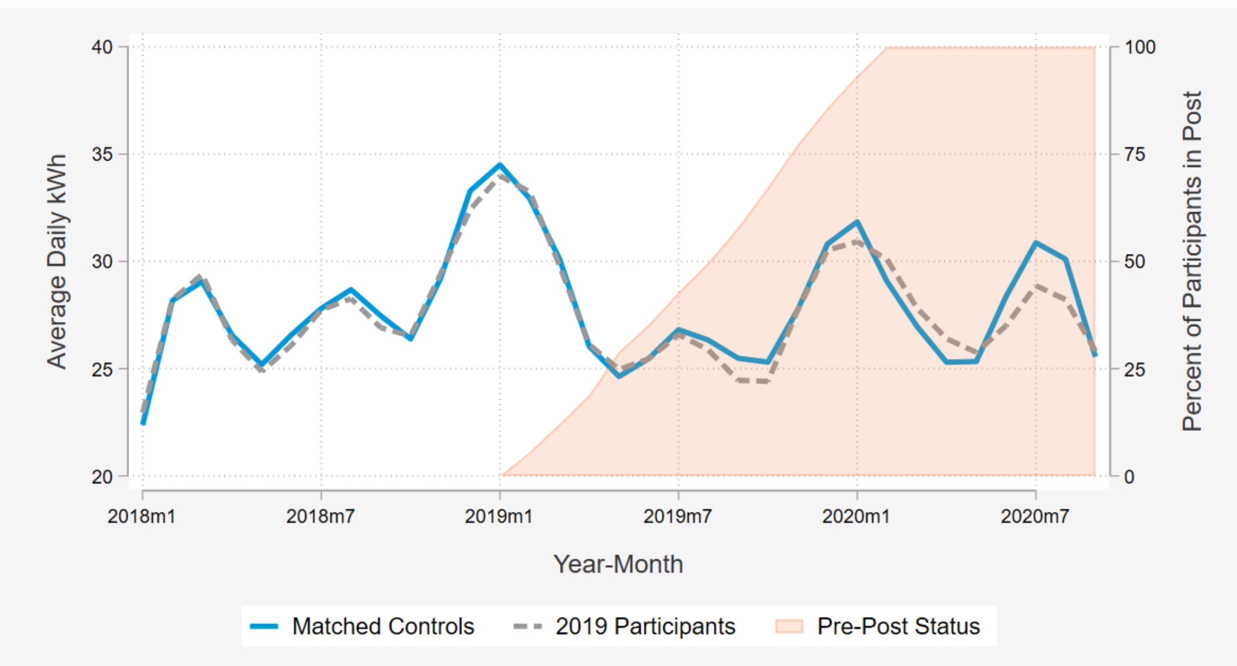


Figure A-8: Regression Output – REAP

```
Linear regression, absorbing indicators         Number of obs     =     80,767
Absorbed variable: group                        No. of categories =      1,402
                                                F(  37,    1401)  =      43.12
                                                Prob > F          =     0.0000
                                                R-squared         =     0.7213
                                                Adj R-squared     =     0.7163
                                                Root MSE          =     7.5996

                           (Std. Err. adjusted for 1,402 clusters in group)
```

daily_kwh	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
post	.3296547	.2118047	1.56	0.120	-.0858338	.7451432
treatpost	-1.542404	.1870401	-8.25	0.000	-1.909312	-1.175495
ym3						
2018-02	.1054093	.2709961	0.39	0.697	-.4261925	.6370111
2018-03	-.40476	.3075257	-1.32	0.188	-1.00802	.1985004
2018-04	-1.502549	.2851593	-5.27	0.000	-2.061934	-.943164
2018-05	-1.633606	.2972607	-5.50	0.000	-2.21673	-1.050482
2018-06	.8196741	.3164938	2.59	0.010	.1988214	1.440527
2018-07	4.018883	.3471835	11.58	0.000	3.337828	4.699939
2018-08	4.342457	.3518453	12.34	0.000	3.652257	5.032658
2018-09	2.06683	.3259056	6.34	0.000	1.427514	2.706145
2018-10	-.1764008	.3004698	-0.59	0.557	-.76582	.4130185
2018-11	.2907901	.3003851	0.97	0.333	-.2984629	.880043
2018-12	1.310634	.3078456	4.26	0.000	.7067459	1.914522
2019-01	1.98174	.3207643	6.18	0.000	1.35251	2.61097
2019-02	1.324342	.3208847	4.13	0.000	.6948754	1.953808
2019-03	-.1311739	.3091807	-0.42	0.671	-.7376809	.4753331
2019-04	-1.56816	.3022301	-5.19	0.000	-2.161033	-.9752881
2019-05	-1.569664	.3110704	-5.05	0.000	-2.179878	-.9594498
2019-06	.5567418	.3344232	1.66	0.096	-.0992823	1.212766
2019-07	3.529162	.3680437	9.59	0.000	2.807186	4.251138
2019-08	2.616651	.3615719	7.24	0.000	1.90737	3.325932
2019-09	.5663094	.351454	1.61	0.107	-.1231235	1.255742
2019-10	-.779422	.3418777	-2.28	0.023	-1.450069	-.1087745
2019-11	-.2247867	.3496876	-0.64	0.520	-.9107544	.4611811
2019-12	.7165265	.3607654	1.99	0.047	.008828	1.424225
2020-01	.6758341	.3673254	1.84	0.066	-.044733	1.396401
2020-02	.2183212	.3723013	0.59	0.558	-.512007	.9486494
2020-03	-.634755	.3635389	-1.75	0.081	-1.347894	.0783842
2020-04	-.7094617	.3666	-1.94	0.053	-1.428606	.0096824
2020-05	-.2404198	.3703545	-0.65	0.516	-.9669289	.4860893
2020-06	2.35638	.3953569	5.96	0.000	1.580825	3.131935
2020-07	5.838256	.4325823	13.50	0.000	4.989677	6.686835
2020-08	5.237139	.4303201	12.17	0.000	4.392998	6.081281
2020-09	1.688168	.4076675	4.14	0.000	.8884638	2.487873
2020-10	-.736336	.3939519	-1.87	0.062	-1.509135	.0364632
2020-11	-.8808504	.3841839	-2.29	0.022	-1.634488	-.1272127
2020-12	.1863372	.437871	0.43	0.670	-.6726162	1.045291
_cons	19.75636	.2791639	70.77	0.000	19.20873	20.30398

