Evaluation of PSEG Long Island Energy Efficiency Programs

Prepared for PSEG Long Island

By Demand Side Analytics, LLC
May 2023

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PREFACE

GLOSSARY OF TERMS

Key Term	Definition
MWh Beneficial Electrification (MWh_{be})	The increase in weather-normalized annual electric energy consumption attributable to beneficial electrification measures.
MWh Energy Efficiency (MWh_{ee})	The reduction in weather-normalized annual electric energy consumption attributable to energy efficiency programs or measures.
Delta MWh	The total change in annual electric energy consumption. Equal to $MWh_{ee} – MWh_{be}$. Energy Efficiency measures, MWh_{ee}, typically result in a reduction in a customer's annual electric consumption and are reported as positive impacts. Beneficial Electrification measures, MWh_{be}, result in an increase in the customer's annual electric consumption. A negative value of Delta MWh indicates the measure or program increases electric consumption on the PSEG Long Island system as a whole. A positive value of Delta MWh 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 5.66% in the 2022 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. These savings are calculated using planning assumptions and algorithms.
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 and line losses. The evaluation team uses the ex-post net impacts in the cost-effectiveness calculation to reflect the current best industry practices.

Key Term	Definition
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 Impacts (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.
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 $kW/year.
Levelized Cost of Energy	The equivalent cost of energy (kWh) over the life of the equipment that yields the same present value of costs, using a nominal discount rate of 6.16%. The levelized cost of energy is a measure of the program administrator's program costs in a form that planners can compare to the cost of supply additions.
Line Loss Factor	The evaluation team applies line losses of 5.67% on energy consumption (resulting in a multiplier of 1.0601 = [1 ÷ (1 – 0.0567)]) and of 7.19% on peak demand (resulting in a multiplier of 1.0775 = [1 ÷ (1 – 0.0719)]) to estimate energy and demand savings at the power plant.
MMBtu Beneficial Electrification ($MMBtu_{be}$)	For fuel-switching measures, the reduction in site-level fossil fuel consumption minus the site level increase in the electric consumption (MWh_{be}) converted to MMBtu at 3.412 MMBtu per MWh.
MMBtu Energy Efficiency ($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 MWh_{ee} impacts by a static 3.412 MMBtu per MWh 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.

Key Term	Definition
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 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 Impact	The primary performance metric starting program year 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.

Key Term	Definition
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.

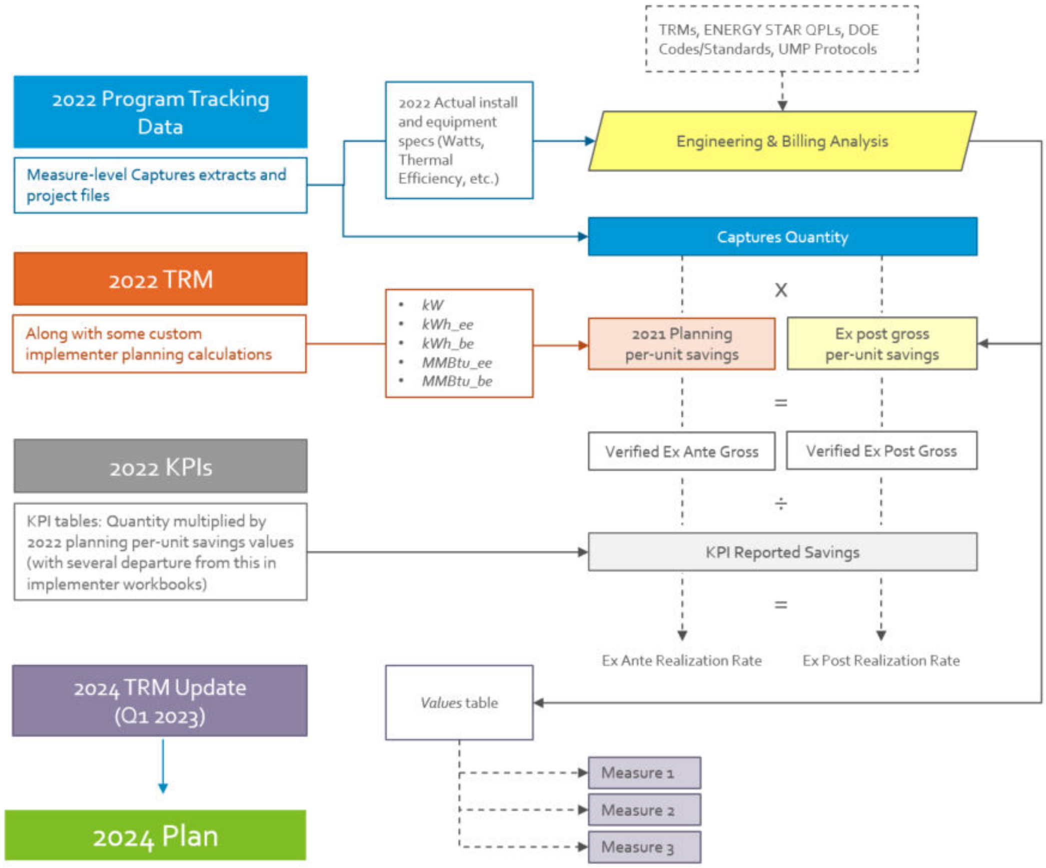
ANNUAL EVALUATION TASKS AND CYCLE TIMELINE

Figure 0-1 outlines annual energy efficiency and beneficial electrification programming timeline for planning, verified ex-ante, and verified ex-post and the resources that inform assumptions for each deliverable. The verified ex-ante audit asks if the ex-ante gross energy impacts claimed by the implementation contractors were calculated consistently with the calculations and assumptions approved by PSEG Long Island and LIPA. To verify claimed savings, the evaluation team independently calculates the savings 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, and results are submitted in the Verified Ex-Ante, Appendix B.

Volumes I and II of this report outline the results from the ex-post evaluation. The ex-post evaluation estimates energy and demand savings for the portfolio using the most current methods and data available at the time of the evaluation. Assumptions and algorithms from the most up-to-date TRMs, DOE Codes and Standards, and other sources are utilized in this portion of the evaluation. The output informs recommendations for future planning cycles.

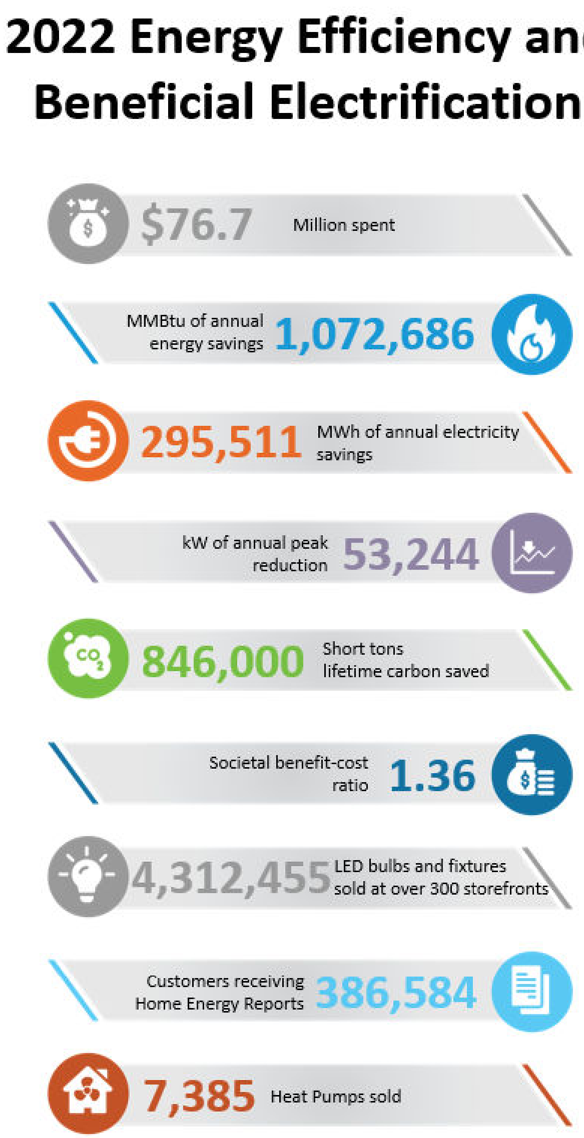
It is important to note that the feedback loop is a nearly two-year cycle. PSEG Long Island has already established 2023 goals and planning assumptions, therefore findings and recommendations from the 2022 ex-post evaluation will not be reflected in the 2023 program claimed savings methodology. The findings and recommendations of this 2022 impact evaluation will be reflected in 2024 planning assumptions, goal setting, and ex-ante savings values. Additionally, any major drivers in differences between ex-post and claimed ex-ante savings discovered in the 2021 evaluation were expected to persist in the 2022 evaluation results.

Figure 0-1: Annual Evaluation Data Flow



1 INTRODUCTION

PSEG Long Island's Energy Efficiency and Beneficial Electrification programs offer a wide array of incentives, rebates, and programs to PSEG Long Island residential and commercial customers to assist them in either reducing their energy usage through energy efficiency, thereby lowering their energy bills, or in electrifying their homes and avoid fossil fuel-based costs through beneficial electrification. 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 2022 Energy Efficiency and Beneficial Electrification Portfolio program evaluation ex-post gross results and covers the period from January 1, 2022 to December 31, 2022.



The Demand Side Analytics evaluation team produced two volumes that together compose the entire Annual Evaluation Report. This document, the 2022 Program Guidance Document (Volume II), provides detailed program-by-program impact analysis results. The 2022 Annual Evaluation Report (Volume I) provides an overview of the portfolio-level evaluation findings.

In 2022, PSEG Long Island spent $76.7 million implementing the Energy Efficiency and Beneficial Electrification Portfolio. The investment led to 1,072,686 of total MMBtu savings and avoided 846,000 short tons of CO2 emissions – the equivalent of removing over 164,272 combustion engine cars for a year.[1] PSEG Long Island's efforts led to $150 million in net societal benefits, with a societal benefit cost ratio of 1.36.

New York has established many statewide energy efficiency and emission reduction targets. The Climate Leadership and Community Protection Act (CLCPA) set the overall goal of reducing GHG emissions by 40%

[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

by 2030. In 2018, New Efficiency: New York set a statewide energy efficiency target of 185 TBtu in energy savings by 2025. These New York goals establish savings targets on an energy (Btu) basis for the State of New York. By laying out these targets, New York established fuel-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:

- **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 3.412 MMBtu per MWh - the thermal efficiency of the electric power generation fleet does not affect the calculations.
- **Incorporated and expanded beneficial electrification measures in its offerings**. PSEG Long Island has continued to pioneer efforts to expand their 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.

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. Because energy efficiency has a unique lexicon, we include a comprehensive Glossary of Terms with definitions and encourage readers who are less familiar with the key terms to review them.

Figure 1-1 below shows the energy efficiency program cycle, the main objectives at each step, and the key terms. The feedback loop is a nearly two-year cycle. The planning activities for 2022 were conducted in 2021 and set the goals, rules, and algorithms for calculating energy savings. The 2021 energy efficiency and beneficial electrification measures were not evaluated until the spring of 2022, meaning 2022 programs were already being implemented before performance metrics were available from the 2021 evaluation. Considering this lag, we expected any major drivers in differences between claimed savings and ex-post impacts that were discussed in the 2021 evaluation to persist into 2022. Additionally, most of the findings and recommendations of this 2022 impact evaluation will be reflected in 2024, not 2023, planning assumptions, goal setting, and ex-ante savings values since PSEG Long Island has already established 2023 goals and planning assumptions.

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 2021**: Planning for 2022 using draft 2022 TRM assumptions	• **2022**: Portfolio Programs implemented	• **January 2023**: Verified Ex-Ante Savings Calculated using planning assumptions from 2021	• **Spring 2023**: Ex-Post evaluation of 2022 portfolio using most up-to-date methods (including PSEG Long Island TRMs 2021-2024, NYS TRMs v8 and v9)	• **Spring 2023**: 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

While the COVID-19 pandemic has largely subsided, there were residual effects in many implementation practices across the energy efficiency and beneficial electrification portfolio. Additionally, with remote work or hybrid work models becoming more permanent, fundamental shifts in customer behaviors should be taken into consideration. With a strong housing market, customers continuing to work from home, and customers trading vacations for home improvement projects, a renewed appetite for home improvements might prove a beneficial target for the energy efficiency and beneficial electrification portfolio implementers. Despite any potential disruptions to program delivery, PSEG Long Island showed strong performance compared to goals.

In 2022, PSEG Long Island administered seven 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.
Multi-Family	The Multifamily program was launched in October 2020. At launch, the Multifamily program targeted New Construction Multifamily developments. In 2021, the Multifamily Program expanded to include Existing Building Multifamily properties. The Multifamily program offers rebates for Common Area Lighting (Indoor and Outdoor), Common Area Heating and Cooling, Common Area Pool

Program	Description
	Equipment, Common Area VFDs, In-Unit Heating and Cooling, and In-Unit Appliances.
Energy Efficient Products	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 such as heat pumps. The program supports the stocking, sale, and promotion of efficient residential products at retail locations.
Home Energy Management	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	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 to both market and income eligible customers. The program has established strong business partnerships with heating and cooling contractors, manufacturers, and program support contractors.
Home Performance	The program serves residential customers and 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 both market and income eligible 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	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.
All Electric Homes	The All Electric Homes program is an extension of New York state policy goals to reduce reliance on fossil fuel combustion appliances in homes. This program offers incentives and rebates to developers who build single-family all-electric homes or convert existing single-family homes from fossil fuel heating and appliances to all-electric.

1.1 PORTFOLIO ENERGY SAVINGS AND PERFORMANCE

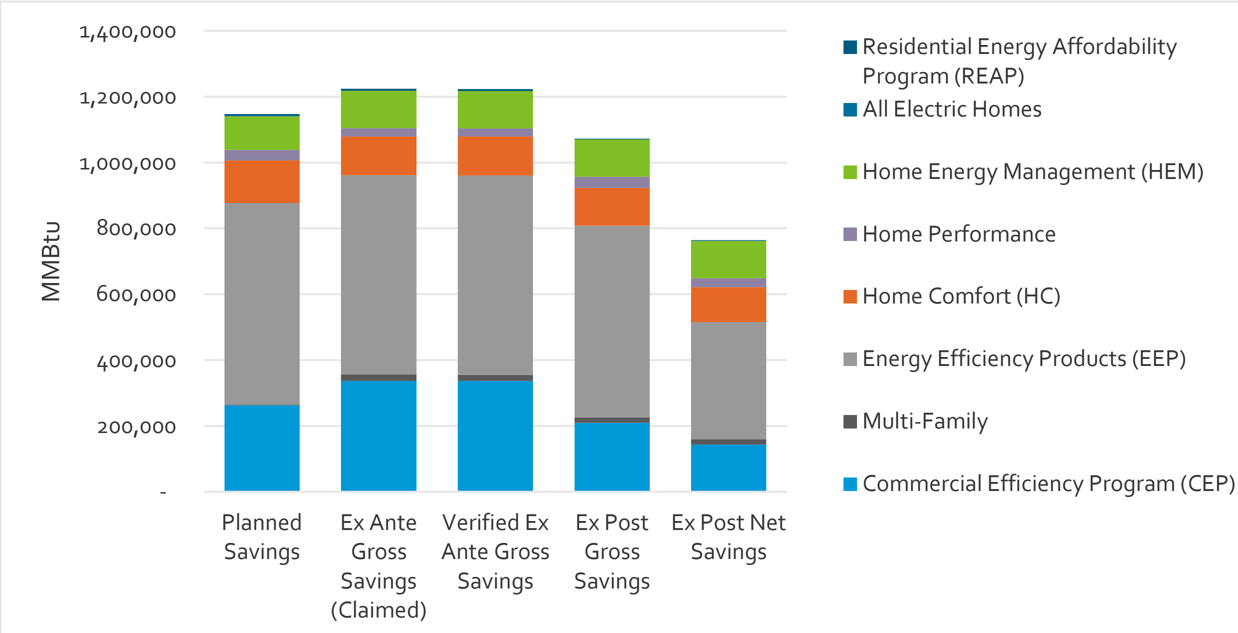
Table 1-2 below compares planned, claimed, verified, and ex-post gross and net savings under the primary performance metric, MMBtu. At the portfolio level, the claimed and verified ex-ante values exceeded planning targets. Implementation contractor performance is to be judged using the verified ex-ante metric. For 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. Results of the Verified Ex-Ante are included in Appendix B.

Table 1-2: Summary of 2022 Energy Program Performance

Sector	Program	Planned Savings (Goals)	Ex-Ante Gross Savings (Claimed)	Verified Ex-Ante Gross Savings	Ex-Post Gross Savings (Evaluated)
		MMBtu	MMBtu	MMBtu	MMBtu
Commercial	Commercial Efficiency Program (CEP)	262,559	337,103	336,381	209,304
	Multi-Family	2,423	18,763	18,763	16,778
Residential	Energy Efficiency Products (EEP)	612,027	605,812	605,943	582,358
	Home Comfort (HC)	129,673	117,818	117,803	114,784
	Home Performance	31,917	25,113	24,783	34,049
	Home Energy Management (HEM)	101,952	113,362	113,362	113,219
	Residential Energy Affordability Program (REAP)	5,953	6,008	5,967	2,108
	All Electric Homes	560	80	79	85
Subtotal Commercial:		**264,982**	**355,867**	**355,144**	**226,082**
Subtotal Residential:		**882,082**	**868,192**	**867,938**	**846,604**
Total Portfolio:		**1,147,064**	**1,224,059**	**1,223,083**	**1,072,686**

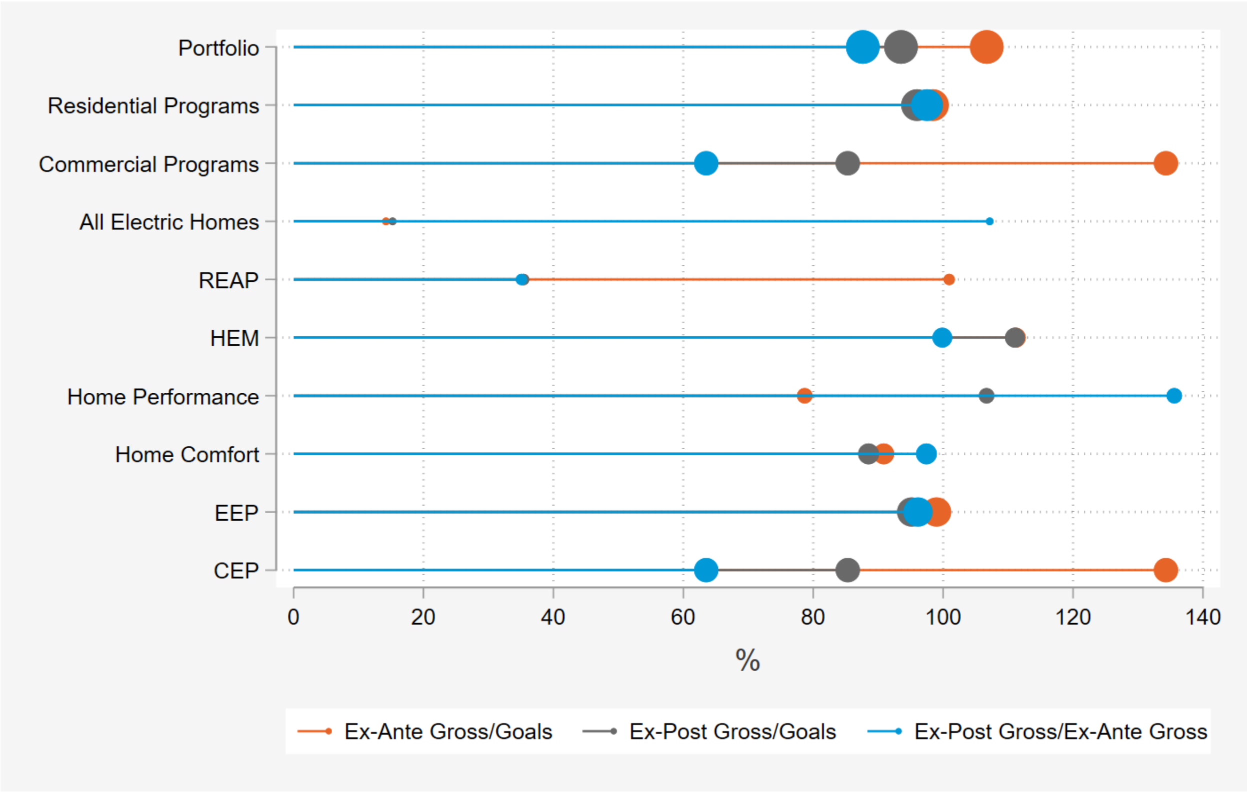
Figure 1-2 and Figure 1-3 visualize the program performance. Because the goals are based on MMBtu gross savings, the appropriate comparisons are between MMBtu planned, claimed, and ex-post gross savings. Each program section provides the energy (MWh) and demand (kW) savings to facilitate comparison with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

Figure 1-2: Portfolio MMBtu Savings



The ex-post results are driven by a couple of measures in the two most prominent programs, Commercial Efficiency Program (CEP) and Energy Efficient Products (EEP). Figure 1-3 visualizes how evaluated savings compare to claimed savings (the Realization Rate, blue bars), how evaluated savings compare to planned savings (grey bars), and how claimed savings compare to planned savings (orange bars). The size of the circle in the plots is scaled based on the goals for the program. At the portfolio level, the ex-post gross savings were 94% of planned savings. For residential programs, the ex-post gross savings was 96% of planned savings while ex-post gross savings for commercial programs was 85% of planned savings. Please note, for HEM the ratio for both the Ex-Post Gross/Goals and Ex-Post Gross/Ex-Ante Gross was 100%, so they overlap perfectly in the chart below.

Figure 1-3: Portfolio Performance Metrics



As Table 1-3 shows, the biggest drivers of the gap between claimed and ex-post gross savings are the results for CEP and EEP. For EEP, the main driver for differences between claimed and ex-post evaluated results are LED lighting and heat pump pool heaters, a carryover issue first identified as part of the 2020 Evaluation. For CEP, the gap between claimed and ex-post gross (evaluated) savings is almost entirely driven by Golf Carts under Nonroad Electric Vehicles. In fact, differences between ex-ante and ex-post values for golf carts were the largest driver of overall portfolio Realization Rate.

Table 1-3 summarizes the primary reasons as to why portfolio ex-post gross (evaluated) savings departed from the planned and claimed savings. These items led to a 143,772 MMBtu decrease between ex-ante gross and ex-post gross savings. The portfolio level difference between ex-ante gross and ex-post gross was 151,374 MMBtu. 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. Additionally, PSEG Long Island's focus on expanding Beneficial Electrification measures has come with certain growing pains. Beneficial Electrification is fairly new to the industry, and as a pioneer of Beneficial Electrification measures in New York, PSEG Long Island has not had many established TRMs to key off of when developing their BE offerings. As a result, some BE measures, such as Golf Carts and Heat Pump Pool Heaters, have become the largest drivers in the overall portfolio realization rate.

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

Portfolio Component	Difference Between Ex-Ante Gross and Ex-Post MMBtu Savings	Summary of Savings Difference
CEP Nonroad Electric Vehicles	▪ Ex-Post Gross < Ex-Ante Gross ▪ 108,668 MMBtu difference ▪ 12% Measure Realization Rate	▪ Electric Golf carts were the single largest driver of the overall 2022 Portfolio realization rate. ▪ The TRM methodology used for planning savings for this category dates back to 2019 but had received little scrutiny due to limited participation. TRC correctly applied the 2022 PSEG Long Island TRM methodology to 2022 projects, resulting in a VEA realization rate of 100%. During the summer 2022 as part of a continuous TRM improvement process, PSEG LI requested a review of the methodology and savings assumptions. DSA reviewed the golf cart and forklift savings algorithms and assumptions and made some changes to the methodology and parameters, including: ➢ Reduction in estimated baseline annual gasoline consumption from 799 gallons (96 MMBtu equivalent) to 120 gallons (15 MMBtu) ➢ The resulting assumption is 3,300 miles traveled annually for the gasoline and electric unit, revised from about 22,000 miles for the gasoline unit. ➢ Broader methodology update that changes the algorithm to a miles-traveled-per-year basis and MPG / miles-per-kWh.
CEP Lighting	▪ Ex-Post Gross < Ex-Ante Gross ▪ 16,601 MMBtu difference ▪ 89% Measure Realization Rate	▪ In some of the analyzed building types, operating hours differed from values specified in the PSEG-LI TRM. While the PSEG LI TRM has adopted lighting operating hours values from the NYS TRM for more than three years, TRC's commercial lighting savings calculation tools have not been consistently updated to align with the NYS TRM across all building types including: auto related, food stores, office, parking garages, and retail.
EEP Lighting – Standard and Specialty LEDs	▪ Ex-Post Gross < Ex-Ante Gross ▪ 12,447 MMBtu difference ▪ 97% Measure Realization Rate	▪ Within the specialty lighting measure category, integrated fixtures and downlights were the most common product type. Evaluated savings

Portfolio Component	Difference Between Ex-Ante Gross and Ex-Post MMBtu Savings	Summary of Savings Difference
		use the actual wattage and baseline of each program supported product instead of a weighted average value based on an assumed mix. Additionally, the evaluation team uses a 50:50 blend of halogen and incandescent efficacy values to determine the baseline for integrated fixtures. ▪ Much of the product claimed as Linear LEDs were non-linear integrated specialty fixtures. The wattage differential between LED and baseline for these products was much larger than the assumed wattage reduction for Linear LEDs so this led to large realization rates for the Linear LED category. The difference in categories is a function of baseline efficacy. The Linear LED measure assumes a T8 efficacy, while integrated non-linear fixtures assume a 50:50 blend of halogen and incandescent efficacy (lumen/W). ▪ The distinction between the specialty LED and linear LED product category becomes incredibly important in 2023. Beginning August 1, 2023 specialty LEDs are no longer eligible to claim savings in the PSEG Long Island TRM due to changes in federal standards. Linear LEDs remain an eligible measure for all of 2023 and beyond. If PSEG Long misclassifies LED fixtures and rebates them after August 1st, this could have significant impacts on 2023 realization rates and cost-effectiveness.
EEP HPPH	▪ Ex-Post Gross < Ex-Ante Gross ▪ 6,056 MMBtu difference ▪ 86% Measure Realization Rate	▪ In the 2020 program year evaluation, heat pump pool heaters went through much of the same scrutiny that golf carts are going through in this year's evaluation. Most of the heat pump pool heater issues were addressed, and the continuing difference can be entirely contributed to 2021 carryover planning assumptions: Applied to 124 out of 1,216 projects.

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.

The critical driver of portfolio SCT ratio and net benefit changes in 2022 compared to prior years was:

- **Change in Lighting EUL from 20 years to 15 years:** The estimated useful life of lighting was decreased from 20 years to 5 years in the NYS TRM and PSEG Long Islands TRM to accommodate the updated EISA standards which made LED lighting the baseline starting July 2023. The decrease in lighting EULs decreased the SCT for EEP and REAP programs, which both had a large lighting component in 2022. If the lighting EUL had stayed at 20 years, the portfolio SCT ratio would be 1.93.

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 1.22 and 2.13 for Commercial and Residential Energy Efficiency programs, respectively. The full energy efficiency portfolio SCT value is 1.71. 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).

[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.

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	$39,280	$35,032	1.12
	Multi-Family	$4,383	$3,202	1.37
Total Commercial Portfolio:		$43,663	$38,234	1.14
Residential	Energy Efficient Products	$53,866	$36,345	1.48
	Home Comfort	$41,108	$22,747	1.81
	Residential Energy Affordability Partnership	$329	$1,495	0.22
	Home Performance	$7,666	$7,507	1.02
	All Electric Homes	$39	$38	1.02
	Home Energy Management	$3,324	$2,073	1.60
Total Residential Portfolio:		$106,333	$70,204	1.51
Total Portfolio[1]:		**$149,996**	**$110,311**	**1.36**

[1] Portfolio costs include $1.87M 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 only the REAP program, though the reasons for the change in SCT relative to prior years vary by program. Some key observations are:

- **CEP**: The SCT ratio for CEP is 1.12 in 2022 compared to 1.22 in 2021. Because it is close to 1.0, all inputs have the potential to tip the outcome. SCT results for the CEP 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. Relative to 2021, the levelized costs for energy for the measures in the CEP portfolio increased dropping the SCT ratio to 1.12.
- **Multi-Family:** The SCE ratio for Multi-Family is 1.37.
- **EEP:** The SCT ratio for EEP is 1.48 in 2022, a large decrease over the 3.43 ratio from in 2021. Despite this drop, EEP was one of the most cost-effective program in the portfolio for 2022. The reason for this drop lies primarily with lighting EULs. In 2021, the lighting EUL was 20 years, and this dropped to 5 years in 2022 as a result of the EISA LED standards. This matches the 2022 PSEG Long Island TRM. As a whole, the role of lighting is expected to diminish as LEDs are required under changing federal standards.
- **Home Comfort**: The SCT ratio for Home Comfort is 1.81 in 2022 compared to 1.66 in 2021. In 2022 the avoided costs of natural gas and fuel were updated resulting in higher values associated with these fuels. This could lead to an increase in SCT.

- **REAP**: The SCT ratio for REAP is 0.22 in 2022 compared to 0.74 in 2021. Like EEP, the lighting EUL dropped from 20 years to 5 years. Lighting is 42% of the REAP program's impacts. Cost-ineffectiveness is not unusual for income-qualified programs, which typically are not required to be cost-effective. In section **Error! Reference source not found.**, we discuss additional non-utility impacts that can potentially be incorporated into cost effectiveness as low-income benefits.
- **Home Performance**: The SCT for Home Performance is 1.02 in 2022. The ratio has been close to 1 since 2020. These are long term, capital intensive investments in the home, and as a result, so an SCT ratio around 1 is expected.
- **All Electric Homes:** The SCE for AEH is 1.02. 2022 is the first year that the All Electric homes was evaluated.
- **HEM**: The SCT is 1.6 in 2022 compared to 1.07 in 2021. The cost effectiveness increased relative to 2021 due to a relative increase in per customer MMBtu impact. Additionally, program costs decreased substantially, while savings and benefits increased.

Figure 1-4: Societal Cost Test Ratios by Program

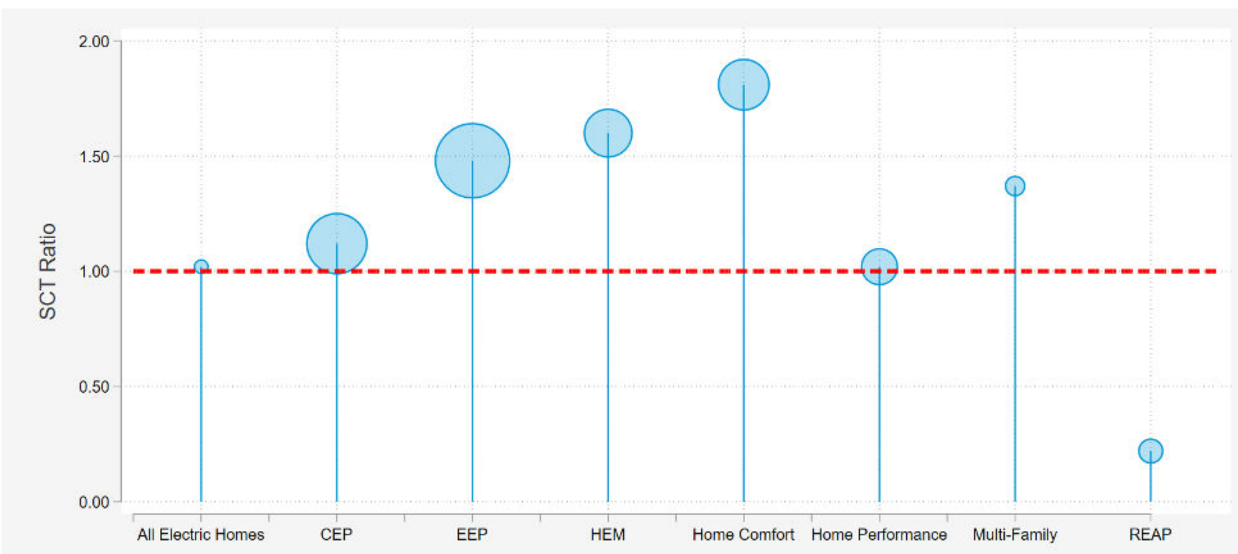
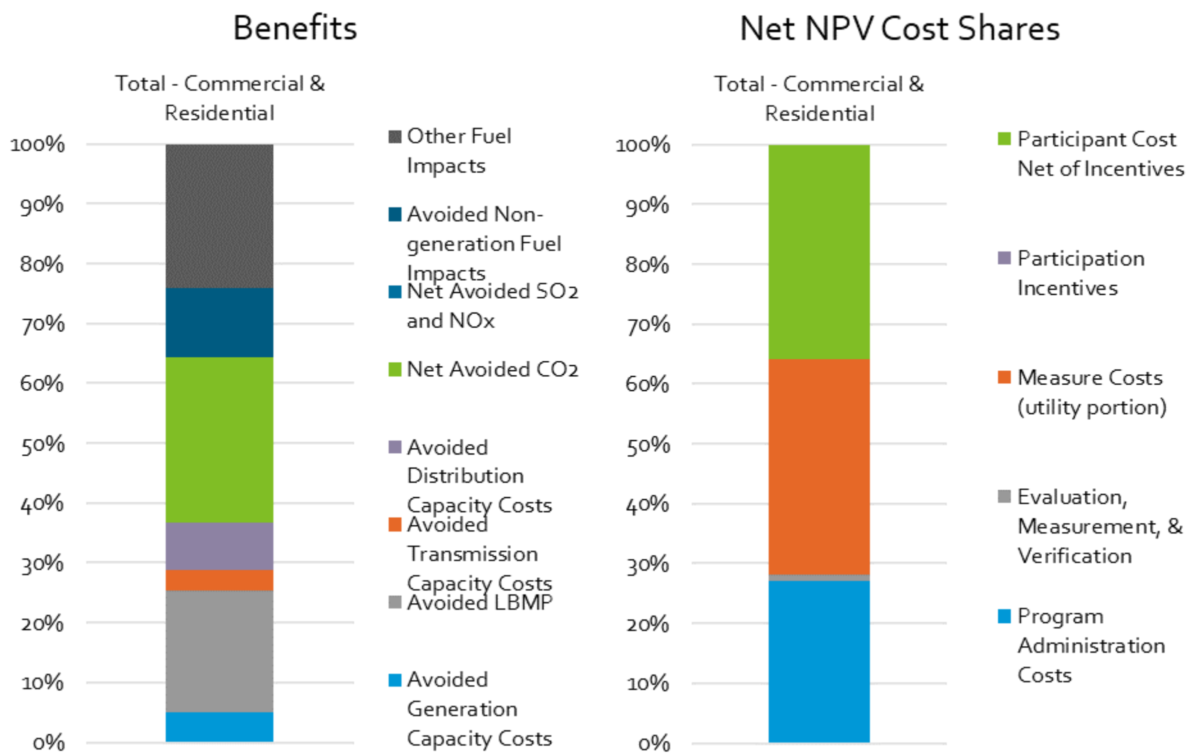


Figure 1-5 summarizes the benefit and cost categories analyzed and the share each contributed to the SCT. The primary two benefits for the SCT are avoided carbon emissions at 28% of benefits[3,4], and other fuel impacts at 24% of benefits. The combined benefits for capacity (generation, transmission, distribution) together comprise about 16% of societal benefits. From a societal perspective, the largest two cost categories are the measure costs borne by participants and the measure costs borne by the utility in the form of customer rebates and contractor incentives. Both account for 36% of the Net NPV

[3] 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
[4] 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

Cost Shares. 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 27% of societal costs.

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



2 COMMERCIAL EFFICIENCY PROGRAM

2.1 COMMERCIAL EFFICIENCY PROGRAM DESCRIPTION

PSEG Long Island's Commercial Efficiency Program (CEP) helps non-residential customers save 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.
Multifamily		The Multifamily program was launched in October 2020. At launch, the Multifamily program targeted New Construction Multifamily developments. In 2021, the Multifamily Program expanded to include Existing Building Multifamily properties. The Multifamily program offers rebates for Common Area Lighting (Indoor and Outdoor), Common Area Heating and Cooling, Common Area Pool Equipment, Common Area VFDs, In-Unit Heating and Cooling, and In-Unit Appliances.
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.
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, refrigeration, and pool equipment.

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 claimed savings exceeded its MMBtu goals in 2022, as shown in Table 2-2.

Table 2-2: 2022 CEP Verified Ex-Ante Gross Program Performance vs. Goals

Metric	MMBtu
Goal	264,982
Verified Ex-Ante Gross Savings	355,144
% of Goal	134%

Comprehensive Lighting projects accounted for the largest share of CEP ex-ante gross energy savings in 2022. As shown in Table 2-3, Comprehensive Lighting projects accounted for 39% of ex-ante gross MMBtu savings, outpacing Fast Track (2%) and Refrigerated Lighting (2%) measure groups within the lighting category. Golf cart and forklift electrification in the Nonroad Vehicle Electrification category accounts for the 35% of ex-ante gross savings and far exceeds the contribution to savings of Refrigeration, Motors & VFDs, Compressed Air, and Other Commercial Equipment measures in the Standard category.

Table 2-3. 2022 CEP Percent of Total Ex-Ante Gross Savings by Program Component

Category	Program Component	Ex-Ante Gross Savings		
		% MMBtu	% MWh	% kW
Lighting	Comprehensive Lighting	39.2%	73.9%	76.7%
	Fast Track Lighting	2.4%	4.7%	6.2%
	Refrigerated Case Lighting	1.6%	2.5%	1.4%
	Lighting Subtotal	**43.2%**	**81.1%**	**84.3%**
Multi-Family	Multi-Family	5.3%	2.1%	2.6%
STANDARD	Refrigeration	1.0%	1.5%	4.1%
	Motors & VFDs	1.4%	2.1%	0.7%
	Compressed Air	0.3%	0.5%	0.4%
	Nonroad Vehicle Electrification	34.6%	-1.9%	-0.1%
	Other Commercial Equipment	0.6%	0.8%	2.5%
	Standard Subtotal	**37.8%**	**3.1%**	**7.7%**
Custom	Custom	13.1%	12.8%	4.4%
HVAC	HVAC	0.6%	0.9%	1.0%

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. Realization rates were calculated by dividing ex-post gross savings values by ex-ante gross savings values. Overall, CEP realized 64% of its ex-ante gross MMBtu energy savings claims, 89% of MWh savings claims, and 106% of kW savings claims. Most savings claims were found to be reasonable however the 64% Realization Rate for MMBtu savings was disproportionately impacted by use of an improved savings methodology and assumptions for golf carts in the Nonroad Vehicle Electrification category. This resulted in significantly lower MMBtu savings estimates than in previous years. Opportunities to refine MMBtu savings claims are further addressed in Table 2-7.