Figure A-9: Regression Output – Home Performance

```
Linear regression, absorbing indicators         Number of obs     =     66,348
Absorbed variable: id                           No. of categories =      2,394
                                                F(  37,    2393)  =      31.20
                                                Prob > F          =     0.0000
                                                R-squared         =     0.6759
                                                Adj R-squared     =     0.6636
                                                Root MSE          =    11.5686

                                    (Std. Err. adjusted for 2,394 clusters in id)
```

daily_kwh	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
post	1.073947	.3850123	2.79	0.005	.3189547	1.828939
treatpost	-2.235909	.3430753	-6.52	0.000	-2.908664	-1.563153
ym3						
2018-02	2.231142	.3935817	5.67	0.000	1.459345	3.002938
2018-03	2.258048	.4534327	4.98	0.000	1.368886	3.147209
2018-04	-.7835744	.4320309	-1.81	0.070	-1.630768	.0636192
2018-05	-2.710257	.4718799	-5.74	0.000	-3.635593	-1.784921
2018-06	-1.727659	.5021379	-3.44	0.001	-2.712329	-.7429886
2018-07	-.3800861	.5298705	-0.72	0.473	-1.419139	.6589666
2018-08	.2599375	.5368443	0.48	0.628	-.7927904	1.312665
2018-09	-.9076217	.5055832	-1.80	0.073	-1.899048	.0838046
2018-10	-1.324869	.4768785	-2.78	0.006	-2.260006	-.3897312
2018-11	2.07363	.4765276	4.35	0.000	1.139181	3.00808
2018-12	6.071598	.5278842	11.50	0.000	5.03644	7.106755
2019-01	7.15001	.5496132	13.01	0.000	6.072243	8.227778
2019-02	6.656649	.5559729	11.97	0.000	5.566411	7.746887
2019-03	3.329148	.5237983	6.36	0.000	2.302002	4.356293
2019-04	-1.20693	.4911139	-2.46	0.014	-2.169982	-.2438772
2019-05	-3.138519	.5103478	-6.15	0.000	-4.139288	-2.137749
2019-06	-2.808649	.5386306	-5.21	0.000	-3.86488	-1.752418
2019-07	-1.592341	.5638539	-2.82	0.005	-2.698033	-.4866479
2019-08	-2.173216	.5531321	-3.93	0.000	-3.257883	-1.088548
2019-09	-3.080512	.5480921	-5.62	0.000	-4.155297	-2.005728
2019-10	-2.965424	.5451564	-5.44	0.000	-4.034452	-1.896396
2019-11	.3888199	.5726482	0.68	0.497	-.7341179	1.511758
2019-12	3.476243	.6038639	5.76	0.000	2.292093	4.660393
2020-01	4.460849	.6088184	7.33	0.000	3.266983	5.654716
2020-02	2.865107	.5906124	4.85	0.000	1.706942	4.023272
2020-03	.6470005	.572301	1.13	0.258	-.4752564	1.769257
2020-04	-.9579194	.5683877	-1.69	0.092	-2.072503	.1566638
2020-05	-1.542016	.5984971	-2.58	0.010	-2.715643	-.3683901
2020-06	.1711326	.634046	0.27	0.787	-1.072204	1.414469
2020-07	1.710019	.6688347	2.56	0.011	.3984639	3.021575
2020-08	1.102021	.6667068	1.65	0.098	-.2053614	2.409404
2020-09	-1.252293	.6352175	-1.97	0.049	-2.497926	-.0066592
2020-10	-3.015212	.611257	-4.93	0.000	-4.21386	-1.816564
2020-11	-2.185294	.6027236	-3.63	0.000	-3.367209	-1.00338
2020-12	1.845838	.7623406	2.42	0.016	.3509215	3.340754
_cons	27.97324	.4409733	63.44	0.000	27.10851	28.83796

H. LIGHTING INTERACTIVE EFFECTS METHODS AND RECOMMENDATION

SUMMARY

This section summarizes the evaluation team's comparison of commercial and residential lighting HVAC interaction factors provided in the NY TRM with those from other jurisdictions and recommends factors to be incorporated in PSEG Long Island's PY2022 TRM. Rather than adopt assumptions directly from another jurisdiction, we recommend that PSEG Long Island adopt the HVAC interaction effects calculation framework from the Efficiency Maine TRM. We've estimated new factors using the Efficiency Maine TRM methodology with Long Island weather and HVAC fuel shares and Pennsylvania 8760 commercial lighting profiles. Table A-7 summarizes the recommended HVAC interaction factors for peak demand ($HVAC_d$), electric energy ($HVAC_e$), and fossil fuel heating ($HVAC_{ff}$).

Table A-7: Recommended HVAC Interaction Factors

Sector	$HVAC_d$	$HVAC_e$	$HVAC_{ff}$ (MMBtu/kWh)
Commercial	1.18055	1.05894	-0.00077
Residential	1.14226	1.01587	-0.00148

BACKGROUND

Energy dissipates in the form of heat when lighting equipment converts electrical energy to light. Energy efficient lighting upgrades result in a reduction of heat gain to a given space and accordingly reduce the load on cooling equipment. However, this reduced heat gain has the added consequence of increasing the load on the heating system. Complete estimation of a lighting upgrade's energy savings considers the associated impacts on the space's heating and cooling systems, or the "HVAC interaction effects."