Table 2-4: 2022 CEP Ex-Post Gross MMBtu Impacts by Program Component

Category	Program Component	N	Ex-Ante Gross Savings (Claimed) MMBtu	Ex-Post Gross Savings MMBtu	Realization Rate %
Lighting	Comprehensive Lighting	1,285	139,428	123,727	89%
	Fast Track Lighting	370	8,500	8,294	98%
	Refrigerated Case Lighting	38	5,776	5,083	88%
	Lighting Subtotal	1,693	153,705	137,104	89%
Multi-Family	Multi-Family	22	18,763	16,778	89%
Standard	Refrigeration	3,435	3,443	3,443	100.0%
	Motors & VFDs	164	4,892	4,990	102.0%
	Compressed Air	21	1,108	1,108	100.0%
	Nonroad Vehicle Electrification	1,311	122,970	14,302	11.6%
	Other Comm. Equipment	55	2,142	2,142	100.0%
	Standard Subtotal	4,986	134,555	25,986	19.3%
Custom	Custom	57	46,719	44,383	95.0%
HVAC	HVAC	264	2,125	1,832	86.2%
Total[1]		**7,022**	**355,867**	**226,082**	**64%**

[1] One project adjustment of 175 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: 2022 CEP Ex-Post Gross MWh Impacts by Program Component

Category	Program Component	N	Ex-Ante Gross Savings (Claimed)[a]	Ex-Post Gross Savings	Realization Rate
			MWh	MWh	%
Lighting	Comprehensive Lighting	1,285	50,057	44,136	88%
	Fast Track Lighting	370	3,166	3,089	98%
	Refrigerated Case Lighting	38	1,693	1,490	88%
	Lighting Subtotal	1,693	54,916	48,715	89%
Multi-Family	Multi-Family	22	1,449	1,042	72%
Standard	Refrigeration	3,435	1,009	1,009	100.0%
	Motors & VFDs	164	1,434	1,463	102.0%
	Compressed Air	21	325	325	100.0%
	Nonroad Vehicle Electrification	1,311	-1,266	-1,752	138.5%
	Other Comm. Equipment	55	571	571	100.0%
	Standard Subtotal	4,986	2,073	1,615	77.9%
Custom	Custom	57	8,691	8,256	95.0%
HVAC	HVAC	264	596	536	89.9%
Total[1]		**7,022**	**67,724**	**60,164**	**89%**

[1] One project adjustment of 51.4 MWh is included in ex-ante total gross savings and overall realization rates, but not shown as a separate line item in this table

Table 2-6: 2022 CEP Ex-Post Gross kW Impacts by Program Component

Category	Program Component	N	Ex-Ante Gross Savings (Claimed)	Ex-Post Gross Savings	Realization Rate
			kW	kW	%
Lighting	Comprehensive Lighting	1,285	9,752	10,397	107%
	Fast Track Lighting	370	786	828	105%
	Refrigerated Case Lighting	38	182	350	192%
	Lighting Subtotal	1,693	10,721	11,575	108%
Multi-Family	Multi-Family	22	328	355	108%
Standard	Refrigeration	3,435	526	526	100.0%
	Motors & VFDs	164	89	99	110.3%
	Compressed Air	21	54	54	100.0%
	Nonroad Vehicle Electrification	1,311	-10	-15	153.3%
	Other Comm. Equipment	55	317	317	100.0%
	Standard Subtotal	4,986	978	981	100.4%
Custom	Custom	57	557	445	80.0%
HVAC	HVAC	264	128	133	104.2%
Total		**7,022**	**12,711**	**13,490**	**106%**

2.2.2 Key Drivers for Differences in Impacts

Table 2-7 summarizes the major differences that contributed to the MMBtu realization rates, along with the evaluation team's recommendations to improve savings claims moving forward.

Table 2-7: Key Contributors to CEP MMBtu RR and Proposed Solutions

Component	Summary of Savings Difference	Recommendation
Comprehensive Lighting	▪ In some of the analyzed building types, operating hours differed from values specified in the PSEG-LI TRM. While the PSEG LI TRM has adopted lighting operating hours values from the NYS TRM for more than three years, TRC's commercial lighting savings calculation tools have not been consistently updated to align with the NYS TRM across all building types.	▪ Align savings assumptions with PSEG-LI TRM.

Component	Summary of Savings Difference	Recommendation
	▪ The gross savings calculated by TRC's commercial lighting savings calculation tools were higher than reported savings in Captures for 51 lighting projects in 2022. For example, the gross savings estimated for one project by the lighting tool was 78,641 kWh, but the savings reported towards KPI scorecards was 73,696 kWh. This specific project underwent manual adjustments to the claimed savings.	▪ Align worksheet savings calculations with Captures. ▪ Provide a list of all project numbers with manually adjusted savings claims.
Fast Track Lighting	▪ Operating hours by building type differed from values in the 2024 PSEG-LI TRM for a few building types analyzed.	▪ Align savings assumptions with PSEG-LI TRM.
Refrigerated Case Lighting	▪ TRC applied PSEG 2010 assumptions for savings, which are based on the 2010 NYS Tech Manual.	▪ Align savings assumptions with PSEG-LI TRM.
Multifamily Lighting	▪ TRC assumed that all interior lighting measures were installed in common areas. A closer look at the project documentation for incented lighting projects suggested that the lights were to be installed "in-unit". We assumed a 50-50 common area vs. in-unit blend for the installation of LED downlights only in the evaluation. This resulted in differences to lighting hours of use and coincidence factors for "in-unit" measures compared to ex-ante assumptions.	▪ Use residential interior lighting hours of use and coincidence factors for savings estimation if "in-unit" lighting installations are applicable.
Nonroad Vehicle Electrification	**Golf Carts** ▪ Reduction in estimated baseline annual gasoline consumption from 799 gallons (96 MMBtu equivalent) to 120 gallons (15 MMbtu) ▪ The resulting assumption is 3,300 miles traveled annually, revised from about 22,000 miles. ▪ Broader methodology update that changes the algorithm to a miles-traveled-per-year basis and MPG / miles-per-kWh.	▪ Use the 2023 PSEG Long Island TRM planning assumptions for golf carts and forklifts going forward. ▪ Refine assumptions around equipment specs and usage if better information about equipment usage on Long Island becomes available. ▪ Consider that gasoline-powered golf carts for fleet use may not remain in the market for much longer- adoption of battery-

Component	Summary of Savings Difference	Recommendation
	Forklifts ▪ Updated gal/hr assumption to 1.0 from 1.7 based on industry standard. ▪ Revision to efficient case kWh based on customer operating days, battery specs, and typical user schedule of 8/8/8 hrs.	powered units is widespread and upfront equipment costs are nearly identical.
HVAC	▪ Categories for six buildings were corrected to align with the actual building type. The corrected building types had significantly fewer full-load hours which reduced savings and the resultant MMBtu realization rate to 86%.	▪ Ensure better alignment of building type in Captures with the actual building type.

2.2.2.1 Nonroad Vehicle Electrification Measure Specification Findings

Realization rates for battery-powered golf carts and forklifts are 11.6% for MMBtu, 138.5% for kWh, and 153.3% for kW. The TRM methodology used for planning savings for this category dates back to 2019 but has received little scrutiny due to limited participation. TRC correctly applied the 2022 PSEG Long Island TRM methodology to 2022 projects, resulting in a VEA realization rate of 100%. During the summer 2022 as part of a continuous TRM improvement process, PSEG LI requested a review of the methodology and savings assumptions. CEP saw a sharp increase in adoption of Nonroad Vehicle Electrification projects in 2022 and noticed a conspicuously low ratio of program expenditures to MMBtu savings from golf carts. In response, DSA reviewed the golf cart and forklift savings algorithms and assumptions and made some changes to the methodology and parameters. These changes exist in the 2023 and 2024 PSEG Long Island TRMs, and a memo explaining this in more detail is included in Appendix D of this report.

2.2.2.1.1 GOLF CARTS

A synopsis of the changes to the golf carts TRM entry is shown in Table 2-8. Default per-project MMBtu savings decrease from 93 MMBtu to 10 MMBtu.

Table 2-8: Golf Carts Update Summary

	Metric (annual)	Prior to Update	Updated
Miles traveled	miles	21,971[5]	3,306
Baseline	gallons of gasoline	799	120
	MMBtu	96	14
Efficient	kWh	913	1,302

[5] Derived from 799 gallons of gasoline * 27.5 mpg

	Metric (annual)	Prior to Update	Updated
	MMBtu	3	4
Savings	MMBtu	93	10

2.2.2.1.2 FORKLIFTS

A synopsis of changes to the Forklifts TRM entry is shown in Table 2-9. Default per-project MMBtu savings decrease from 272 MMBtu to 159 MMBtu.

Table 2-9: Forklift Update Summary

	Metric (annual)	Prior to Update	Updated
Hours of use	hours	1,800[6]	2,000
Gals/hour	gallons of propane	1.7	1.0
Baseline	gallons of propane	3,008	2,000
	MMBtu	305	183
Efficient	kWh	9,485	6,913
	MMBtu	32	24
Savings	MMBtu	272	159

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 2-10. In most cases, our recommendations apply to the 2024 program year. Planning for the 2023 program year was finalized a year ago, and program delivery is almost half complete. These types of changes are often most efficient to implement at the beginning of a new program year. Most of our recommendations are also reflected in the recently completed 2024 PSEG Long Island TRM. However, our ex-post evaluation of the Nonroad Vehicle Electrification measure category was based on updated mileage assumptions that were included in the 2023 TRM update.

[6] Derived from 3,008 gals / 1,800 hours

Table 2-10: Commercial Efficiency Findings and Recommendations

Finding	Recommendation
▪ CEP's non-lighting measures have become increasingly prominent, while lighting's share of savings has gradually decreased year to year. Lighting in 2022 accounted for 61% of ex-post gross MMBtu savings compared to 78% in 2021 (excluding impacts from Combined Heat and Power which has been discontinued by the program).	▪ PSEG Long Island should continue to expand its program offerings beyond lighting to offset the declining share of program savings attributed to lighting. This could be achieved by focusing on non-lighting segments, such as refrigeration and HVAC, as well as lighting controls, for which the market is rapidly evolving. Additionally, the program should prioritize the expansion of heat pump offerings within the HVAC segment, as this technology is rapidly gaining traction in the commercial sector. By diversifying its program offerings and staying up-to-date with evolving technologies, PSEG Long Island can continue to deliver value to its customers while adapting to changing market trends.
▪ For select measures such as lighting, 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 measures.	▪ CEP administrators should start collecting and tracking relevant measure- and project-specific data in measure records. This would allow evaluators to extract data that informs savings for all projects rather than refer to project workbooks one by one. Most notably for the following data field: ➢ Existing fixture quantity (Comprehensive Lighting program component)
▪ The ex-post MMBtu savings estimate for Nonroad Vehicle Electrification was based on the assumption that gasoline and electric golf cart mileage was equal. In planning, it was assumed that electric golf carts travels 88.4% fewer miles travelled than a gas golf cart. This resulted in 88.4% lower MMBtu savings and a realization rate of 11.6%.	▪ CEP administrators should continue to use the 2023 TRM assumptions for golf carts and forklifts going forward. These assumptions are subject to change as better information about equipment use and costs become available and motor technologies evolve. PSEG Long Island may also want to revisit and right-size the incentive level for these measures given the reduced savings per unit.

3 ENERGY EFFICIENCY PRODUCTS PROGRAM

3.1 ENERGY EFFICIENCY PRODUCTS PROGRAM DESCRIPTION

The following sections detail the program design, implementation strategies, and PY2022 participation and performance for the Energy Efficiency Products (EEP) program.

3.1.1 PROGRAM DESIGN AND IMPLEMENTATION

The objective of EEP 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 2022 include LED lighting, thermostats, heat pump pool heaters (HPPH), ENERGY STAR appliances such as dehumidifiers and air purifiers, and appliance recycling. Smaller measures include heat pump water heaters (HPWH) and battery-operated lawn equipment.

TRC is responsible for the overall delivery of EEP and manages the rebated components of the program. Subcontractor ARCA manages the appliance recycling component of EEP. Subcontractor EFI manages the retail and online marketplace components of EEP. Additionally, TRC subcontracts CLEAResult to aid in lighting rebate promotions.

3.1.2 PROGRAM PARTICIPATION AND PERFORMANCE

The EEP program achieved 99% of 2022 program MMBtu goals, saving 605,819 MMBtu on a verified ex-ante basis. Ninety-five percent of EEP verified ex-ante savings are attributable to three measure categories: LED lighting (76%), thermostats (12%), and heat pump pool heaters (7%). No other measure category contributes more than 2% of overall EEP ex-ante savings. Table 3-1 shows 2022 EEP program performance compared to goals.

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

Metric	MMBtu
Goal	612,027
Verified Ex-Ante Gross Savings	605,819
% of Goal	98.99%

In 2022, the EEP program incentivized more than 4.6 million energy efficient products to PSEG Long Island residential customers. PSEG Long Island rebated 13,375 smart thermostats, 13,260 dehumidifiers, 3,693 washers and dryers, 2,881 air purifiers, and 1,217 heat pump pool heaters through EEP in 2022.

The biggest contributor to EEP program savings is LED Lighting (76% of ex-post MMBtu). In 2022, EEP Lighting measures provided point-of-sale discounts on over 4.3 million LED lamps and fixtures at Long Island retailers and online.

Several measures that contributed to EEP savings in prior years no longer contribute in 2022: pool pumps, dishwashers, refrigerators, and freezers (although 2,638 refrigerators were collected for recycling and incentivized accordingly). Pool pumps are no longer part of the EEP program due to an updated federal requirement for variable-speed pumps, effectively eliminating savings opportunities. Fifteen pool pumps are included in 2022 quantities as 2021 carryover projects, but claimed no savings. Refrigerators, freezers, and dishwashers are no longer included in EEP as of 2022.

Table 3-2 summarizes participation for each program measure compared to the planning goal.

Table 3-2. 2022 EEP Program Participation vs. Goals, by Measure

Measure	Number of Units	Planned Units (Goal)	Percentage of Goal Achieved
EEP ES Room Air Purifier (<200 CADR)	307	-	
EEP ES Room Air Purifier (>200 CADR)	252	-	
EEP ES Room Air Purifiers (<150)	1,413	1,060	133%
EEP ES Room Air Purifiers (>150)	909	940	97%
EEP Advanced Power Strip Tier 1	1,201	5,000	24%
EEP Advanced Power Strip Tier 2	256	500	51%
EEP Clothes Dryer - Electric Resistance	1,782	2,500	71%
EEP Clothes Dryer - Most Efficient	54	350	15%
EEP ME Clothes Washer	1,857	3,500	53%
EEP ES Dehumidifier	13,260	7,500	177%
EEP Heat Pump Water Heater - Small	126	205	61%
EEP Heat Pump Water Heater - Large	68	88	77%
Tankless Water Heater <12 kW	2	180	1%
Tankless Water Heater >12 kW	17	90	19%
Pool Pump Variable Speed	15	-	
Heat Pump Pool Heater	1,217	2,000	61%
Solar Pool Covers	31	200	16%
EEP Refrigerator Recycle- Pre 2001	971	800	121%
EEP Refrigerator Recycle- Post 2001 & Pre 2010	1,667	2,000	83%
EEP Dehumidifier Recycle	182	150	121%
LED Standard	1,819,386	1,500,000	121%
LED Specialty	2,367,208	2,400,000	99%
EEP Redeemed Recycling Voucher	12	-	
Connected Thermostat	7,030	6,000	117%
Learning Thermostat	6,345	10,000	63%
EEP Electric Lawn Mower <4aH	1	-	
EEP Electric Lawn Mower 4-5aH	18	-	
EEP Electric Lawn Mower >5aH	21	-	
Electric Lawn Mower	883	1,550	57%
EEP Electric Weed Trimmer	757	1,500	50%
EEP Electric Leaf Blower	784	1,500	52%

Measure	Number of Units	Planned Units (Goal)	Percentage of Goal Achieved
EEP ES Storm Window	-	5,000	0%
ES Linear Fixture	125,861	2,000	6293%
In-storage LEDs	272,032	272,032	100%
Total	**4,625,925**	**4,226,645**	**109%**

The number of smart thermostat rebates grew by 41% relative to 2021, dehumidifiers by 263%, and dehumidifier recycling by 44%. Table 3-3 compares quantities for 2021-2022 by measure category.

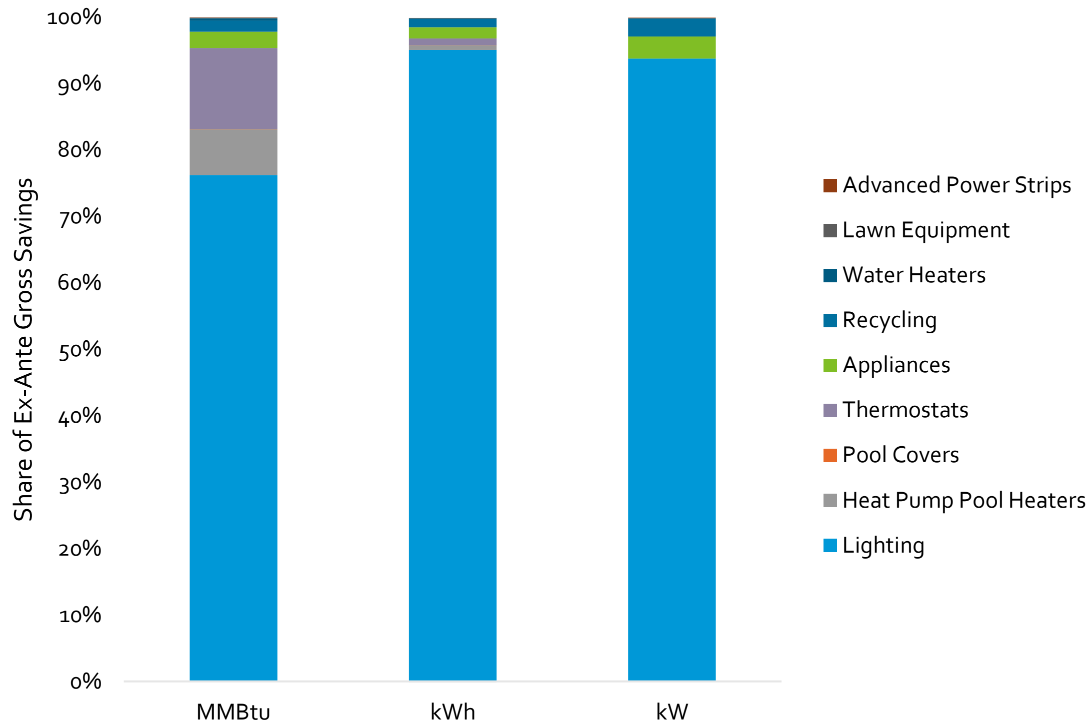
Table 3-3: 2021-2022 Quantity Comparison, by Measure Category

Measure Category	2021 Units	2022 Units	Percentage Change
Lighting*	3,952,300	4,584,487	16%
Heat Pump Pool Heaters	1,867	1,217	-35%
Pool Covers	0	31	-
Pool Pumps	3,519	15	-100%
Thermostats	7,612	13,375	76%
Appliances	10,823	19,834	83%
Recycling	1,850	2,832	53%
Water Heaters	188	213	13%
Lawn Equipment	4,003	2,464	-38%
Advanced Power Strips	1,728	1,457	-16%
Windows	93	-	-100%
Bathroom Exhaust Fans	1	-	-100%
Total	**3,983,984**	**4,625,925**	**16%**

*Includes in-storage lighting, which is why the quantity is inconsistent with totals in the prior section

Figure 3-1 shows the distribution of ex-ante gross energy and demand savings across the EEP program. Lighting measures (LED Standard/Specialty, Linear LEDs, and In-storage LEDs) account for most of the ex-ante gross savings across all resources. Smart thermostats, heat pump pool heaters, and air purifiers are the other top measures. Along with LED lighting, these measures account for 98% of ex-ante gross MMBtu savings. For a comparison of MMBtu savings between 2021 and 2022, see Figure 3-4.

Figure 3-1: 2022 EEP Program Ex-Ante Gross Savings by Resource and Measure Category



3.1.2.1 Lighting Detail

EEP includes a variety of different LED lighting types and classification of specific equipment into categories proved to be an important factor in the evaluation. Table 3-4 displays examples of these lighting types, describing their uses and appearances.

Table 3-4: Retail Lighting and Efficient Products

Bulb	Description
	**Standard** (A-line): these bulbs work well for a variety of applications such as table or floor lamps, wall sconces, pendant and ceiling fixtures
	**Decorative** (Candelabra): these bulbs are commonly used in chandeliers, wall sconces, pendant lights, and other decorative home lighting applications
	**Globes**: these bulbs are used in wall sconces, pendant fixtures, bathroom vanities and other specialty fixtures
	**Reflectors**: these bulbs are used in many directional applications such as perimeters of houses, decks, landscapes, patios, recessed cans, and track lighting
	**Three-way**: these bulbs look like standard bulbs, but have the ability to give three levels of illumination
	**Fixture**: these products combine the traditional fixture and lamps into a single integrated product with no "socket" or "lamps".
	**Linear Fixture**: these fixtures house long tubes and distribute the light over a narrow area. They are commonly found in closets, garages, and basements.

Similarly, Table 3-5 below displays the most common product sold by each lighting type. Feit Electric was the most common manufacturer of program-supported lighting products in 2022 for each category except Linear Fixtures.

Table 3-5: Most Common Product by Product Type

Product	Bulb Type	Description
	A-Lamp	Feit Electric 60W Dimmable Omni-Directional Glass LED, 6 Count
	Candelabra	Fiet Electric 40W Dimmable LED Chandelier Vintage/ Filament Style 6-Pack Tier 2
	Fixture	Feit Electric 5-6" Retrofit Kit 2PK 850L 9.4W Tier 2
	Globe	Feit Electric 40W Filament LED Globe 4pk White Bulb Tier 2
	Reflector	Feit Electric 65W High Power BR30 Dimmable 6-Pack 8.3W
	Linear Fixture	Active Energy Partners Koda 46" LED Shop Light

Customers could purchase these LEDs from various retailers throughout Long Island. Figure 3-2 shows the geographic dispersion of purchases using retailer zip codes. Each polygon represents a different zip code and the shade represents the share of LED products sold in 2022 (darker shade means more). Note the figure is not normalized to the population.

Figure 3-2: Geographic Distribution of LED Products

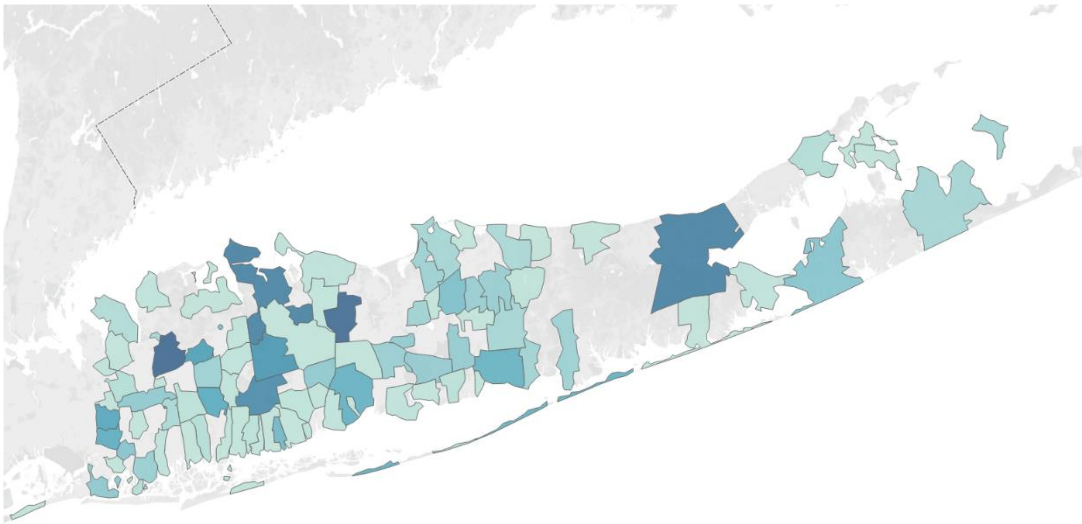


Table 3-6 shows the distribution of LED bulbs sold by Long Island retailers. Aggregated in "Other" are several small retail partners with limited 2022 program volume. Home Depot was the largest retailer in 2022, selling approximately 45% of all bulbs included in this program. Lowe's and Costco came next, selling a combined 29% of bulbs. Additionally, customers had the option to purchase products through the PSEG Online Marketplace where bulbs were commonly bundled with other energy efficient products. About 33,014 LED bulbs, or 1.1%, were sold through the Marketplace.

Table 3-6: Distribution of Standard and Specialty LED Bulbs by Retailer and Bulb Type

Retailer	A-Lamp	Reflectors	Candelabra	Globe	Three-Way	Total
ACE Hardware	76,514	28,182	22,513	11,654	678	139,541
Costco	347,534	79,548	84,684	10,008	---	521,774
Home Depot	723,956	212,393	236,280	131,943	27,415	1,331,987
Lowe's	188,787	64,552	53,937	11,372	894	319,542
N&S Electric	3,733	5,691	40	13		9,477
Other	292,953	56,781	33,204	5,673	184	388,795
PSEG Online Marketplace	29,837	1,488	1,001	688	---	33,014
Revco	8,946	40,535	5,235	---	---	54,716
Schwing	21,111	11,432	2,418	---	---	34,961
Target	41,630	4,938	6,767	3,319	430	57,084
Walmart	70,837	10,320	7,651	2,725	193	91,726
Total	**1,805,838**	**515,860**	**453,730**	**177,395**	**29,794**	**2,982,617**

Program-supported LED fixtures followed a different distribution of retail sales in 2022 as displayed in Table 3-7. Home Depot was still the largest retailer selling approximately 52% of all fixtures; however, N&S Electric, REVCO, and Schwing Lighting made up much larger portion of fixtures sales compared to bulb sales. These three electrical supply companies represented a combined 28% of fixture sales.

Table 3-7: Distribution of LED Fixtures by Retailer and Fixture Type

Retailer	Ceiling Mount	Downlight Fixture	Other Integrated Fixtures	Linear Fixture	Total
Ace Hardware	162	13,269	399	165	13,995
Costco	707	44,216	---	2,437	47,360
Home Depot	38,817	631,776	7,682	8,558	686,833
Lowe's	192	37,401	6,760	3,867	48,220
N&S Electric	620	131,549	---	---	132,169
Other	863	154,345	4,951	4,287	164,446
PSEG Online Marketplace	---	77	4	---	81
Revco	848	100,001	17	565	101,431
Schwing	495	134,302	145	246	135,188
Target	---	34	---	---	34
Walmart	---	81	---	---	81
Total	**42,704**	**1,247,051**	**19,958**	**20,125**	**1,329,838**

It is important to note, many non-linear LED fixtures were rebated under the LED Linear category in the second half of 2022. This classification issue stemmed from an August 2022 memorandum between PSEG Long Island and TRC allowing all indoor ENERGY STAR fixtures to be claimed under the LED Linear category. This led to a crossover of what was actually linear versus what was claimed as linear. Table 3-8 shows the category that LED bulbs and fixtures were rebated under as columns and the evaluation team's classification as rows. Interestingly, Downlight Fixtures made up approximately 81% of fixtures rebated under the LED Linear category.

Table 3-8: Distribution of LED Fixtures and Bulbs by Rebate Measure

Product Type	LED Standard	LED Specialty	LED Linear	Total
A-Lamp	1,804,727	1,111	---	1,805,838
Candelabra	---	453,730	---	453,730
Globe	---	177,395	---	177,395
Reflectors	2,378	513,482	---	515,860
Three-Way	12,281	17,513	---	29,794
Ceiling Mount	---	32,635	10,069	42,704
Downlight Fixture	---	1,145,117	101,934	1,247,051
Linear Fixture	---	6,502	13,623	20,125
Other Fixtures	---	19,723	235	19,958
Total	**1,819,386**	**2,367,208**	**125,861**	**4,312,455**

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 3-9 shows ex-ante and ex-post gross MMBtu impacts and realization rates by measure category. Table 3-10 and Table 3-11 show the equivalent impacts for MWh and kW.

Table 3-9: 2022 EEP MMBtu Impacts by Measure Category

Measure Category	Ex-Ante Gross Savings (Claimed)	Ex-Post Gross Savings	Realization Rate
	MMBtu	MMBtu	%
Lighting	462,754	450,306	97%
Heat Pump Pool Heaters	41,882	35,827	86%
Pool Covers	92	96	104%
Thermostats	73,117	71,760	98%
Appliances	14,811	9,835	66%
Recycling	10,155	11,487	113%
Water Heaters	2,074	2,062	99%
Lawn Equipment	542	611	113%
Advanced Power Strips	385	374	97%
Total	605,812	582,358	96%

Table 3-10: 2022 EEP MWh Impacts by Measure Category

Measure Category	Ex-Ante Gross Savings (Claimed[1])	Ex-Post Gross Savings	Realization Rate
	MWh	MWh	%
Lighting	205,184	200,429	98%
Heat Pump Pool Heaters	3,404	1,550	46%
Pool Covers	27	28	104%
Thermostats	2,168	2,323	107%
Appliances	3,616	2,440	67%
Recycling	2,976	3,419	115%
Water Heaters	(123)	(131)	107%
Lawn Equipment	(36)	(8)	23%
Advanced Power Strips	113	110	97%
Total	**217,328**	**210,158**	**97%**

[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.

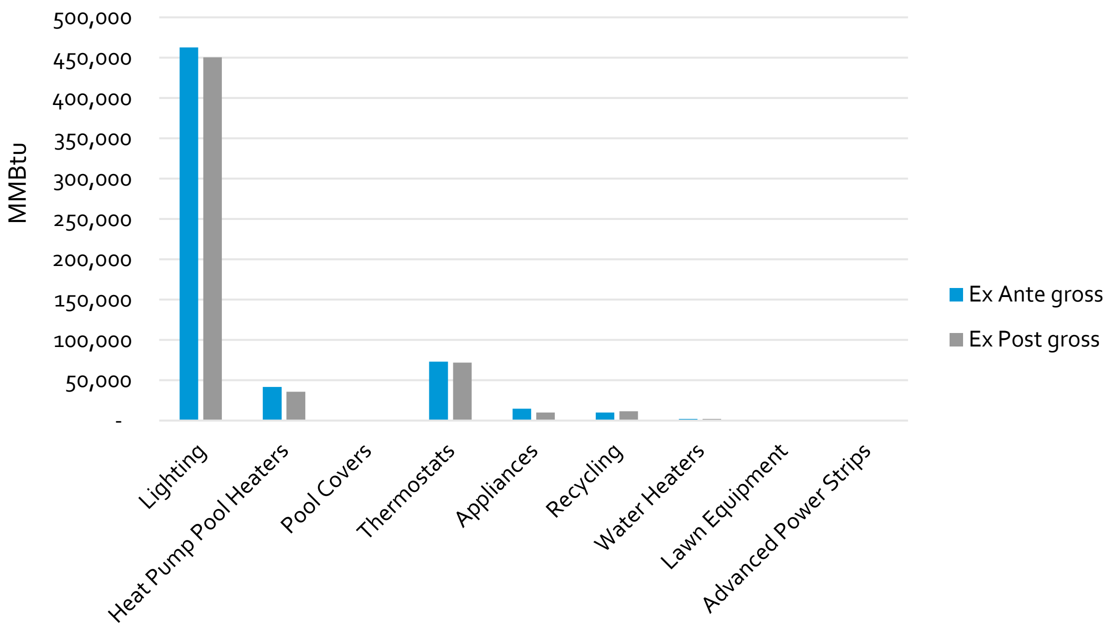
Table 3-11: 2022 EEP kW Impacts by Measure Category

Measure Category	Ex-Ante Gross Savings (Claimed)	Ex-Post Gross Savings	Realization Rate
	kW	kW	%
Lighting	15,252	28,361	186%
Heat Pump Pool Heaters	-	-	
Pool Covers	-	-	
Thermostats	-	-	
Appliances	547	653	119%
Recycling	447	556	124%
Water Heaters	(1)	(14)	1971%
Lawn Equipment	-	-	
Advanced Power Strips	12	12	97%
Total	**16,257**	**29,568**	**182%**

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 96%. Lighting measures account for 47% of the program level difference between the claimed and ex-post gross MMBtu (the MMBtu variance), mainly due to inclusion of integrated fixtures in the Linear LED reporting category as previously explained. Heat Pump Pool Heaters contribute the second-most (23%) to overall MMBtu variance. The EEP program achieved 95% of the 2022 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

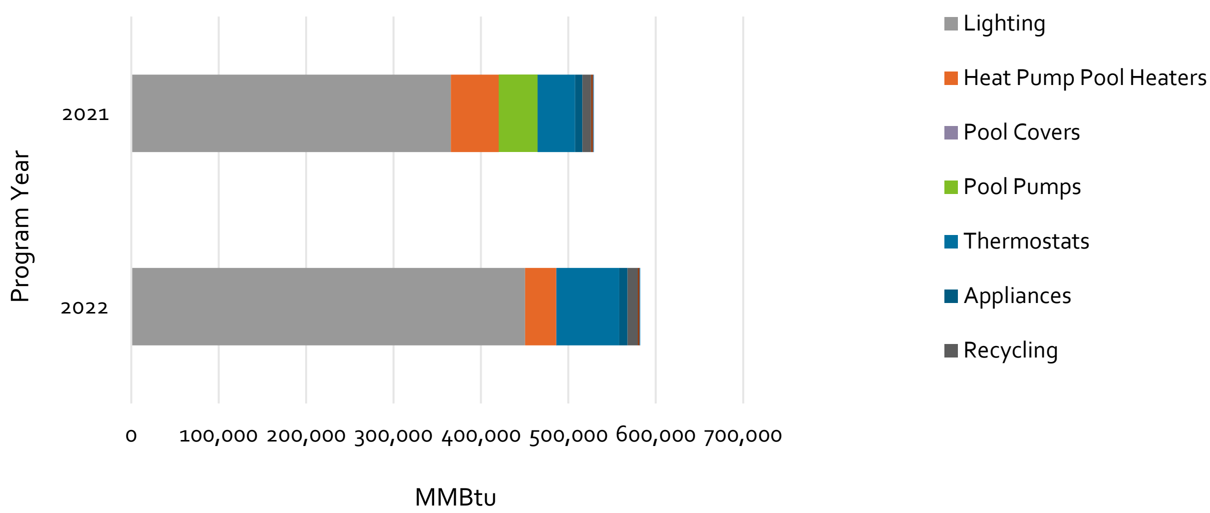


Overall, 18 out of 37 EEP measures have MMBtu realization rates of greater than 100%, and 19 measures have realization rates of less than 100%. The highest MMBtu realization rate is for Linear LED fixtures (244%). The lowest realization rate is for Tankless Water Heaters > 12 kW (20%). The biggest positive ex-post gross MMBtu variance is in Linear LEDs, which exceeds ex-ante values by 5,527 MMBtu. The biggest negative ex-post gross variance is in LED Specialty, where ex-post savings came up short of ex-ante by 19,834 MMBtu.

3.2.1.2 Comparison to 2021

EEP MMBtu savings increased by 10% from 2021 to 2022. The biggest increase is in thermostats (68%), as the number of incented units grew by 76%. This is slower than the growth between 2020 and 2021, when the number of rebated WiFi and Learning thermostats more than tripled. Figure 3-4 shows how EEP MMBtu savings changed from 2021 to 2022.