The 2020 PSEG Long Island Technical Reference Manual (TRM)[24] savings assumptions for PSEG Long Island's commercial interior lighting measures (LED lamps and fixtures) accounted for energy savings associated with cooling load reduction but did not account for increased fossil fuel heating consumption. To improve the accuracy of lighting program savings, all changes in HVAC usage associated with the installation of efficient lighting should be accounted for. While the residential assumptions did include penalties associated with increases in fossil fuel heating consumption, it was important to produce methodologically analogous waste heat factors for both sectors. The scope of this analysis is to benchmark existing values and methods for calculating waste heat factors, as well as to construct defensible factors specific to PSEG Long Island's territory, for both residential and commercial sectors. These factors estimate the lighting measures' fossil fuel heating increases and

[24] Fossil fuel impacts were not considered at the time, as PSEGLI did not track or measure fossil fuel impacts in goals or performance

incorporate these increases into the final ex-post MMBtu impacts for the commercial sector, and were documented for both residential and commercial lighting measures in the 2022 TRM.

The NY TRM's HVAC interaction factors have not been updated since 2010 to account for changes in commercial building stock, operation, or HVAC equipment makeup. Additionally, the NY TRM Version 8 (effective January 1, 2021) eliminates a significant digit for fossil-fuel HVAC interaction factors compared to its prior versions, resulting in exaggerated penalties from fossil fuel-based space heating. As a result of these issues, the evaluation team sought to identify more appropriate lighting interactive effects factors to quantify the full impact of residential and commercial lighting programs.

Lighting Savings Algorithms

The summer peak demand and annual energy impacts for commercial interior lighting fixtures are calculated using the following equations:

Summer coincident peak demand savings:

$$\Delta kW = \left[\frac{(Watts * units)_{baseline} - (Watts * units)_{efficient}}{1{,}000}\right] * Coincidence\ Factor * HVAC_d$$

Annual electric energy impacts:

$$\Delta kWh = \left[\frac{(Watts * units)_{baseline} - (Watts * units)_{efficient}}{1{,}000}\right] * Operating\ Hours * HVAC_e$$

Annual fossil fuel energy impacts:

$$\Delta MMBtu = \left[\frac{(Watts * units)_{baseline} - (Watts * units)_{efficient}}{1{,}000}\right] * Operating\ Hours * HVAC_{ff}$$

where,

$HVAC_d$ = HVAC interaction factor for summer peak demand

$HVAC_e$ = HVAC interaction factor for annual electric energy consumption

$HVAC_{ff}$ = HVAC interaction factor for annual fossil fuel consumption in MMBtu/kWh

HVAC Interaction Factors - Comparison across TRMs

We compared the HVAC interactivity factors used for PSEG Long Island's commercial and residential lighting in PY2020 planning with methodologies and assumptions in NY TRM, Mid-Atlantic TRM, Massachusetts TRM and Efficiency Maine TRM. The comparisons for the commercial sector are shown in Table A-8, while residential results are in Table A-9.

Table A-8: Comparison of Commercial HVAC Interaction Factors across East Coast States

Source	$HVAC_d$	$HVAC_e$	$HVAC_{ff}$ (MMBtu/kWh)
2020 Planning	1.320	1.130	0
NY TRM v8	1.175	1.080	-0.00200
Pennsylvania TRM and TRC Order	1.192	1.031	-0.00179
Mid-Atlantic TRM Method	1.350	1.080	-0.00077
Massachusetts TRM[25]	N/A	N/A	-0.00069
Efficiency Maine SBDI Evaluation[26]	1.075	1.022	-0.00110
Final PSEG Long Island Method	**1.18055**	**1.05894**	**-0.00077**

Table A-9: Comparison of Residential HVAC Interaction Factors across East Coast States

Source	$HVAC_d$	$HVAC_e$	$HVAC_{ff}$ (MMBtu/kWh)
2020 Planning	1.07301	1.03776	-0.00181
NY TRM V8[27]	1.0850	1.0770	-0.0020
Pennsylvania TRM and TRC Order[28]	1.1729	0.9914	-0.00117
Mid-Atlantic TRM[29]	1.1700	1.0770	-0.00123
Massachusetts TRM[30]	1.2000	1.0100	-0.002295
Efficiency Maine Retail Lighting Evaluation[31]	1.0611	1.0086	-0.00130
Final PSEG Long Island Method	**1.14226**	**1.01587**	**-0.00148**

As seen in the tables, each of the factors span a wide range of values across multiple TRMs, illustrating a broad array of methods and assumptions. To identify the factors most appropriate for Long Island, we

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[25] The Massachusetts TRM does not provide values for HVACe and HVACd. The HVAC interaction adjustment factors are included in the energy realization rates and demand coincidence factors and realization rates that are applied to ex-ante savings in tracking databases.
[26] https://www.efficiencymaine.com/docs/Small-Business-Initiative-Final-Impact-Evaluation-Report-2021.pdf
[27] Single Family, NYC, AC with Gas Heat. TRM can be found at: https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V8.pdf
[28] Statewide average value. TRM can be found at: https://www.puc.pa.gov/pcdocs/1648126.docx
[29] https://neep.org/sites/default/files/resources/Mid_Atlantic_TRM_V9_Final_clean_wUpdateSum
[30] Simulation modeling calibrated with RASS results
[31] https://www.efficiencymaine.com/docs/Retail-and-Distributor-Lighting-Final-Impact-Evaluation-Report-2021.pdf

reviewed the underlying methods and assumptions in each source and have made the following observations:

- **Out of date:** Many of the listed results come from studies from 2010-2013 and do not reflect more recent building stock, operations or HVAC equipment efficiencies.
- **Lack of empirical data:** Some studies rely entirely on simulation modeling to construct the interactive effects, with only a subset directly calibrated on empirical data.
- **Missing significant figures:** Lack of significant digits can result in loss of precision and overstatement of interactive effects
- **Not calibrated to Long Island characteristics:** Studies relying on lighting logger profiles and HVAC inventories were not designed to capture relevant characteristics of Long Island commercial and residential lighting and HVAC use.