Figure 3-4: EEP MMBtu Impacts by Measure Category, 2021 and 2022 (ex-post gross)



3.2.1.3 Beneficial Electrification Impacts

Table 3-12 shows the breakdown of Energy Efficiency (EE) and Beneficial Electrification (BE) MMBtu and kWh for measures where a BE component exists. The clothes dryer, 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 3-12: 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 Resistance	0.07	0.14	0.22	22	202.47	(180.53)
EEP-310 EEP Clothes Dryer - Most Efficient	0.52	0.24	0.75	152	79.53	71.97
EEP-600 EEP Heat Pump Water Heater - Small	1.17	10.81	11.98	342	695.68	(353.35)
EEP-610 EEP Heat Pump Water Heater - Large	0.33	7.23	7.56	97	668.38	(571.47)
EEP-650 Tankless Water Heater <12 kW	0.09	5.51	5.59	25	2,343.84	(2,318.56)
EEP-655 Tankless Water Heater >12 kW	(0.72)	2.35	1.63	(211)	2,343.84	(2,554.35)
EEP-720 Heat Pump Pool Heater	7.79	21.65	29.44	2,283	1,009.12	1,273.43
EEP-1900 EEP Electric Lawn Mower <4aH	-	0.44	0.44	-	4.40	(4.40)
EEP-1905 EEP Electric Lawn Mower 4-5aH	-	0.44	0.44	-	4.40	(4.40)
EEP-1910 EEP Electric Lawn Mower >5aH	-	0.44	0.44	-	4.40	(4.40)
EEP-1950 Electric Lawn Mower	-	0.44	0.44	-	4.40	(4.40)

Measure	$MMBtu_{ee}$	$MMBtu_{be}$	$MMBtu_{total}$	kWh_{ee}	kWh_{be}	ΔkWh
EEP-1920 EEP Electric Weed Trimmer	-	0.11	0.11	-	1.61	(1.61)
EEP-1930 EEP Electric Leaf Blower	-	0.16	0.16	-	3.68	(3.68)

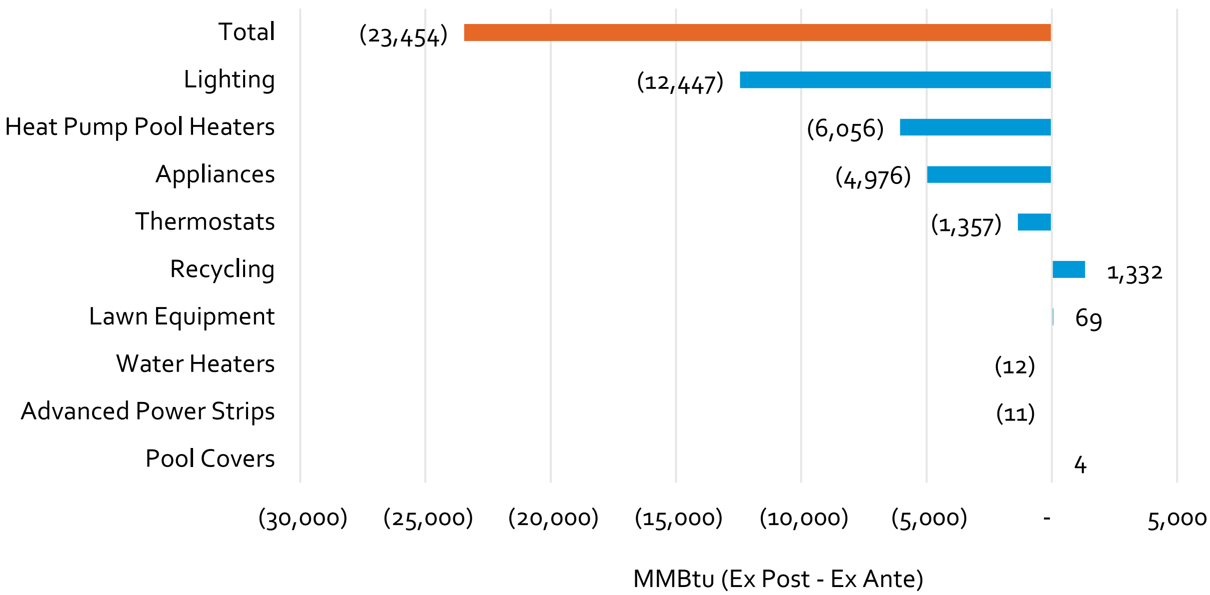
3.2.2 Key Drivers for Differences in Impacts

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:

- **2021 carryover planning assumptions.** Many of the EEP measures underwent significant revisions to planning assumptions between 2021 and 2022, and in some categories— for instance, heat pump pool heaters, tankless water heaters, and most efficient clothes washers— between 10-25% of the units reported in 2022 were 2021 carryover projects. For heat pump pool heaters in particular, 100% of the MMBtu variance can be attributed to the 124 carryover pool heaters (out of 1,216 total) that were reported with a 2021 per-unit MMBtu assumption nearly 3X the 2022 value.
- **Use of equipment characteristics from units installed during 2022 to inform and refine per-unit savings assumptions.** For example, by cross-referencing model numbers from the 1,836 clothes dryers rebated in PY2022, we were able to use ENERGY STAR specifications for energy factors and average capacity, which varied slightly from 2022 planning assumptions. In cases like this, the 2022 actuals are used to refine inputs to the PSEG LI TRM, in this case for 2024.
    - This type of adjustment was most impactful for lighting, where we not only adjusted equipment characteristics, but reclassified products based on their product type designation in the ENERGY STAR Qualified Products List. Almost 90% of the units reported as Linear LED were reclassified as downlights or other integrated LED fixtures.
- **Refinement to other algorithm inputs, such as a baseline efficiency standard or coincidence factor (CF), based on an improved source or revised assumption.** For instance, the lighting coincidence factor in the NYS TRM changed from 8% to 16%, contributing (along with wattage actuals) to an overall lighting kW realization rate of 186 percent.
- **Improvement of the calculation method/algorithm itself as compared to planning assumptions, often enabled by install data.** For example, for Air Purifiers, we updated the baseline efficiency standard (CFM/Watt) to reference the best available market data— Version 11 of the Illinois TRM— instead of the blanket assumption of 1.0 CFM/W for all size tiers used in the NYS TRM and previously applied to planning assumptions. This is another revision reflected in the 2024 TRM update, and is explained in more detail in the Appliances section below.
- **Updated climate assumptions.** Version 10 of the NYS TRM updated its assumptions of long-term weather conditions from 1981-2010 averages to 1991-2020 averages. This led to updated parameters for heating and cooling effective full-load hours (EFLH), inlet water temperature, and other weather-dependent parameters.

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 (Lighting, Thermostats, Heat Pump Pool Heaters, and Appliances) account for nearly all of the overall EEP MMBtu variance.

Figure 3-5 MMBtu Variance by Measure Category (Ex-Post Gross Minus Ex-Ante Gross)



3.2.2.1 Lighting

As shown in Table 3-13, the gross realization rates (ratio of Ex-Post Gross to Claimed savings) for lighting measures combined are 97% for MMBtu savings, 98% for kWh savings, and 186% for kW.

Table 3-13: EEP Lighting Realization Rates by Measure

Measure	N	MMBtu RR	kWh RR	kW RR
EEP-1200 LED Standard	1,819,386	101%	101%	198%
EEP-1250 LED Specialty	2,367,208	93%	93%	181%
EEP-2200 ES Linear Fixture	125,861	244%	250%	488%
LED-S In-storage LEDs	272,032	100%	100%	100%
Total (Weighted Average)	**4,584,487**	**97%**	**98%**	**186%**

Table 3-14 lists the key drivers of differences between ex-ante gross and ex-post gross impacts for EEP lighting measures.

In April 2022, the US Department of Energy released its final rulemaking regarding the Energy Independence and Security Act (EISA) backstop provision. This standard establishes a baseline efficiency requirement of 45 lumens per Watt for most categories of general service light bulbs (A-lamps, reflectors, globes, candelabra) and effectively prohibits the sale of non-LED lamps. DOE lays out a timeline in an Enforcement Policy Statement[7]. By July 2023, full enforcement will be applied to all retailers and distributors meaning that lighting will effectively be phased out of the EEP program by mid-2023.

Table 3-14: Key Contributors to Lighting RR Variance and Recommendations

Component	Summary of Contributing Factors	Recommendations
Standard and Specialty LEDs	▪ **Wattage:** Actual 2022 product wattages, baseline wattage, and the difference between the two varied slightly from planning assumptions. LED Standard lamp delta wattages were slightly lower, while LED Specialty exceeded planning assumptions by about 3W or 7 percent. ▪ **Product Classification:** Much of the product claimed as Linear LEDs were actually integrated specialty fixtures. The wattage differential between LED and baseline for these products was much larger than the assumed wattage reduction for Linear LEDs so this led to large realization rates for the Linear LED category. The difference in categories is a function of baseline efficacy. The Linear LED measure assumes a T8 efficacy, while integrated non-linear fixtures assume a 50:50 blend of halogen and incandescent efficacy (lumen/W). ▪ **Planning Assumptions:** The planning characterization in the 2022 PSEG Long Island TRM proved conservative compared to the actual product mix. The TRM assumed a single 4-ft. tube while the actual linear fixtures were often two or three lamp fixtures. ▪ **Interior Coincidence Factor:** Updated from 8% in the 2022 PSEG LI TRM to 16% to align with the NYS TRM as of v9.	▪ Communicate the wind down strategy clearly with retailers. Due to federal EISA standards, EEP lighting measures will largely vanish during summer 2023. This change has been known for over a year, but it will be important to clearly communicate the business rules around eligibility and timing of invoice submissions to ensure a smooth exit from the market. While the LED lighting opportunity is coming to an end, retailer relationships remain critical for other EEP measures. ▪ The distinction between the specialty LED and linear LED product category becomes incredibly important in 2023. Beginning August 1, 2023 specialty LEDs are no longer eligible to claim savings in the PSEG Long Island TRM due to changes in federal standards. Linear LEDs remain an eligible measure for all of 2023 and beyond. If PSEG Long misclassifies LED fixtures and rebates them after August 1st, this could have significant impacts on 2023 realization rates and cost-effectiveness.

3.2.2.2 Thermostats

[7] https://www.energy.gov/sites/default/files/2022-04/GSL_EnforcementPolicy_4_25_22.pdf

Smart Thermostats provided 12% of EEP ex-post gross MMBtu savings in 2022. Realization rates are 98% for MMBtu and 107% for kWh. Zero kW are claimed. Table 3-15 shows key contributors to Thermostat variance.

Table 3-15: Key Contributors to RR Variance and Recommendations: Thermostats

Component	Summary of Contributing Factors	Recommendations
Smart Thermostats	▪ **Effective Full Load Hours (EFLH):** Updated to align with the NYS TRM v10. ▪ **Output Heating Capacity:** Updated to align with the average capacity from 2022 Home Comfort installations.	▪ **Use the 14.0 SEER baseline for planning starting in 2024.** This was introduced in v10 of the NYS TRM and incorporated into the 2024 PSEG LI TRM.

3.2.2.3 Heat Pump Pool Heaters

Heat Pump Pool Heaters accounted for 6% of EEP ex-post gross MMBtu savings in 2022. HPPH realization rates are 86% for MMBtu and 46% for MWh (PY2020 was 38% and 8% respectively). Demand (kW) savings are assumed to be zero because we assume limited pool heating is required on the system peak day.

Realization rate variance for heat pump pool heaters can be fully explained by 124 projects (out of 1,216 total) reported using 2021 carryover planning assumptions, which were 267% (MMBtu) and 762% (kWh) of the values used for 2022.

Table 3-16 shows how per-unit HPPH resource impact assumptions changed between 2021 and 2022.

Table 3-16: HPPH Assumptions and Resource Savings by Source

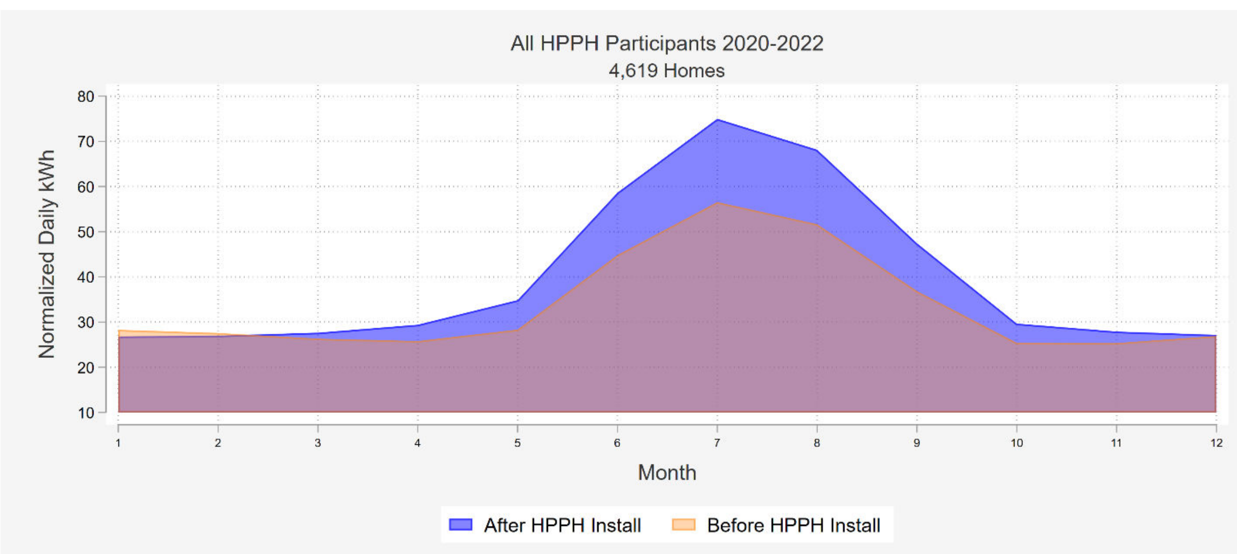
Resource	2021 Planning	2022 Planning
kW	0	0
kWh_{ee}	17,392	2,282
kWh_{be}	1,167	1,009
ΔkWh	16,225	1,273
$MMBtu_{ee}$	59	8
$MMBtu_{be}$	19	22
$MMBtu_{total}$	79	29

Table 3-17 Key Contributors to RR Variance and Recommendations: Heat Pump Pool Heaters

Component	Summary of Contributing Factors	Recommendations
Heat Pump Pool Heaters	▪ **2021 carryover planning assumptions:** Applied to 124 out of 1,216 projects.	▪ Connect with pool contractors to assess the viability of 31% electric resistance baseline. Process evaluation surveys indicated many HPPH are installed in new pools or pools that were not previously heated so the baseline fuel mix is primarily a question of market baseline on Long Island.

Heat pump pool heaters were a top EEP measure for the third year in a row. Prior evaluations have stabilized the measure characterization and minimized realization rate variance, but opportunities remain to improve heat pump pool heater savings estimates. While beneficial electrification measures target greenhouse gas emission reductions and societal benefits, they create real impacts on the electric grid. Figure 3-6 shows the results of pre-post consumption analysis of Long Island homes which received a HPPH rebate between 2020 and 2022. The result is generally consistent with the algorithmic measure characterization, with a net increase in kWh consumption concentrated during the summer months. Many of these homes also installed rebated pool pumps – and we cannot tell from the program tracking data whether the homes had a heated pool, or even a pool, prior to the HPPH install. However the average magnitude of the increased kWh consumption is approximately what our TRM algorithm assumes for the annual consumption of a HPPH.

Figure 3-6: Weather-Normalized Monthly Consumption Patterns Among HPPH Participants



The process evaluation survey following the 2021 program year asked customers about the circumstances when they were installing a new heat pump pool heater. Table 3-18 summarizes the response to the question "**Is the new heater for a new pool, a pre-existing pool that was not previously heated, or a previously heated pool?"** Among customers with previously heated pools, the desire to fuel-switch and better utilize renewable energy sources were common motivations.

Table 3-18: Heat Pump Pool Heater Survey Responses from PY2021 Evaluation Survey

Response	Count	Percent
New pool	23	43%
Pre-existing pool not previously heated	15	28%
Previously heated pool	15	28%

What would pool-owning customers have purchased in absence of a rebate? The 97% HPPH net-to-gross ratio from the same survey tells us that most customers would have purchased a fossil-fuel unit if the HPPH incentive was not available. The baseline assumption of fossil-fuel-fired (69%) vs. resistance electric heating (31%) units in the NYS TRM reference the2015 EIA Residential End Use Consumption Survey (RECS). Meanwhile, Long Island pool contractor websites typically promote only heat pump and gas/propane pool heaters. This fuel split warrants further research, and the evaluation team's hypothesis is that the fossil fuel baseline should be closer to 100%.

3.2.2.4 Appliances

Combined Appliance realization rates are 66% for MMBtu, 61% for kWh and 67% for kW. In 2022, dehumidifiers overtook air purifiers as the largest contributor to Appliance savings, as the number of dehumidifiers rebated grew by 263 percent.

Table 3-19: Appliance Category Savings by Appliance Type

Appliance Type	Ex Ante MMBtu	Ex Post	MMBtu RR	% of Appliance MMBtu
Air Purifier	7,515	3,273	44%	33%
Clothes Dryer	418	426	102%	4%
Clothes Washer	1,852	897	48%	9%
Dehumidifier	5,025	5,240	104%	53%
Total	**14,811**	**9,835**	**66%**	**100%**

Table 3-20: Key Contributors to RR Variance and Recommendations: Appliances

Component	Summary of Contributing Factors	Recommendations
Air Purifier	▪ **2021 Carryover:** 314 of the 2,636 Air Purifiers in 2022 used 2021 planning assumptions. ▪ **2022 Actuals:** Efficient unit specs (standby power, cfm/W, and CADR) were updated based on actual installs. ▪ **Assumed baseline efficiency:** Baseline efficiency standard (CFM/Watt) was updated to reference the best available market data—Version 11 of the Illinois TRM— instead of the blanket assumption of 1.0 CFM/W for all size tiers used previously.	▪ **Continue to revise planning assumptions on an ongoing basis to align with the PSEG LI TRM.** ▪ **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, make sure to only rebate units that comply with current ENERGY STAR standards.
Clothes Dryer	▪ **2021 Carryover:** 351 of the 1,485 Clothes Dryers in 2022 used 2021 planning assumptions. ▪ **2022 Actuals:** Energy factors and average load size were updated based on 2022 actuals.	
Clothes Washer	▪ **2021 Carryover:** 336 of the 1,857 units in 2022 used 2021 planning assumptions. ▪ **2022 Actuals:** Very slight revisions to washer equipment specs based on actual installs.	
Dehumidifier	▪ **2021 Carryover:** 111 of 13,260 dehumidifiers in 2022 used 2021 planning assumptions. ▪ **2022 Actuals:** Base and efficient energy factors and pints/day were informed by actual installs.	

3.2.2.5 Other EEP Measures

Table 3-21 presents a summary for other EEP program components where ex-post gross savings differed materially from ex-ante gross savings. Overall, these realization rates are closer to 100% than they were in 2021, due to planning refinements ahead of the 2022 program year.

Table 3-21 Key Contributors to RR Variance and Recommendations: Other EEP Measures

Component	Summary of Contributing Factors	Recommendations
Recycling	Combined realization rates for recycling measures (refrigerators and dehumidifiers) are 113% for MMBtu, 115% for kWh, and 124% for kW. Recycling measures combine for just under 2% of EEP savings in 2022.	
	▪ **Recycling realization rates are driven by the removal of the replacement equipment energy consumption from the energy usage differential.** Ex-Post savings account for the removed unit only, in accordance with the industry standard practice, the NYS TRM, and the Uniform Methods Project protocol. ▪ **Dehumidifier algorithm update:** this algorithm was updated starting with the 2023 TRM.	▪ **Revisit the refrigerator recycling application/data-gathering component.** Recycled equipment attributes including refrigerator volume and age are critical for calculating savings. Currently PSEG LI is getting more kWh per refrigerator than the NY IOUs, largely due to the prevalence of older units (20+ years).
Water Heaters	Combined Water Heater realization rates across Heat Pump and Instantaneous measures are 99% for MMBtu, 107% for kWh, and 1,971% for kW. Water heaters combine for 0.35% of EEP savings in 2022. Install data informed uniform energy factor (UEF) averages for baseline and efficient cases based on model numbers and ENERGY STAR standards for tank capacity.	
	▪ **2021 Carryover:** 24% of >12 kW Tankless Water Heaters used a 2021 planning assumption MMBtu value that was 25X the 2022 value. ▪ **Revised temp data:** Water main supply temp was updated to use MacArthur Airport 20-yr averages. ▪ **kW Algorithm update:** the large kW RR is explained by a reporting issue where 32 (out of 126) of the smaller capacity water heaters (EEP-600) claimed *positive* kW impacts, offsetting the reporting from the other units.	▪ **Revise planning assumptions** to align with the PSEG LI TRM. Double check the reported kW savings for EEP-600.
Pool Covers	Pool Cover realization rates are 104% for MMBtu and kWh. Demand savings are zero.	
	▪ **Updated weather data:** temperature inputs were updated using MacArthur Airport 30-year averages.	▪ **Revise planning assumptions** to align with the PSEG LI TRM.
Lawn Equipment	Lawn equipment realization rates are 113% for MMbtu and 3,831% for kWh. Demand savings are zero.	

Component	Summary of Contributing Factors	Recommendations
	▪ **Reporting oversight:** EFI reporting includes delta kWh reported as kWh EE.	▪ **Report kWh EE, kWh BE, and delta kWh independently for all measures in EFI and LMC KPI Scorecard data.** Make sure that Captures fields are accurate for these same kWh fields.
Advanced Power Strips	Advance Power Strip realization rates are 97% for MMBtu, kWh, and kW.	
	▪ **Revised deemed savings estimates:** kWh savings estimates were updated with v10 of the NYS TRM, affecting MMBtu and kWh accordingly.	

4 HOME COMFORT PROGRAM

PSEG Long Island's Home Comfort Residential Heating and Cooling Program provides residential customers rebates for the purchase and installation of efficient and clean 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 and multi split heat pumps (DMHP), and ground source heat pumps (GSHP). Each year the Home Comfort program has evolved to align more closely with New York State's aggressive greenhouse gas reduction goals. The Climate Leadership and Community Protection Act (CLCPA), a significant achievement of New York State, along with the Governor's commitment to electrify 2 million homes by 2030, has motivated state officials to reinforce and expand their efforts to install heat pumps across their territory. The Long Island Power Authority (LIPA) is leading the way in the implementation of New York State's policy goals. Around 40% of the households in LIPA's service territory still use fossil fuel for heating, and the Home Comfort program administered by PSEG Long Island specifically displaces fossil fuels for heating and decarbonizes buildings by promoting and installing heat pump technologies. In 2022, the Home Comfort Program installed 3,821 heat pumps, 3,756 air source heat pumps and 65 heat pump water heaters.

4.1 HOME COMFORT PROGRAM DESIGN AND PARTICIPATION

The following sections detail the program design, implementation strategies, and PY2022's participation and performance for the Home Comfort program.

4.1.1 Program Design and Implementation

The Home Comfort program offers customer rebates to both market and income eligible customers and contractor incentives for heating and cooling system upgrades. Weatherization measures are promoted with heat pump installations through the program in order to better provide holistic whole home solutions. Program participation is primarily driven through partnerships with installation contractors, also called Home Comfort Participating Contractors.

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[8] in 2022 required a Quality Installation Verification installation.

4.1.2 Program Participation and Performance

Based on verified ex-ante estimates, the Home Comfort program reached 91% of its energy savings goal in 2022. Table 4-2Table 4-1 presents 2022 Home Comfort programs verified ex-ante gross MMBtu savings compared to goal.

[8] A whole-house heat pump system is sized and installed to provide between 90% and 120% 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	129,673
Verified Ex-Ante Gross Savings	117,803
% of Goal	91%

Table 4-2 presents Home Comfort measure installations from 2020 through 2022. The installation of ductless and ducted ASHPs through the Home Comfort program continued to be a high contributor to the overall Home Comfort portfolio in 2022, consistent with PSEG Long Island MMBtu-based savings goals and New York State Clean Heat initiatives. The program started incentivizing heat pump water heater (HPWH) installations in 2021, and had a sharp rise in installations in 2022.

Table 4-2: Comparison of Home Comfort Program Measures Installed – 2020 to 2022

Measure	2020	2021	2022	Percent Difference 2021 to 2022
Split CAC	1,304	0	0	0%
Smart Thermostats	227	68	84	+24%
Ducted ASHPs	822	985	1,192	+21%
Ductless ASHPs	2,837	2,917	2,564	-12%
GSHP	132	146	201	+38%
HPWH	0	11	65	+491%
Total	**5,322**	**4,127**	**4,106**	**-1%**

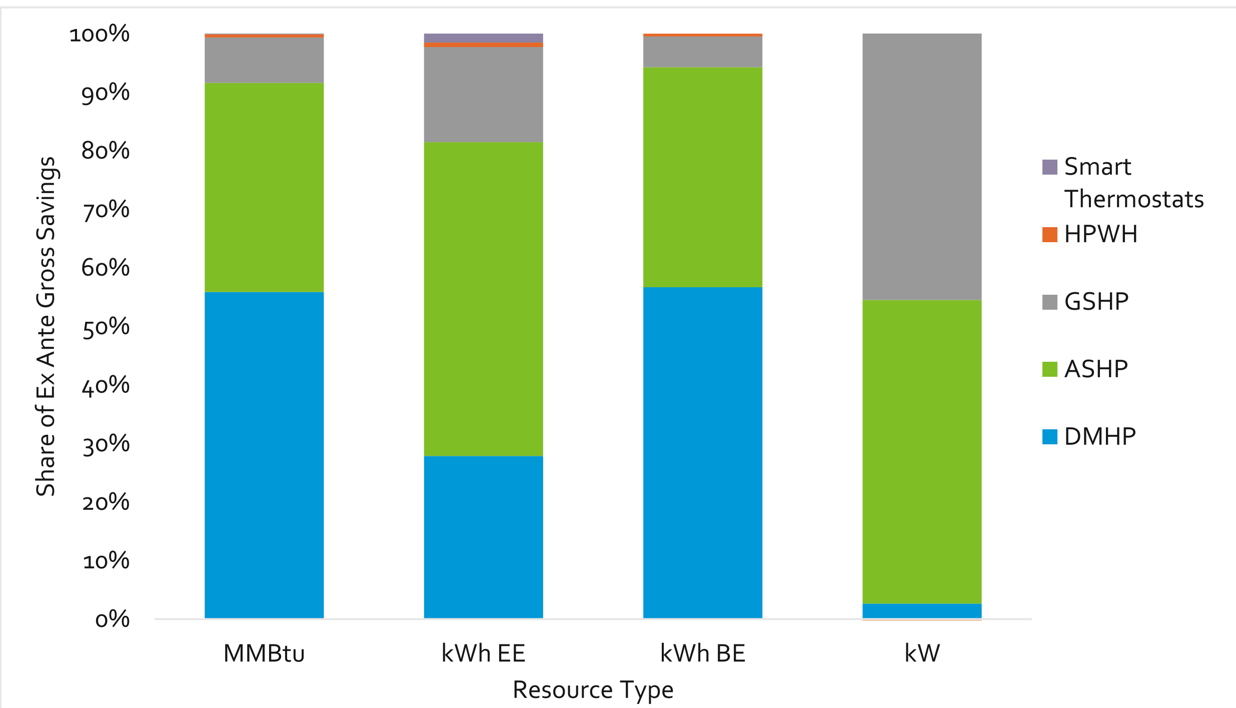
Figure 4-1 shows the distribution of ex-ante gross energy and demand savings across the Home Comfort program. Ducted and ductless mini/multi split heat pumps accounted for a combined 92% of the ex-ante gross MMBtu savings in 2022. These installations also resulted in beneficial electrification impacts for which a baseline heating load supplied by a fossil fuel source was displaced by the incented heat pump. When planning for the 2022 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
1	New Construction	N/A	N/A	Code Compliant HP	Code compliant fossil fuel furnace
2	Retrofit	AC or Heat Pump	Fossil Fuel	Preexisting AC or HP	Preexisting fossil fuel furnace/boiler
3	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 8-2 shows ex-post gross MMBtu impacts by measure category. Table 8-3 and Table 8-4 show the ex-post MWh and kW impacts, respectively. Realization rates are calculated by dividing ex-post gross savings values by ex-ante gross savings values. Overall, the Home Comfort program realized 97% of its ex-ante gross MMBtu energy savings claims, 121% of MWh impacts claims, and 86% 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 8.2.1.1.

Table 4-4: 2022 Home Comfort Program Ex-Post Gross MMBtu Impacts

Measure	N	Ex-Ante Gross Savings (Claimed) MMBtu	Ex-Post Gross Savings MMBtu	Realization Rate %
Ductless Mini- and Multi-split heat pumps	2,564	65,827	61,611	94%
Ducted ASHPs	1,192	42,101	42,841	102%
GSHP	201	9,142	9,546	104%
Smart Thermostats	84	118	144	122%
Heat Pump Water Heaters (HPWH)	65	629	642	102%
Totals[1]	**4,106**	**117,818**	**114,784**	**97%**

Note: Totals may not sum due to rounding.
[1] One project adjustment of -14 MMBtu is included in ex-ante and ex-post total gross savings and overall realization rates, but not shown as a separate line item in this table.

Table 4-5: 2022 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)
Ductless Mini- and Multi-split heat pumps	2,564	-5,166,015	-6,085,131	118%
Ducted ASHPs	1,192	-2,693,971	-3,260,034	121%
GSHP	201	-199,165	-393,799	198%
Smart Thermostats	84	31,656	42,203	133%
HPWH	65	-31,377	-29,729	95%
Totals[1]	**4,106**	**-8,058,872**	**-9,726,491**	**121%**

Note: Totals may not sum due to rounding.
[1] One project adjustment of 11.08 MWh is included in ex-ante and ex-post total gross savings and overall realization rates, but not shown as a separate line item in this table.
[2] MWh impacts include both energy efficiency (EE) and beneficial electrification (BE) components. MWh impacts are negative for heat pump and water heater measures 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: 2022 Home Comfort Program Ex-Post Gross kW Impacts

Measure	N	Ex-Ante Gross Savings (kW)	Ex-Post Gross Savings (kW)[1]	Realization Rate (kW)
Ductless Mini- and Multi-split heat pumps	2,564	12	-20	-160%
Ducted ASHPs	1,192	241	232	96%
GSHP	201	213	191	90%
Smart Thermostats	84	0	0	N/A
HPWH	65	-1	-4	323%
Totals	**4,106**	**465**	**400**	**86%**

Note: Totals may not sum due to rounding.
[1] kW impacts include both energy efficiency (EE) and beneficial electrification (BE) components. kW impacts are negative for ductless ASHPs since EERs of a majority of installed units were lower than code minimum EER from NYS TRM v9. kW impacts are negative for heat pump water heater measures due to the displacement of preexisting fossil fuel heating with electricity.

4.2.1.1 Beneficial Electrification Impacts

Table 8-5 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 ductless mini splits and ducted ASHPs, GSHP and HPWH 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)
Ductless Mini- and Multi-split heat pumps	368	6,453	-6,085	1,256	60,355	61,611
Ducted ASHPs	846	4,106	-3,260	2,886	39,955	42,841
GSHP	273	667	-394	861	8,685	9,546
HPWH	15	44	-30	50	592	642
Total	**1,502**	**11,270**	**-9,769**	**5,052**	**109,588**	**114,640**

We estimate that 2022 program-supported heat pump and water heater measures added 11,270 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 and water heaters that, when compared with code-compliant or pre-existing electric equipment, led to 1,502 MWh of energy savings. The overall electric consumption therefore increased by 9,769 MWh. However, accounting for the consumption of displaced fossil fuels in the $MMBtu_{be}$ column, Home Comfort heat pumps led to 109,588 MMBtu of annual energy savings.

4.2.2 Key Drivers for Differences in Impacts

We conducted a measure-level savings approach to calculate the total PY2022 ex-post gross impacts for ductless mini splits, ducted ASHPs, GSHP and Smart Thermostats. To estimate gross savings for

HPWH measures, we applied the per unit ex-post gross impacts from EEP to the Home Comfort 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. Similar to 2020 and 2021, there was an increased emphasis on electrification of fossil fuel systems in 2022, 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.

The New York State Joint Utilities made adjustments to the cooling and heating equivalent full load hours (EFLHs) in version 10 of the New York State TRM, which became effective on January 1, 2023. These adjustments were made based on a linear evaluation of the relative cooling and heating degree hours, with a base of 65°F, between the TMY3 data and the 30-year National Oceanic and Atmospheric Administration (NOAA) Climate Normals from 1991 to 2020. As a result of these updates to the NYS TRM, we updated the EFLHs in the 2024 version of the PSEG Long Island TRM to reflect these changes. Furthermore, these updated EFLHs have been utilized in the evaluation of Home Comfort measures in 2022. Overall, the cooling and heating degree hours for the New York City region dropped slightly based on the updates resulting in lower cooling and heating EFLHs compared to the prior versions of the New York State TRM.

Overall, the evaluation resulted in negative summer peak demand impacts for ductless mini- and multi-split heat pumps. We identified that this was primarily driven by lower installed EER ratings compared to the baseline EER specified in the 2022 New York State TRM and PSEG Long Island TRM for a majority of the cold-climate ductless mini- and multi-split heat pumps installed in 2022. A cold-climate heat pump is driven by an inverter, or variable speed drive compressor compared to a conventional heat pump which has a single speed compressor unit. The cold-climate units perform more efficiently at part loads compared to conventional heat pumps, while sacrificing on peak load efficiencies. Figure 4-2 shows the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) certificate of an actual heat pump that was incented by the Home Comfort program in 2022, where the EER rating of the unit is lower than baseline EER specified in the 2022 New York State TRM of 11.76.

Figure 4-2: Example AHRI Certificate of a Cold-Climate Ductless Mini-split Heat Pump Incented in 2022

AHRI CERTIFIED®
www.ahridirectory.org

Certificate of Product Ratings

AHRI Certified Reference Number : 205123810 Date : 10-27-2021 Model Status : Active

AHRI Type : HRCU-A-CB (Mini-Split System: Heat Pump with Outdoor Unit-Air-Source, Ducted)

Outdoor Unit Brand Name : [redacted]

Outdoor Unit Model Number : [redacted]

Indoor Type : Mini-Splits (Ducted)

Indoor Model Number(s) : [redacted]

Rated as follows in accordance with the latest edition of AHRI 210/240 with Addendum 1, Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment and subject to rating accuracy by AHRI-sponsored, independent, third party testing:

Cooling Capacity (95F) : 45500

EER (95F) : 8.20

SEER : 17.00

High Heat (47F) : 53000

Low Heat (17F) : 39500

HSPF : 10.20

Sold in? : USA, Canada

Below we describe the reasons for differences between gross ex-ante savings and ex-post savings for each measure. **In most cases, our recommendations apply to the 2024 program year.** Planning for the 2023 program year was finalized a year ago, and program delivery is almost half complete. These types of changes are often most efficient to implement at the beginning of a new program year. Most of our recommendations are also reflected in the recently completed 2024 PSEG Long Island TRM.

Table 4-8: Key Contributors to Home Comfort Realization Rates and Recommended Adjustments

Component	Summary of Contributing Factors	Recommendation
Ductless Mini splits and Ducted ASHPs	▪ The NOAA updated climate normals for 1991-2020 have been integrated into the 2023 New York State TRM, and replacing the 1981-2010 climate normals with the newer data resulted in lower estimates of cooling and heating EFLHs in the TRM. This, in turn, has led to lower energy realization rates as we used the updated EFLH values in energy savings estimations.	**Align the full load heating and cooling hours with 2024 PSEG-LI TRM.** The 2024 PSEG-LI TRM recommendations align with values provided for residential units in 2023 NYS TRM. Since the 2023 program is already underway, the 1981-2010 climate normals will be used to calculate EFLHs in the impact calculations. Therefore, we expect this driver to persist in 2023.

Component	Summary of Contributing Factors	Recommendation
	▪ Coincidence factors differed from 2024 PSEG-LI TRM recommendations for approximately 22% of the incented heat pumps resulting in lower realization rates for summer peak demand.	▪ None. Corrective action has been implemented by TRC beginning 2022. The lower coincidence factor values were found in older application workbooks from 2020 and 2021.
	▪ Ductless mini- and multi-split cold-climate heat pumps resulted in negative summer peak demand savings, due to lower installed EER ratings compared to the baseline EER specified in the 2022 New York State TRM and PSEG Long Island TRM. Minimum EER requirements are not specified by federal standards for the state of New York, nor are they mandated by state or city code for residential equipment. Therefore, the baseline EER specified by New York State TRM is established as: $EER = (1.12 \times SEER) - (0.02 \times SEER^2)$ ▪ We believe that the baseline EERs calculated by New York State TRM are high and not appropriate for cold-climate heat pump units	▪ Discuss with the Joint IOUs and DPS whether it is appropriate to have such a high EER baseline when there is no federal standard for EER (or EER2 beginning 1/1/2023) in NY.
Geothermal Heat Pumps	▪ The NOAA updated climate normals for 1991-2020 have been integrated into the 2023 New York State TRM, and replacing the 1981-2010 climate normals with the newer data resulted in lower estimates of cooling and heating EFLHs in the TRM. This, in turn, has led to lower energy realization rates as we used the updated EFLH values in energy savings estimations.	▪ **Align the full load heating and cooling hours with 2024 PSEG-LI TRM.** The 2024 PSEG-LI TRM recommendations align with values provided for residential units in 2023 NYS TRM. Since the 2023 program is already underway, the 1981-2010 climate normals will be used to calculate EFLHs in the impact calculations. Therefore, we expect this driver to persist in 2023.

Component	Summary of Contributing Factors	Recommendation
	▪ Coincidence factors differed from 2024 PSEG-LI TRM recommendations for approximately 24% of the incented GSHPs resulting in lower realization rates for summer peak demand.	▪ None. Corrective action has been implemented by TRC beginning 2022. The lower coincidence factor values were found in older application workbooks from 2020 and 2021.
Smart Thermostats	▪ The NOAA updated climate normals for 1991-2020 have been integrated into the 2023 New York State TRM, and replacing the 1981-2010 climate normals with the newer data resulted in lower estimates of cooling and heating EFLHs in the TRM. This, in turn, has led to lower energy realization rates as we used the updated EFLH values in energy savings estimations. ▪ We identified 2 instances where a home installed two smart thermostats connected to a single air-source heat pump (e.g. a zoned system). The claimed savings effectively double-count the heating and cooling capacity controlled in the home.	▪ **Align the full load heating and cooling hours with 2024 PSEG-LI TRM.** The 2024 PSEG-LI TRM recommendations align with values provided for residential units in 2023 NYS TRM. Since the 2023 program is already underway, the 1981-2010 climate normals will be used to calculate EFLHs in the impact calculations. Therefore, we expect this driver to persist in 2023. ▪ Create an indicator for zoned systems and configure all connected thermostat calculations to account for savings from a single air-source heat pump.

5 HOME PERFORMANCE PROGRAM

PSEG Long Island's Home Performance programs have three components: Home Energy Audits (HEAs), 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 overall goal of the Home Performance with Energy Star programs is to reduce the carbon footprint of customers who utilize electric, oil, or propane as a primary heating source. To achieve this goal, the Home Performance with Energy Star Program encourages customers to consider high efficiency options when updating their home's envelope or heating systems. Home Performance Direct Install targets customers with electric heating and includes an energy assessment and certain free efficiency upgrades. Home Energy Assessments (HEAs) are free energy audits offered to certain single-family homeowners. Participants in the HEA or HPDI programs may also be eligible for rebates through the HPwES program.

5.1 HOME PERFORMANCE PROGRAM DESIGN AND PARTICIPATION

5.1.1 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 Home Performance incentives and all projects must be pre-approved by the program team contractor. Program design in 2021 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 addition to the assessment, TRC mails a "Thank You" Kit that contains four 9-Watt LED bulbs to each HEA participant.