EVALUATION TEAM RECOMMENDATION

Our recommended factors follow the HVAC interaction factor calculation algorithms from the Efficiency Maine TRM, adjusted for Long Island-specific inputs. This approach was selected because it combines a transparent calculation method, reliance on an empirical approach, and the ability to easily update underlying data. The commercial and residential lighting profiles are taken from a 2015 Pennsylvania statewide lighting metering study[32]. We use the Pennsylvania study because it is geographically close, methodologically robust, and the 8760 load shapes, by building type, are publicly available. We use TMY3 weather for McArthur Islip airport on Long Island to identify concurrent operation of lighting and HVAC systems, and HVAC fuel mix and efficiency assumptions from the 2019-2038 PSEG Long Island Potential Study. The Efficiency Maine TRM provides the following HVAC interaction factor algorithms for both residential and commercial interior lighting.

$$HVAC_d = 1 + \frac{IGC \times \%A \times C}{Eff_{HVAC}}$$

$$HVAC_e = 1 + \frac{IGC \times \%A \times C}{Eff_{HVAC}} \times \%Electric$$

$$HVAC_{ff} = -\frac{IGC \times \%A \times C}{Eff_{HVAC}} \times 0.003412 \frac{MMBtu}{kWh} \times \%Fossil$$

Where,

- Internal Gain Contribution, IGC (%): the percent of waste heat that remains inside the building, contributing to the increased or decreased need for heating or cooling from the HVAC system.

[32] https://www.puc.pa.gov/pcdocs/1340978.pdf

- Applicability, %A (%): the percentage of lighting that is installed in spaces that are heated or cooled by the HVAC system.
- Concurrency, C (%): the percent of time that both lighting and HVAC systems are operating concurrently.
- HVAC Efficiency, Eff_{HVAC} (%): efficiency of the HVAC system
- % Fossil & % Electric are the shares of each fuel type in PSEG Long Island's territory.

Note that for fossil fuel HVAC factor, the applicable share is the % of fossil fuel *heating*. To compute the energy interactive effects, we first compute cooling-related HVACe (where % electric is assumed to be 100% as only electric impacts apply for cooling) then heating-related HVACe (where the relevant % of electric heat is assumed) and then combined according to $1 + HVAC_e^c - HVAC_e^h$. Table A-10 summarizes the factors calculated for each of the three interaction effect values.

Table A-10: Interactive Factor Calculations

Factor	Sector	Electric Heat (for HVACe)	Fossil Heat (for HVACff)	Cooling (for HVACe)	Cooling (for HVACd)	Reference
IGC	Commercial	55%	55%	55%	55%	Efficiency Maine SBDI Impact evaluation. Weighted average of high-bay and non-high-bay.
	Residential	60%	60%	60%	60%	Efficiency Maine Retail & Distributor Impact evaluation.
Applicability	Commercial	97.0%	97.0%	94.0%	94.0%	AC/Heating penetration on Long Island
	Residential	100.0%	100.0%	95.0%	95.0%	
Concurrency	Commercial	40.47%	40.47%	42.78%	100%	PA 8760 lighting profiles and Long Island Weather Data
	Residential	62.08%	62.08%	21.36%	95.53%	
Eff_{HVAC}	Commercial	170.3%	82%$	286%	286%	2019-2038 Potential Study, incorporating HVAC system types and fuel shares on Long Island
	Residential	163.5%	80.0%	382.8%	382.8%	
Fuel Share	Commercial	14%	83%	94%	94%	
	Residential	7%	93%	95%	95%	

APPENDIX B: COST EFFECTIVENESS TABLES

Table B-1: CEP Ex-Post Net Data for Cost Effectiveness

Resource		Measure	Ex-Post Gross Savings	Net-to-Gross Ratio	Line Loss Factor	Ex-Post Net
MMBtu	Lighting	Fast Track Lighting	183,880	72%	1.00	131,566
		Comprehensive Lighting	25,613	72%	1.00	18,326
		Refrigerated Case Lighting	6,649	72%	1.00	4,757
	Distributed Generation	Fuel Cells	55,732	100%	1.00	55,732
	Standard	Refrigeration	7,327	72%	1.00	5,242
		Motors & VFDs	3,437	72%	1.00	2,459
		Compressed Air	3,236	72%	1.00	2,315
		Cool Roof	-314	72%	1.00	(225)
		Other Comm. Equipment	6,022	72%	1.00	4,309
	Custom	Custom	11,682	72%	1.00	8,358
	HVAC	HVAC	3,079	72%	1.00	2,203
		MMBtu Total:	**306,343**		**1.00**	**235,044**
MWh	Lighting	Fast Track Lighting	64,771	72%	1.06	49,302
		Comprehensive Lighting	9,523	72%	1.06	7,248
		Refrigerated Case Lighting	1,949	72%	1.06	1,483
	Distributed Generation	Fuel Cells	15,925	100%	1.06	16,941
	Standard	Refrigeration	2,160	72%	1.06	1,644
		Motors & VFDs	1,007	72%	1.06	767
		Compressed Air	949	72%	1.06	722
		Cool Roof	255	72%	1.06	194
		Other Comm. Equipment	-58	72%	1.06	(44)
	Custom	Custom	2,336	72%	1.06	1,778
	HVAC	HVAC	695	72%	1.06	529
		MWh Total:	**99,512**		**1.06**	**80,565**
kW	Lighting	Fast Track Lighting	13,518	72%	1.09	10,618
		Comprehensive Lighting	2,133	72%	1.09	1,676
		Refrigerated Case Lighting	472	72%	1.09	371
	Distributed Generation	Fuel Cells	1,818	100%	1.09	1,987
	Standard	Refrigeration	197	72%	1.09	155
		Motors & VFDs	35	72%	1.09	27
		Compressed Air	185	72%	1.09	145
		Cool Roof	103	72%	1.09	81
		Other Comm. Equipment	-11	72%	1.09	(9)
	Custom	Custom	293	72%	1.09	230
	HVAC	HVAC	461	72%	1.09	362

Resource	Measure	Ex-Post Gross Savings	Net-to-Gross Ratio	Line Loss Factor	Ex-Post Net
	kW Total:	**19,204**		**1.09**	**15,643**