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. Additionally, customers with electric hot water might also qualify for DHW offerings under the HPDI program. Once the free direct install measures are completed (LEDs, duct sealing, low flow DHW devices, smart strips), the customer receives their free HEA and may be eligible for additional rebates through HPwES.

5.1.2 PROGRAM PARTICIPATION AND PERFORMANCE

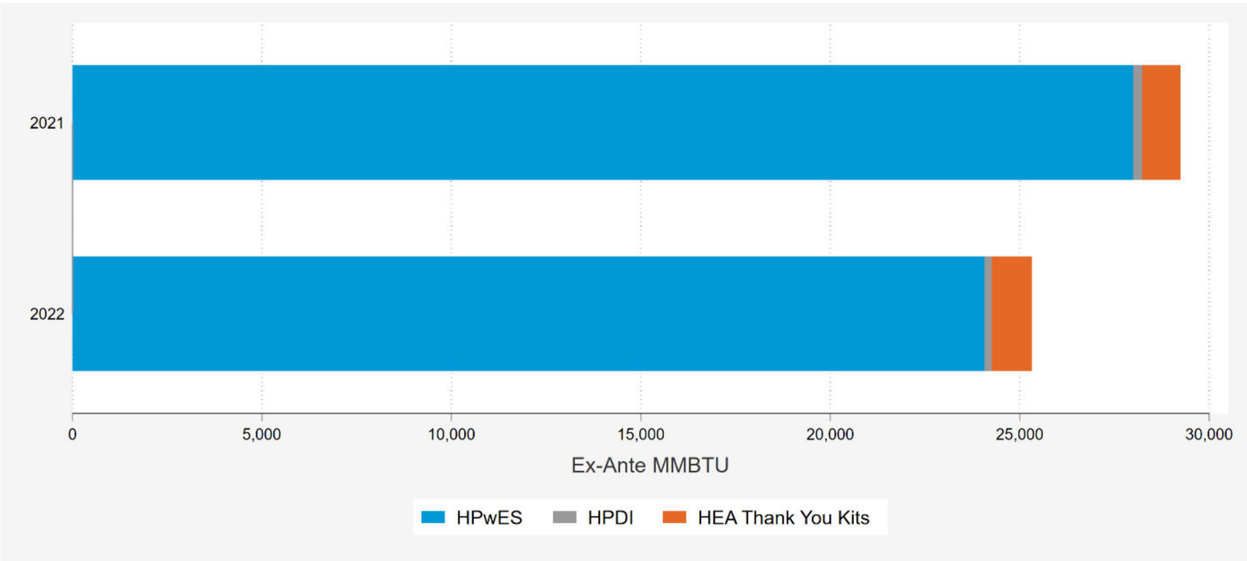
Based on verified ex-ante estimates, the Home Performance program reached 77.6%. of its energy savings goal in 2022. Table 5-1 presents 2022 Home Performance programs verified ex-ante gross MMBtu savings compared to goal.

Table 5-1: Home Performance Programs Verified Ex-Ante Gross MMBtu Savings versus Goals

Metric	MMBtu
Goal	31,917
Verified Ex-Ante Gross Savings	24,783
% of Goal	77.6%

Figure 5-1 shows the claimed MMBtu savings by Home Performance program component.

Figure 5-1: Ex-Ante MMBtu Savings by Program Component and Year



In 2022, the HPDI program completed projects with 69 customers, while the HPwES program treated 688 customers. A total of 8 customers participated in all three Home Performance programs. The HEA program delivered thank you kits to 2,702 customers. Of the HEA recipients, 528 customers also participated in the HPDI or HPwES programs. Overall, 3,305 unique customers were treated by the Home Performance programs in 2022. These counts include the 255 HPwES customers who installed beneficial electrification measures. Relative to 2021, the Home Performance program had far fewer HPwES participants, with 688 participants in 2022 compared to the 1,310 in 2021. The program claimed similar per customer savings in 2022, so the drop in overall HPwES participation likely contributed to the program falling short of its goals in 2022.

5.2 HOME PERFORMANCE PROGRAMS IMPACTS

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

5.2.1 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 2022. To calculate ex-post gross MWh savings due to energy efficiency (EE MWh savings), we applied the consumption analysis realization rate (116.6%) to the ex-ante gross EE savings. To calculate the ex-post gross MWh 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/MWh and MMBtu/MWh ratio respectively developed from the engineering analysis and applied to the ex-post gross energy savings.

The combined consumption and engineering analyses found that the programs generated approximately 34,665 MMBtu in ex-post gross energy savings in 2022, or approximately 136% of the ex-ante gross MMBtu savings. Table 5-2 shows ex-ante gross impacts, ex-post gross impacts, and the realization rate by resource (MMBtu, MWh, and kW) category.

Table 5-2: 2022 Home Performance Program Ex-Post Impacts

Resource	Ex-Ante Gross Savings	Ex-Post Gross Savings	Realization Rate
MMBtu	25,113	34,049	136%
MWh	735	1,040	142%
kW	580	684	118%

5.2.2 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.

5.2.2.1 Consumption Analysis – Approach

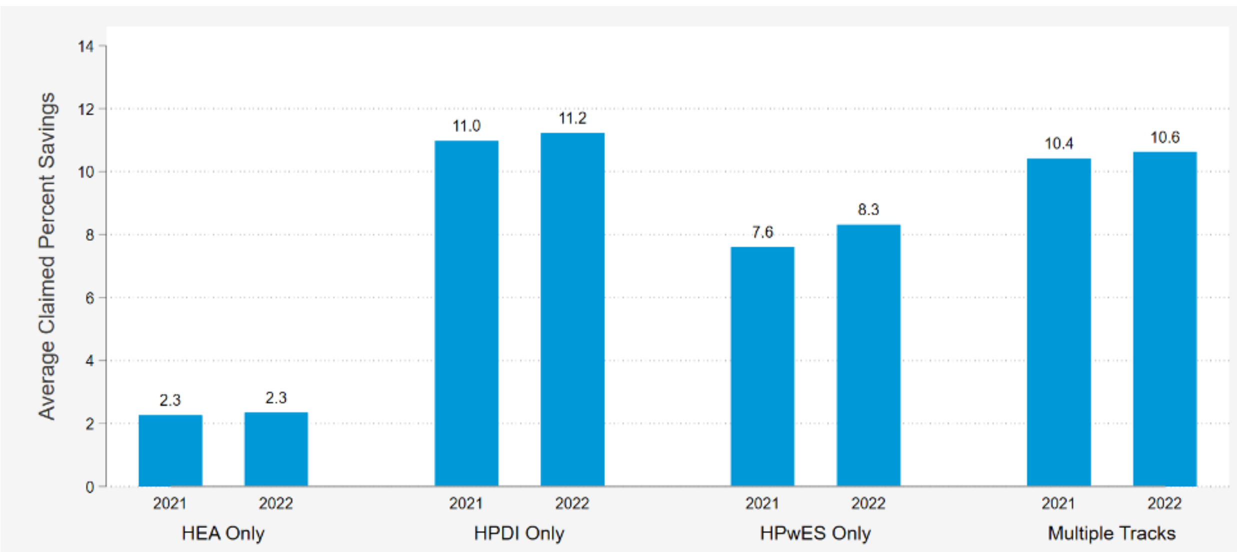
The Home Performance programs are well-suited to consumption analysis for several reasons.

- **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.
- **We have a large pool of homes to analyze**. With over 3,000 participating households per year in 2021 and 2022, the Home Performance billing analysis are stable across model specifications and robust to 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 capture in engineering equations.

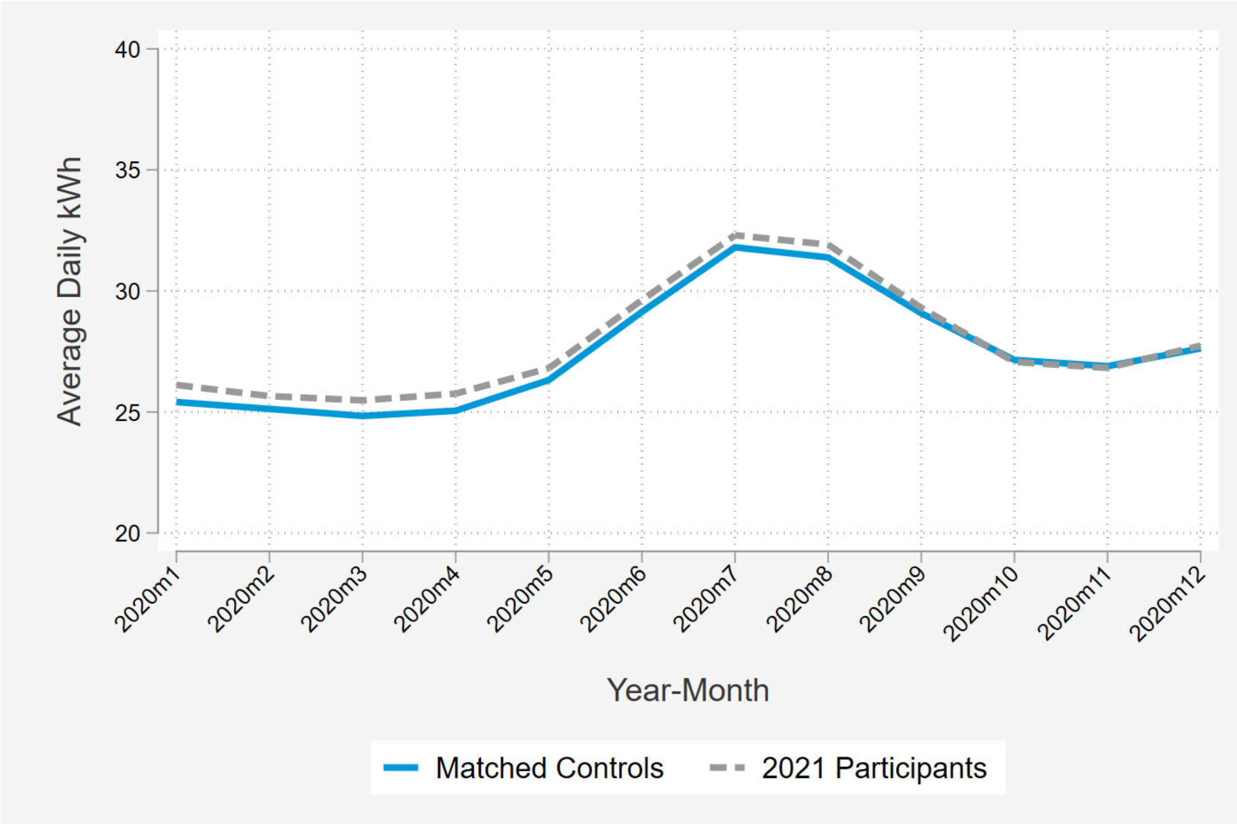
- **Savings are reasonably large on a percent basis**. On average, the ex-ante gross claimed kWh savings represented 4.6% of pre-retrofit annual billed electricity usage. As shown in Figure 5-2, ex-ante kWh savings as a percentage of weather-normalized pre-retrofit electric consumption varies by program component. Households that only participate in HEA show the smallest expected percent savings. HEA Only participants accounted for over two-thirds of all Home Performance participation in 2021 and 2022. This pulls down the average savings per household compared to the HPDI and HPwES components, which claim more kWh per participant, on average.

Figure 5-2: Average Ex-Ante kWh as a Percentage of Annual Household Consumption



Because the consumption analysis requires post-installation electricity usage data for approximately one year after treatment, we use 2021 participants as the treatment group and construct a matched comparison group from the 2022 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 of propensity score matching with replacement. Figure 5-3 compares the average monthly billing analysis of the 'treatment group' and matched control group during 2020, which is the year prior to the treated homes' participation. We employ a difference-in-differences regression model that nets out pre-period differences from the impact estimates.

Figure 5-3: Comparison of Pre-Treatment Consumption for Home Performance Consumption Analysis



The consumption analysis model uses calendarized 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 2022) 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 2021, the status the participant group in aggregate gradually shifts.

The consumption analysis model is a weather normalized 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 A, Subsection H. 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, HEA, HPDI, as well as homes that participated in multiple program components. During 2021 and 2022 the HPwES program included a mix of electric conservation and beneficial electrification measures. We use a two-step filtering process to exclude homes with beneficial electrification measures from the consumption analysis.

1. Use the "Current Savings BE MMBtu" field in the measure-level HPwES Captures data to flag households that installed a measure with non-zero beneficial electrification savings.

2. Cross-reference the Home Performance participants with Home Comfort participation data and flag households with non-zero beneficial electrification savings.

The consumption analysis method is indifferent to the direction of the savings. However, including a mix of homes with positive and negative electric savings pulls the average towards zero and makes it more difficult to precisely estimate the impacts. Since the 2021 beneficial electrification measures were mostly heat pumps, we elected to use consumption analysis for homes that did strictly energy efficiency and analyzed beneficial electrification measures using the same methods as the Home Comfort program.

A key assumption with this model framework is that our estimates of 2021 performance and realization rates are applicable to 2022 measures and projects. The measure mix and ex-ante savings assumptions were generally consistent across years so we are comfortable applying the realization rate determined using 2021 participants to 2022.

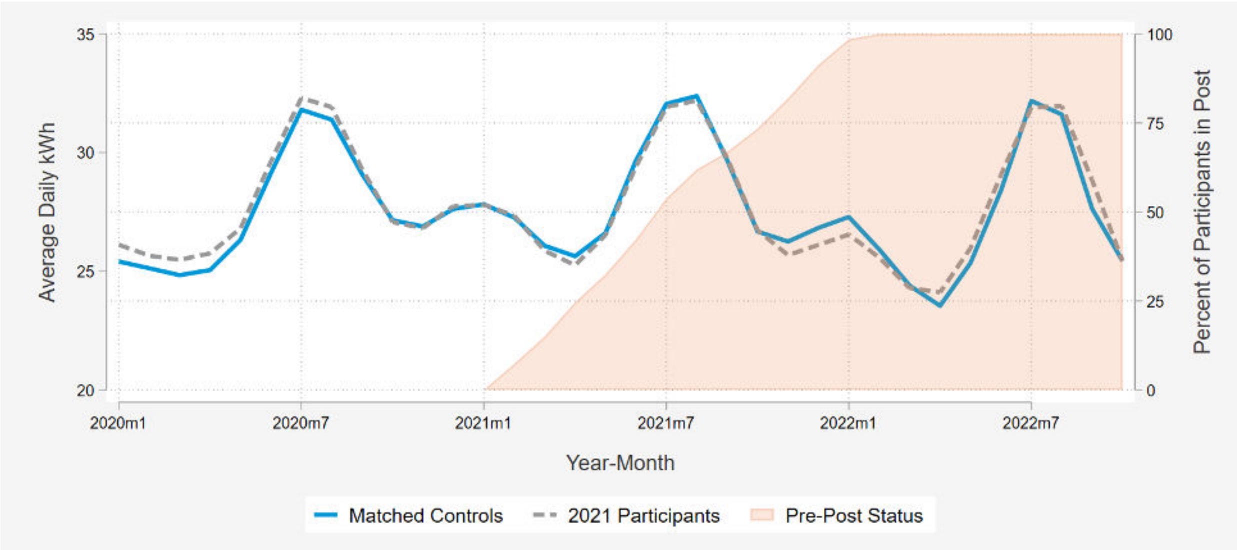
5.2.2.2 Consumption Analysis – Results

In Table 5-3, we use the results of the combined Home Performance programs model to estimate average savings for 2021 participants and compare the estimated impact to the ex-ante gross kWh savings claimed by the implementer. Across the 2,879 Long Island homes included in the regression model, the average annualized savings was 434.2 kWh. This equals 116.6% of the average ex-ante gross kWh savings claimed for the same homes. We applied the 116.6% realization rate to the ex-ante gross kWh savings claim of 2022 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 5-4 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 departure 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 5-3: Home Performance Consumption Analysis Results (n=2,879)

Parameter	Estimate	Lower Bound of 95% CI	Upper Bound of 95% CI
Daily Treatment Effect (kWh Saved)	1.19	0.78	1.60
Daily Treatment Effect (% Savings)	4.3%	2.8%	5.8%
Annual Savings	434.2	284.8	583.7
Ex-Ante Gross kWh	372.5		
Realization Rate	116.6%	76.5%	156.7%

Figure 5-4: 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 deliver 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 ratio to the energy savings estimates derived from the consumption analysis to generate ex-post demand savings.

5.2.2.3 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 2022 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 5-4, Table 5-5, and Table 5-6 show the engineering analysis gross savings for each HPDI measure category in MMBtu, MWh, and kW, respectively.

Table 5-4: 2021 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	587	73.3	55.6	75.8%
Domestic Hot Water	66	30.8	32.2	104.3%
Duct Sealing	28	53.5	55.1	103.1%
Advanced Power Strips	59	32.0	32.0	100.0%
HPDI Subtotal	**740**	**190**	**174.8**	**92.2%**

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

Table 5-5: 2021 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	587	21.5	16.3	75.7%
Domestic Hot Water	66	9.0	9.4	104.3%
Duct Sealing	28	15.7	16.2	103.1%
Advanced Power Strips	59	9.4	9.4	100.0%
HPDI Subtotal	**740**	**56**	**51.2**	**92.2%**

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

Table 5-6: 2021 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	587	2.2	3.24	147.2%
Domestic Hot Water	66	46.1	23.13	50.1%
Duct Sealing	28	6.1	6.22	101.8%
Advanced Power Strips	59	1.2	0.93	79.0%
HPDI Subtotal	**740**	**56**	**33.52**	**60.3%**

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

5.2.2.4 Reasons for Differences in Engineering Impacts: HPDI

Baseline wattage discrepancies were found for several lamp types and are summarized in Table 5-7. Ex-ante common and specialty lamp baseline watts were 63 watts and 57 watts respectively. Ex-post baselines exhibited greater variation among lamp types. Negative wattage variances generally corresponded with realization rates less than 100% for interior lamps.

Table 5-7: HPDI Lighting, Baseline Wattage Comparison, Ex-Post vs. Ex-Ante

	Common 10 Watt "A"Bulb	Common 5 watt Globe	Specialty 4.7 Watt Candelabra B10	Specialty 9 Watt Reflector R-30	Specialty 9 Watt Reflector R-40	-- 0.3 Watt Night Light
Ex-Post	43	29	25	60	60	5.7
Ex-Ante	63	63	57	57	57	5.5
Baseline Wattage Discrepancy	(20)	(34)	(32)	3	3	0.2
Realization Rate	61.2%	44.6%	43.0%	109.8%	105.6%	95.4%

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 5-8 below. In most cases, our recommendations apply to the 2024 program year. Planning for the 2023 program year was finalized a year ago, and program delivery is almost half complete. These types of changes are often most efficient to implement at the beginning of a new program year. Most of our recommendations are also reflected in the recently completed 2024 PSEG Long Island TRM.

Table 5-8: Key Contributors to HPDI Engineering Analysis MMBtu RR and Proposed Solutions

Component	Summary of Savings Difference	Proposed Solution
Lighting	▪ The 75.7% MWh realization rate was largely the result of discrepancies between ex-ante and ex-post and baseline lamp wattage assumptions.	Align savings assumptions with PSEG-LI TRM.

5.2.2.5 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 5-9,

Table 5-10, and

Table 5-11 compare gross engineering analysis savings to ex-ante gross savings by HPwES measure category for MMBtu, kWh, and kW savings, respectively.