Table B-2: EEP Ex-Post Net Data for Cost Effectiveness

Resource	Measure	Ex-Post Gross Savings	Net-to-Gross Ratio	Line Loss Factor	Ex-Post Net
MMBtu	Lighting	262,903	55%	1.00	144,597
	Heat Pump Pool Heaters	48,030	90%	1.00	43,227
	Pool Pumps	21,804	90%	1.00	19,624
	Thermostats	12,140	77%	1.00	9,348
	Appliances	6,830	78%	1.00	5,324
	Recycling	7,863	48%	1.00	3,774
	Heat Pump Water Heaters	3,094	100%	1.00	3,094
	Lawn Equipment	778	90%	1.00	700
	Other (APS, Exhaust Fans)	79	98%	1.00	78
	MMBtu Total:	**363,522**	**64%**	**1.00**	**231,890**
MWh	Lighting	116,892	59%	1.06	72,760
	Heat Pump Pool Heaters	2,078	96%	1.06	2,116
	Pool Pumps	6,391	96%	1.06	6,509
	Thermostats	279	82%	1.06	243
	Appliances	1,447	78%	1.06	1,200
	Recycling	2,304	51%	1.06	1,252
	Heat Pump Water Heaters	-121	106%	1.06	-137
	Lawn Equipment	-49	96%	1.06	-50
	Other (APS, Exhaust Fans)	23	105%	1.06	26
	MWh Total:	**129,245**	**61%**	**1.06**	**83,866**
kW	Lighting	17,040	60%	1.09	11,194
	Heat Pump Pool Heaters	-	-	-	-
	Pool Pumps	1,580	98%	1.09	1,699
	Thermostats	-	-	-	-
	Appliances	266	67%	1.09	196
	Recycling	388	52%	1.09	223
	Heat Pump Water Heaters	39	109%	1.09	46
	Lawn Equipment	-	-	-	-
	Other (APS, Exhaust Fans)	2	107%	1.09	3
	kW Total:	**19,315**	**63%**	**1.09**	**13,398**

Table B-3: Home Comfort Ex-Post Net Data for Cost Effectiveness

Resource	Measure	Ex-Post Gross Savings	Net-to-Gross Ratio	Line Loss Factor	Ex-Post Net
MMBtu	Split CAC (QI installs)	1,517.0	141%	1.00	2,139.0
	Split CAC (Non-QI installs)	283.0	52%	1.00	147.2
	Smart Thermostats with CAC	22.0	90%	1.00	19.8
	Smart Thermostats with HP	194.0	90%	1.00	174.6
	Wifi Thermostats with HP	2.0	90%	1.00	1.8
	ASHP	23,828.0	90%	1.00	21,445.2
	Ductless Mini Splits	50,229.0	90%	1.00	45,206.1
	GSHP	7,412.0	100%	1.00	7,412.0
MMBtu Total:		**83,487.0**	**92%**	**1.00**	**76,545.6**
MWh	Split CAC (QI installs)	444.5	141%	1.06	666.8
	Split CAC (Non-QI installs)	82.9	52%	1.06	45.9
	Smart Thermostats with CAC	6.5	90%	1.06	6.2
	Smart Thermostats with HP	56.7	90%	1.06	54.3
	Wifi Thermostats with HP	0.5	90%	1.06	0.5
	ASHP	(2,125.8)	90%	1.06	(2,035.3)
	Ductless Mini Splits	(3,221.9)	90%	1.06	(3,084.8)
	GSHP	(169.9)	100%	1.06	(180.7)
MWh Total:		**(4,926.5)**	**86%**	**1.06**	**(4,527.3)**
kW	Split CAC (QI installs)	428.0	149%	1.09	697.0
	Split CAC (Non-QI installs)	63.0	52%	1.09	35.8
	Smart Thermostats with CAC	-	90%	1.09	-
	Smart Thermostats with HP	-	90%	1.09	-
	Wifi Thermostats with HP	1.0	90%	1.09	1.0
	ASHP	180.0	90%	1.09	177.0
	Ductless Mini Splits	105.0	90%	1.09	103.3
	GSHP	59.0	100%	1.09	64.5
kW Total:		**836.0**	**118%**	**1.09**	**1,078.6**

Table B-4: REAP Ex-Post Net Data for Cost Effectiveness

Resource	Measure	Ex-Post Gross Savings	Net-to-Gross Ratio	Line Loss Factor	Ex-Post Net
MMBtu	Lighting	840.3	100%	1.00	840.3
	Night Lights	39.5	100%	1.00	39.5
	Room Air Conditioning	67.4	100%	1.00	67.4
	Dehumidifiers	67.4	100%	1.00	67.4
	DHW - Pipe Insulation	53.3	100%	1.00	53.3
	DHW - Temperature Turndown	3.2	100%	1.00	3.2
	DHW - Thermostatic Shower Valves	88.1	100%	1.00	88.1

Resource	Measure	Ex-Post Gross Savings	Net-to-Gross Ratio	Line Loss Factor	Ex-Post Net
	DHW - Low Flow Showerheads	330.8	100%	1.00	330.8
	DHW - Aerators	70.3	100%	1.00	70.3
	Air Purifiers	495.4	100%	1.00	495.4
	Power Strips	502.4	100%	1.00	502.4
	Refrigerators	18.8	100%	1.00	18.8
	MMBtu Total:	**2,577.0**	100%	**1.00**	**2,577.0**
MWh	Lighting	407.0	100%	1.06	432.9
	Night Lights	20.2	100%	1.06	21.5
	Room Air Conditioning	19.8	100%	1.06	21.0
	Dehumidifiers	19.7	100%	1.06	21.0
	DHW - Pipe Insulation	1.9	100%	1.06	2.0
	DHW - Temperature Turndown	0.11	100%	1.06	0.12
	DHW - Thermostatic Shower Valves	2.6	100%	1.06	2.7
	DHW - Low Flow Showerheads	9.7	100%	1.06	10.3
	DHW - Aerators	2.1	100%	1.06	2.2
	Air Purifiers	145.2	100%	1.06	154.4
	Power Strips	147.2	100%	1.06	156.6
	Refrigerators	13.6	100%	1.06	14.5
	MWh Total:	**789.0**	100%	**1.06**	**839.4**
kW	Lighting	67.5	100%	1.09	73.8
	Night Lights	-	100%	1.09	-
	Room Air Conditioning	16.3	100%	1.09	17.8
	Dehumidifiers	3.5	100%	1.09	3.9
	DHW - Pipe Insulation	0.2	100%	1.09	0.23
	DHW - Temperature Turndown	0.01	100%	1.09	0.01
	DHW - Thermostatic Shower Valves	-	100%	1.09	-
	DHW - Low Flow Showerheads	-	100%	1.09	-
	DHW - Aerators	-	100%	1.09	-
	Air Purifiers	16.7	100%	1.09	18.2
	Power Strips	14.6	100%	1.09	16.0
	Refrigerators	1.6	100%	1.09	1.8
	kW Total:	**120.5**	100%	**1.09**	**131.69**

Table B-5: Home Performance Ex-Post Net Data for Cost Effectiveness

Resource		Measure	Ex-Post Gross Savings	Net-to-Gross Ratio	Line Loss Factor	Ex-Post Net
MMBtu		LED Bulbs	109.4	56%	1.00	61.2

Resource		Measure	Ex-Post Gross Savings	Net-to-Gross Ratio	Line Loss Factor	Ex-Post Net
	Home Performance Direct Install	Domestic Hot Water	41.4	107%	1.00	44.3
		Duct Sealing	17.9	107%	1.00	19.1
		Advanced Power Strips	42.0	107%	1.00	45.0
		HPDI Subtotal	**210.7**	**91%**	**1.00**	**169.7**
	Home Performance with ENERGY STAR	Duct Sealing	2,588.2	75%	1.00	1,941.1
		Air Sealing	4,838.3	75%	1.00	3,628.7
		Envelope	15,042.7	75%	1.00	11,282.1
		Heat Pumps	4,157.2	75%	1.00	3,117.9
		Lighting	16.2	75%	1.00	12.1
		HVAC (Non heat pumps)	595.0	75%	1.00	446.3
		DHW	230.1	75%	1.00	172.6
		HPwES Subtotal	**27,467.7**	**75%**	**1.00**	**20,600.7**
	Home Energy Audits	Thank You Kits (HEA)	650.9	75%	1.00	488.2
		HEA Subtotal	**650.9**	**74%**	**1.00**	**488.2**
		MMBtu Total:	**28,329.3**	**75%**	**1.00**	**21,258.6**
MWh	Home Performance Direct Install	LED Bulbs	32.0	56%	1.06	19.1
		Domestic Hot Water	12.1	107%	1.06	13.8
		Duct Sealing	5.2	107%	1.06	6.0
		Advanced Power Strips	12.3	107%	1.06	14.0
		HPDI Subtotal	**61.7**	**81%**	**1.06**	**52.9**
	Home Performance with ENERGY STAR	Duct Sealing	180.7	75%	1.06	144.2
		Air Sealing	181.1	75%	1.06	144.5
		Envelope	304.9	75%	1.06	243.3
		Heat Pumps	(398.3)	75%	1.06	-317.8
		Lighting	8.3	75%	1.06	6.6
		HVAC (Non heat pumps)	18.9	75%	1.06	15.1
		DHW	95.1	75%	1.06	75.9
		HPwES Subtotal	**390.7**	**75%**	**1.06**	**311.7**
	Home Energy Audits	Thank You Kits (HEA)	218.4	75%	1.06	174.3
		HEA Subtotal	**218.4**	**75%**	**1.06**	**174.3**
		MWh Total:	**670.9**	**76%**	**1.06**	**538.9**
kW	Home Performance Direct Install	LED Bulbs	5.8	52%	1.09	3.3
		Domestic Hot Water	0.2	103%	1.09	0.2
		Duct Sealing	7.8	103%	1.09	8.8
		Advanced Power Strips	1.6	103%	1.09	1.8
		HPDI Subtotal	**15.4**	**84%**	**1.09**	**14.1**
	Home Performance	Duct Sealing	152.6	74%	1.09	123.4
		Air Sealing	33.0	74%	1.09	26.7
		Envelope	111.5	74%	1.09	90.2

Resource		Measure	Ex-Post Gross Savings	Net-to-Gross Ratio	Line Loss Factor	Ex-Post Net
	with ENERGY STAR	Heat Pumps	64.6	74%	1.09	52.3
		Lighting	-	74%	1.09	0.0
		HVAC (Non heat pumps)	1.3	74%	1.09	1.1
		DHW	5.6	74%	1.09	4.5
		HPwES Subtotal	**368.6**	**74%**	**1.09**	**298.1**
	Home Energy Audits	Thank You Kits (HEA)	31.4	74%	1.09	25.4
		HEA Subtotal	**31.4**	**74%**	**1.09**	**25.4**
		kW Total:	**415.4**	**74%**	**1.09**	**337.6**

Table B-6: HEM Ex-Post Net Data for Cost Effectiveness

Resource	Measure	Ex-Post Gross Savings	Net-to-Gross Ratio	Line Loss Factor	Ex-Post Net
MMBtu	Home Energy Reports	105,204.24	100%	1.00	105,204.24
MWh		30,833.60	100%	1.06	32,801.70
kW		8,173.00	100%	1.09	8,932.24

APPENDIX C: VERIFIED EX-ANTE MEMO

MEMORANDUM 2020 VERIFIED EX ANTE SAVINGS

Date: February 16, 2021

To: Dan Zaweski, Joseph Fritz-Mauer, and Ashley Kaleita (PSEG Long Island)

From: 2020 Evaluation Team (Demand Side Analytics, ERS, and Mondre Energy)

Re: 2020 Verified Ex Ante Savings for Energy Efficiency and Beneficial Electrification Programs

Background

PSEG Long Island asked the Demand Side Analytics evaluation team to verify ex-ante (VEA) energy savings as part of its evaluation of PSEG Long Island's 2020 energy efficiency and beneficial electrification programs. This memorandum defines "verified ex-ante" savings and presents the 2020 verified ex-ante savings for each program. Program year 2020 was the first year PSEG established conservation goals in MMBTU instead of electric energy (MWh) and peak demand (MW).

Definition of Verified Ex Ante

PSEG Long Island requested the evaluation team develop a verified ex-ante savings metric for comparison with the established annual savings goals. The verified ex-ante calculations seek to answer the question, "were the ex-ante gross energy impacts claimed by the implementation contractors calculated consistently with approved calculations and assumptions?" To answer this question, the evaluation team independently calculated program impacts using the methods and assumptions approved by PSEG Long Island and compared the results to the ex-ante gross values submitted by the implementation contractor. The ratio of these two values is the verified ex-ante realization rate.

The details of the verified ex-ante calculations vary by program and measure. Some measures were assigned static per-unit impacts in the 2020 assumptions, so the verified ex-ante calculation only requires counting the number of units stored in the program tracking data and multiplying that total by the per-unit savings planning assumption. Other measures are more dynamic and require the use of algorithms and project-specific parameter values.

The verified ex-ante savings are the first milestone of the 2020 evaluation. They are a separate and distinct performance metric from the evaluated savings and ex-post savings, which we will be delivering later this spring. Both the ex-ante gross and VEA savings are expressed on a gross basis – meaning they do not reflect adjustments for net-to-gross factors or line losses.

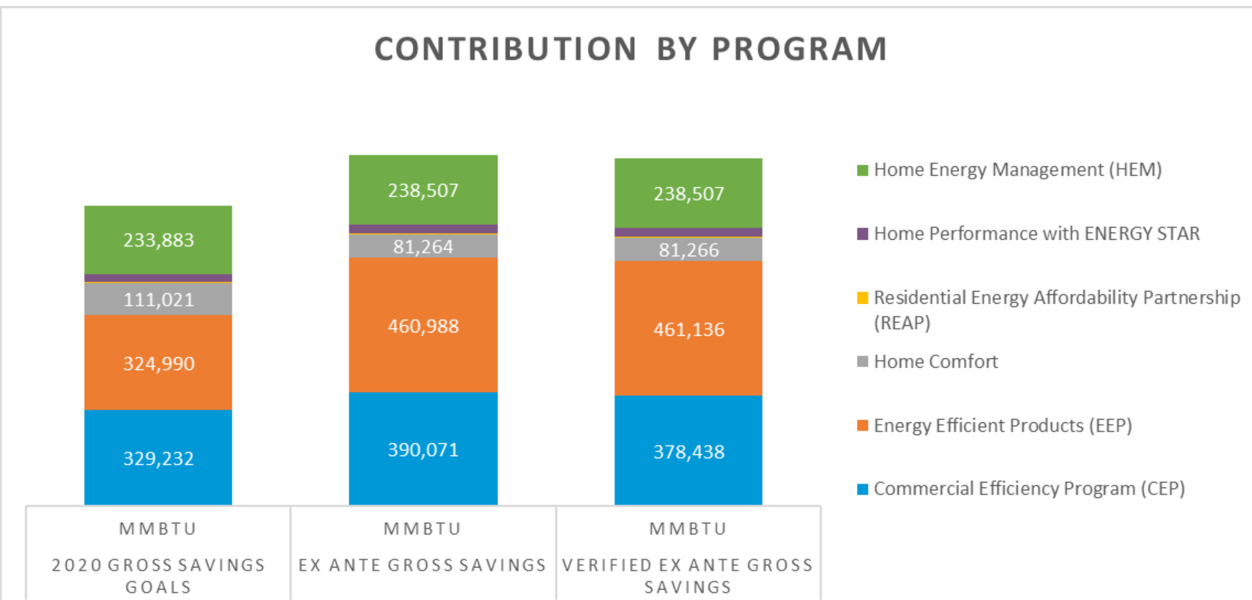
Results

Table 1 summarizes the 2020 verified ex-ante savings. The verified ex-ante savings were 99.0% of the claimed ex-ante gross savings. The evaluation team's independent measure counts were nearly identical to the claimed measure counts. Per-unit MMBTU savings calculations and assumptions matched the approved values almost perfectly for nearly all measures. The main reason 99.0% realization rate (vs. 100%) is the implementer's application of waste heat factors to Fast Track Lighting in the Commercial Efficiency Program.

TABLE 1: SUMMARY OF 2020 VERIFIED EX ANTE SAVINGS AND GOALS

Program		2020 Gross Savings Goals	Ex Ante Gross Savings	Verified Ex Ante Gross Savings	Verified Ex Ante Realization Rate	Verified as % of Goals
		MMBTU	MMBTU	MMBTU	%	%
Commercial	Commercial Efficiency Program (CEP)	329,232	390,071	378,438	**97.0%**	114.9%
Residential	Energy Efficient Products (EEP)	324,990	460,988	461,136	**100.0%**	141.9%
	Home Comfort	111,021	81,264	81,266	**100.0%**	73.2%
	Residential Energy Affordability Partnership (REAP)	3,903	3,038	3,048	**100.3%**	78.1%
	Home Performance with ENERGY STAR	28,387	30,247	30,260	**100.0%**	106.6%
	Home Energy Management (HEM)	233,883	238,507	238,507	**100.0%**	102.0%
Total Commercial:		**329,232**	**390,071**	**378,438**	**97.0%**	**114.9%**
Total Residential:		**702,184**	**814,044**	**814,217**	**100.0%**	**116.0%**
Total Energy Efficiency and Beneficial Electrification:		**1,031,416**	**1,204,115**	**1,192,655**	**99.0%**	**115.6%**

FIGURE 1: CONTRIBUTIONS BY PROGRAM



PSEG Long Island exceeded its goals. The verified ex-ante gross savings were 115.6% of the 2020 savings goals. Moreover, most programs exceed the goals. In particular, the verified savings for Energy Efficient Products (EEP) is 141.9% of the goals. For EEP, approximately 92.7% of the total MMBTU impact came from energy efficiency, and the other 7.3% came from beneficial electrification. The programs that fell short of goals – Home Comfort and Residential Energy Affordability Partnership (REAP) – are a small share of overall savings.

Appendix A: Commercial Efficiency Program Verified Ex-Ante Savings Additional Detail

CEP Program	# Projects	Ex-Ante Savings			Verified Ex-Ante Savings			Utility Gross kW RR	Utility Gross kWh RR	Utility Gross MMBtu RR
		kW	kWh	MMTBTU	kW	kWh	MMBTU			
Lighting		17,452.2	89,654,300	304,956	17,787.3	85,853,879	294,303	101.9%	95.8%	96.5%
Commercial Equipment	2	-1.3	-55,135	4,887	-1.2	-55,135	4,894	99.1%	100.0%	100.1%
Commercial Kitchen Equipment	3	0.4	20,675	71	0.4	20,675	71	100.0%	100.0%	100.0%
Compressed Air	80	69.8	889,865	3,587	163.8	840,057	2,866	234.8%	94.4%	79.9%
Cool Roof	24	104.7	254,973	-226	102.5	254,973	-314	97.9%	100.0%	139.2%
Custom	34	366.5	2,459,237	12,297	315.2	2,360,868	11,805	86.0%	96.0%	96.0%
HVAC	184	336.6	831,732	4,463	336	830,461	4,466	99.8%	99.8%	100.1%
Motors & VFDs	42	43.5	1,000,191	3,413	35.9	1,065,987	3,637	82.4%	106.6%	106.6%
Refrigeration	262	114.6	2,217,887	7,581	114.6	2,217,887	7,669	100.0%	100.0%	101.2%
DG/Fuel Cell	1	1,822.7	14,370,088	49,031	1,822.7	14,370,088	49,031	100.0%	100.0%	100.0%
Project Adjustment	1	3.1	2,943	10	3.1	2,943.1	10.0	100.0%	100.0%	100.0%
Grand Total	**633**	**20,313**	**111,646,756**	**390,069**	**20,680**	**107,762,683**	**378,438**	**101.8%**	**96.5%**	**97.0%**

Appendix B: Differences between Verified Savings and Implementer Calculations

The evaluation team verified the calculations and inputs for hundreds of measures and inputs. Most of the calculations and inputs matched the approved values. The below table summarizes the differences in the calculations that resulted in a 99.0% realization rate of claimed savings.

Program	Source	Description	Implications
Commercial Efficiency Program	Comprehensive Lighting measures	▪ Treatment of waste heat reductions that occur with lighting upgrades in interior spaces ▪ Operating hours by building type had small differences	▪ A 99% MMBtu realization rate for comprehensive lighting measures
	Fast track lighting	▪ The implementer applied both demand and energy waste heat factors to energy savings calculations (both kWh and MMBtu). Evaluators instead only used energy WHFs to energy savings calculations, causing a reduced energy realization rate ▪ For 280 measures, the implementer also claimed gas waste heat effects, which were not included in planning assumptions and caused a reduction in the MMBtu realization rate	▪ Fast Tracking lighting MMBtu realization rate of 83%
	Refrigerated case lighting	▪ Implementer applied 2010 planning assumptions, while the evaluation team applied recommendations from the PSEG Long Island 2020 TRM	▪ Refrigerated case lighting constituted 3% of overall CEP lighting savings
	Compressed air measures	▪ Compressed air measures applications were opened in 2019 and did not contain MMBtu savings. The implementers manually added the MMBtu savings to the measure in Captures. ▪ The evaluation team identified 4 out of 80 PY2020 compressed air measures with incorrect MMBtu savings value, likely due to data entry error.	▪ 79.9% realization rate for compressed air measures ▪ Compressed air measures account for less than 1% of CEP claimed savings

Program	Source	Description	Implications
	Cool Roof projects	▪ The appropriate MMBtu/sf penalty was not applied for the Cool Roof projects with an "Office" building type.	▪ The MMBtu aggregate penalty across all projects changed from -226 MMBtu to -314 MMBtu
Energy Efficient Products (EEP)	Connected lighting measures (EEP-1210 and EEP-2000)	▪ Several measures exhibited "carryover" savings from projects submitted in late 2019 but not processed until 2020. ▪ In most cases, the evaluation team confirmed that TRC applied 2019 planning assumptions to carryover projects in Captures, and the VEA realization rate was 100%. ▪ For connected lighting measures (EEP-1210 and EEP-2000), the per-unit MMBTU impacts stored in Captures were lower than 2019 planning assumptions	▪ Realization rate greater than 100% for EEP-120 and EEP-2000
	Bathroom Exhaust Fan Measures (EEP-1700 and EEP-1710)	▪ The implementer applied 2019 per-unit planning assumptions to the 2020 measure quantities. All measures show the 2019 value.	▪ Realization rate greater than 100% for EEP-1700 and EEP-1710
	Per-unit peak demand savings	▪ Although this memo's focus is total MMBTU savings, the evaluation team also reviewed the peak demand (MW) and energy (MWh) impact values stored in Captures for consistency with 2020 planning assumptions ▪ We observed five distinct per-unit kW savings values among the 168 program-supported ENERGY STAR dishwashers in 2020, and only one of the five matched the 2020 planning assumptions	▪ No impact on MMBtu realization rate

Home Performance with ENERGY STAR	**Home Energy Audits "Thank You" kits**	▪ The program used a per-unit MMBtu savings assumption of 0.073 to estimate ex-ante MMBtu savings, while the program planning assumption was 0.082 MMBtu/unit.	▪ MMBtu VEA realization rate of 112% for "Thank You" kits ▪ kW and kWh realization rates were 100%.
	HPDI	▪ The implementer claimed HPDI savings for four thermostat replacement measures totaling 23 MMBTU that were not in the Plan ▪ Claimed savings for hot water temperature control measures ("Water Temperature Turndown/HH") were low. The PUIs used to estimate MMBTU savings for the hot water temperature control projects were 84% lower than the PUI factors in the Plan	▪ HPDI realization rate of 102%.