Table 5-9: 2022 HPwES Engineering Analysis Gross MMBtu Impacts

Category	N[1]	Ex-Ante Gross Savings[2] (MMBtu)	Engineering Analysis Ex-Post Gross Savings (MMBtu)	Engineering Analysis Realization Rate (MMBtu)
Duct Sealing	472	2,810	2,585	92%
Air Sealing	660	4,036	3,033	75%
Envelope (Attic, wall, basement, and garage insulation)	960	5,206	10,668	205%
Ducted Air-source Heat Pumps	161	7,088	6,823	96%
Ductless Mini-splits	143	3,807	2,406	63%
HVAC (Non heat pumps - thermostats)	129	55	55	100%
DHW	90	866	826	95%
Measure-Level Total	**2,615**	**23,867**	**26,397**	**111%**

[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 5-10: 2022 HPwES Engineering Analysis Gross MWh Impacts

Category	N[1]	Ex-Ante Gross Savings[2] (MWh)	Engineering Analysis Ex-Post Gross Savings (MWh)[3]	Engineering Analysis Realization Rate (%)
Duct Sealing	472	410	343	84%
Air Sealing	660	302	148	49%
Envelope (Attic, wall, basement, and garage insulation)	960	255	258	101%
Ducted Air-source Heat Pumps	161	(391)	(448)	114%
Ductless Mini-splits	143	(337)	(219)	65%
HVAC (Non heat pumps - thermostats)	129	16	16	100%
DHW	90	(43)	(49)	113%
Measure-Level Total	**2,615**	**212**	**49**	**23%[4]**

[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] The Realization Rate is the ratio of Ex-Post/Ex-Ante Savings: 49/212 = 23%

Table 5-11: 2021 HPwES Engineering Analysis Gross kW Impacts

Category	N[1]	Ex-Ante Gross Savings[2] (kW)	Engineering Analysis Ex-Post Gross Savings (kW)	Engineering Analysis Realization Rate (%)
Duct Sealing	472	272	272	100%
Air Sealing	660	56	37	67%
Envelope (Attic, wall, basement, and garage insulation)	960	65	63	97%
Ducted Air-source Heat Pumps	161	75	28	38%
Ductless Mini-splits	143	22	8	36%
HVAC (Non heat pumps - thermostats)	129	0	0	100%
DHW	90	(1)	(1)	73%
Measure-Level Total	**2,615**	**490**	**409**	**83%**

[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.

5.2.2.6 Reasons for Differences in Engineering Impacts: HPwES

Table 5-12 identifies the key contributors to the overall engineering analysis gross MMBtu realization rate of 111%. In most cases, our recommendations apply to the 2024 program year. Planning for the 2023 program year was finalized a year ago, and program delivery is almost half complete. These types of changes are often most efficient to implement at the beginning of a new program year. Most of our recommendations are also reflected in the recently completed 2024 PSEG Long Island TRM.

Table 5-12: Key Contributors to HPwES Engineering Analysis and Proposed Rectification Steps

Component	Summary of Savings Difference	Proposed Solution
Envelope (insulation)	▪ Consistently higher ex-post evaluated savings from the 2024 PSEG-LI TRM savings approach, especially for fossil fuel heating systems and basement ceiling and rim joist applications. The primary difference is a change from the 2021/2022 PSEG-LI TRM for ex-ante analysis to the 2024 PSEG-LI TRM for the ex-post values. Specifically, ex-ante analysis applies adjusted existing and installed insulation R-values that are more conservative than found on-site and applied in the ex-post results	▪ Both the ex-ante and ex-post savings are accurate to the TRM methodologies they applied. Take notice that per unit insulation savings should increase as HPwES begins to align with updated methodologies in the 2023/2024 PSEG-LI TRMs
Air Sealing	▪ Measures in homes with Electric Heat Pumps can be misclassified in the analysis workbook as AC with Electric Heat. This issue overstates electric energy and summer demand savings and results in lower realization rates. This issue was resolved in the 2022 v2 program workbook	▪ Review incoming air sealing measures that apply a Master Internal Workbook earlier than 2022 v2 and revise savings for measures tied to electric heat pumps
HVAC System Properties	▪ Across the projects reviewed we found one HVAC system that was inputted as an Electric Heat Pump with an efficiency of 95%, and the HSPF input was left blank. This data entry oversight generated gas heating savings related to a 95% efficient fossil fuel system and inconsistent with the actual system in use	▪ Given that HVAC system type and efficiency are fundamental to the savings analysis, ensure that values inputted into the analysis tool accurately reflect the home where the energy efficiency improvements are completed

5.2.2.7 Engineering Analysis: HEA Thank You Kits

For each HEA completed by PSEG Long Island in 2022, the program mailed a Thank You Kit to the customer; each kit contained four 9-Watt LED bulbs. Table 5-13, Table 5-14, and Table 5-15 compare ex-post savings (via engineering analysis) with ex-ante gross MMBtu, MWh, and kW savings, respectively, for the Thank You Kits measure.

Table 5-13: 2022 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	2,921	1,056	1,052	100%

Table 5-14: 2022 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	2,921	467	469	100%

Table 5-15: 2022 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	2,921	35	68	195%

To estimate ex-ante gross savings, the TRC applied the planning assumptions for EEP standard LED bulbs using a stipulated mix of bulb types. For the ex-post evaluation, we utilize federal minimum efficiency values, by lamp type, for baseline wattages. Evaluated MMBtu and MWh savings aligned with the ex-ante assumptions resulting in a 100% realization rate. For demand impacts the program assumed the 2022 planning tool kW savings that was approximately half of the ex-post evaluated result leading to a kW realization rate of 195%.

5.2.2.8 Engineering to Billing Calibration Calculations

The 2022 consumption analysis resulted in higher ex-post gross kWh savings compared to ex-ante gross kWh savings, as shown by the 116.6% 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 76.5% to 156.7%. The wide margin of error is expected given the average savings per household. As shown in Figure 5-2, savings from homes that only receive a Home Energy Assessment are modest compared to HPDI and HPwES. Since approximately two-thirds of participants only participated in HEA, this necessarily lowers the average savings per participant.

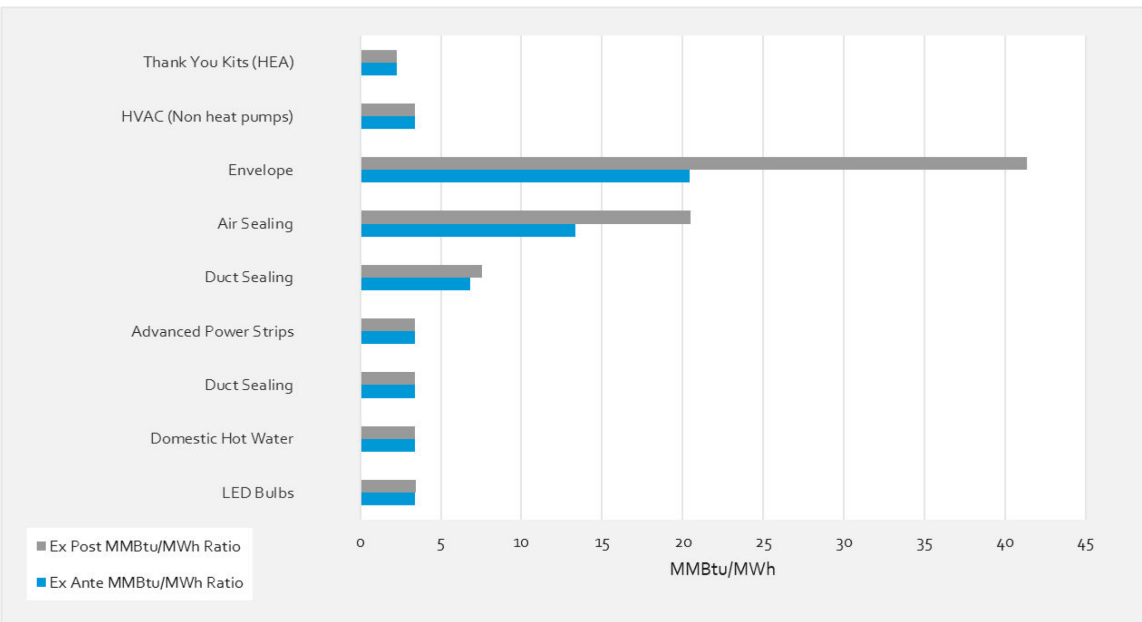
The MMBtu and peak demand savings for Home Performance are estimated via a calibration of the electric consumption analysis and engineering calculations. For both MMBtu and kW, the ex-post gross savings was larger than the ex-ante gross savings. This result is a function of the MMBtu/kWh and kW/kWh ratios in the engineering analysis.

A direct conversion from MWh to MMBtu is 3.412 MMBtu/MWh.

- Measures that save only electricity will therefore have a ratio of MMBtu savings to MWh savings of 3.412. In that case, we would expect measures with relatively equal kWh and MMBtu impact estimates (or similar realization rates) to have a ratio close to 3.412.
- Measures that save fossil fuel was well was electricity with have a ratio greater than 3.412 MMBtu/MWh.
- Measures like LED lighting that save electricity, but also cause increased fossil fuel consumption due to HVAC interactive effects can have a ratio less than 3.412.

PSEG Long Island has a cold weather climate, and many of the HPwES measures primarily reduce energy consumption through a reduction in space heating. The heating fuel mix in Long Island is primarily fossil fuel, so insulating measures tend to offer more fossil fuel savings than electric savings. Figure 5-5 shows that measures like home envelope and air sealing have a much larger fossil fuel impact versus electric. For envelope measures the ratio of MMBtu to MWh was much higher in our ex-post engineering calculations than the ex-ante savings claims.

Figure 5-5: Ex-Ante Gross and Ex-Post Gross MMBtu/MWh Ratios



The billing analysis realization rate for the Home Performance program is 116.6%. Because of the variability in MMBtu per MWh across measure categories and between our engineering calculations and ex-ante assumptions, the Evaluation Team chose to calibrate MMBtu and kW savings to the billing analysis using the aggregate ratios across all measures in the engineering calculations. Table 5-16 shows the steps for MMBtu savings. The aggregate ratio of kW to MWh from our engineering calculations was 0.37.

Table 5-16: Home Performance MMBtu Billing to Engineering Calibration Calculation

Calibration Component	Calculation	Value
Billing Analysis MWh Ex-Post Impacts	MWh Ex-Ante Gross * Billing Realization Rate	1,286 MWh
MMBtu/MWh Ratio	$\frac{\text{Engineering MMBtu Ex Post}}{\text{Engineering MWh Ex Post}}$	13.67 MMBtu/MWh
Calibrated MMBtu Impacts	Billing Analysis MWh Ex-Post Impacts * MMBtu/MWh Ratio	23,994 MMBtu
Add Beneficial Electrification Impacts	Calibrated MMBtu Impacts + HPwES Heat Pumps and HPWH	34,050 MMBtu

5.2.2.9 Beneficial Electrification Impacts

In 2022, the HPwES program completed 365[9] beneficial electrification (BE) projects that resulted in an increase in electric consumption. These measures involved 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. While BE projects increase overall electric consumption, 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 5-17. The energy savings of the displaced fuel after electrification, and positive and negative impacts associated with energy efficiency measures, are expressed in MMBtu.

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

Table 5-17: Separation of EE and BE Impacts for HP Beneficial Electrification Measures

Category	Ex-Post Gross kWh_{ee}	Ex-Post Gross kWh_{be}	Ex-Post Gross ΔkWh (EE - BE)	Ex-Post Gross $MMBtu_{ee}$	Ex-Post Gross $MMBtu_{be}$	Ex-Post Gross MMBtu Total (EE + BE)
Ducted Air-source Heat Pumps	183,379	631,154	-447,775	664	6,159	6,823
Ductless Mini-splits	6,483	225,873	-219,390	22	2,384	2,406
DHW	20,966	69,689	-48,723	72	755	826
Total	**210,828**	**926,716**	**-715,888**	**758**	**9,298**	**10,055**

5.3 CONCLUSIONS AND RECOMMENDATIONS

Our key findings and recommendations based on this evaluation are shown in Table 5-18. In most cases, our recommendations apply to the 2024 program year. Planning for the 2023 program year was finalized a year ago, and program delivery is almost half complete. These types of changes are often most efficient to implement at the beginning of a new program year. Most of our recommendations are also reflected in the recently completed 2024 PSEG Long Island TRM.

Table 5-18: Home Performance Findings and Recommendations

Finding	Recommendation
▪ Many of the Home Performance savings methodologies differ from the recommended algorithms, inputs, and assumptions developed in the PSEG-LI TRM and Planning Documents. Realization rate inconsistencies in the engineering analysis can be minimized if the program savings are based on the same tools developed by the utility.	▪ Review the Home Performance analysis workbooks and align the savings methodologies with data provided in the PSEG-LI TRM and planning documents.
▪ Ex-ante air sealing analysis for many projects is based on a ΔCFM_{50} assumption of square footage divided by two, as provided by the NYS TRM.	▪ Move away from the air sealing assumptions and emphasize the importance of pre- and post-improvement blower door tests to develop site specific air sealing results for these projects. This will help reduce variance across sites and for the measure overall.
▪ The Home Performance program focuses on fossil fuel savings, however PSEG Long Island does not sell gas or oil. This leads to limitations in the billing analysis, since it currently relies on electric billing data. As a result, the consumption analysis only evaluates the impact of EE measures through customer billing data.	▪ Incorporating billing data from National Grid for homes that have natural gas heating would allow the billing analysis to evaluate fossil fuel savings through the Home Performance program. ▪ Explore the possibility of sourcing billing data from National Grid for homes that use natural gas for heating.
▪ Ex-post savings for basement insulation applications (basement ceiling and rim joist) resulted in high realization rates due to the application of different PSEG LI TRMs for ex-ante (2021/2022 TRM) and ex-post (2024 TRM) results	▪ Take notice that per unit insulation savings should increase as HPwES begins to align updated methodologies in the 2023/2024 PSEG-LI TRMs.

6 RESIDENTIAL ENERGY AFFORDABILITY PARTNERSHIP PROGRAM

6.1 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. Eligible customers will have an income of up to 80% of the area median income.

6.1.1 PROGRAM DESIGN AND IMPLEMENTATION

The REAP program includes a free home energy audit and free installation of energy-saving measures. In 2022, 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, smart thermostats, and room air purifiers. 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.

REAP program delivery transitioned back to in-person audits from remote audits in 2022 as the COVID-19 pandemic subsided on Long Island. While the measures offered were largely the same during periods of remote versus in-person audits, the installation mechanism was necessarily different and likely played some role in the evaluated impacts of the consumption analysis.

6.1.2 PROGRAM PARTICIPATION AND PERFORMANCE

Based on verified ex-ante estimates, the REAP program reached 100.2% of its energy savings goal in 2022. Table 6-1 presents verified ex-ante gross MMBtu savings compared to goals for the 2022 REAP program.

Table 6-1. 2022 REAP Program Verified Ex-ante Gross Program Performance against Goals

Metric	MMBtu
Goal	5,953
Verified Ex-ante Gross Savings	5,967
% of Goal	100.2%

Table 6-2 shows the distribution of savings by program component. Lighting continues to account for the largest share of gross REAP program savings, accounting for 44% of ex-ante gross MMBtu savings, 63.0% of ex-ante gross MWh savings, and 70.7% of ex-ante gross kW savings in 2022.

Table 6-2. 2022 REAP Program Component Percent of Total Ex-Ante Gross Savings

Program Component	Ex-Ante Utility Gross Savings		
	MMBtu (%)	MWh (%)	kW (%)
REAP Lighting	44.0%	63.0%	70.7%
Energy Star Refrigerators	1.9%	4.1%	2.7%
Power Strips	16.7%	13.6%	7.3%
Aerators	1.1%	0.1%	0.0%
DHW Pipe Insulation	0.9%	0.1%	0.1%
DHW Temperature Turndown	0.1%	0.0%	0.0%
Energy Star Dehumidifier	1.4%	1.2%	1.1%
Low Flow Showerhead	4.5%	0.4%	0.0%
Room Air Conditioners	2.4%	2.0%	8.8%
Thermostatic Valve	1.2%	0.1%	0.0%
Room Air Purifier	18.4%	14.9%	9.3%
Smart Thermostat	7.3%	0.6%	0.0%
Total	**100%**	**100%**	**100%**

The REAP program treated 1,895 unique participants in 2022 compared to 1,548 customers in 2021 for an increase of 22%. Table 6-3 shows that nearly all REAP participants received Night Lights, LED lighting, and Tier 2 Power Strips.

Table 6-3. Percent of REAP Program Participants Receiving each Measure Category

Category	Percent Receiving
Power Strips	97.8%
Night Lights	97.2%
Lighting	88.2%
Room AC	28.1%
Air Purifiers	15.7%
Dehumidifiers	15.1%
Refrigerators	11.5%
DHW - Aerators	8.1%
DHW - Low Flow Showerheads	7.9%
DHW - Thermostatic Shower Valve	7.3%
DHW - Pipe Insulation	3.2%
DHW - Temp Turndown	2.2%

6.2 REAP PROGRAM IMPACTS

6.2.1 OVERVIEW OF IMPACTS BY RESOURCE

As in previous years, we used both engineering and consumption analysis to estimate savings for the REAP program in 2022. Ex-post gross MMBtu savings and ex-post gross kW savings rely on both the engineering analysis and the consumption analysis, while ex-post gross MWh savings rely exclusively on the consumption analysis. To calculate ex-post gross MWh savings due to energy efficiency (EE MWh savings), we applied the consumption analysis realization rate (31.9%) to the ex-ante gross EE savings. To calculate ex-post gross summer peak demand and MMBtu savings, we used a kW/MWh and MMBtu/MWh ratio respectively developed from the engineering analysis and applied to the ex-post gross MWh savings.

Table 6-4 below shows that the program achieved ex-post gross MMBtu savings of 1,815 MMBtu, ex-post gross MWh savings of 596 MWh, and ex-post gross kW savings of 90 kW. Individually, the engineering calculations resulted in an MMBtu realization rate of 80.2%, and the consumption analysis had an MMBtu realization rate of 31.9%. Sections 6.2.2.2 and 6.2.2.3 provide the distinct results from the consumption analysis and engineering analysis, respectively.

Table 6-4. 2022 REAP Program Impacts

Resource	Ex-Ante Gross Savings	Ex-Post Gross Savings	Realization Rate
MMBtu	6,008	2,108	35%
MWh	2,168	692	32%
kW	400	105	26%

There are a few possible explanations for the low billing analysis realization rate. One contributing factor could be the inherent decoupling of deemed savings from actual customer consumption. There are customers with savings attributed to their home that represent almost half of their annual electric consumption. Additionally, some measures such as air purifiers and dehumidifiers have the potential to add load if they are installed as new technology in the home, and there is not an existing air purifier or dehumidifier replaced. Finally, because of COVID19, program delivery largely followed a remote alternative to in-home visits and measure installs in 2021 – which are the homes analyzed by the billing analysis. Auditors have less control over the installation of measures in a remote audit and it's possible that the installation rate or installation quality suffered under a remote delivery model. An exploration of the drivers behind the billing analysis realization rate is further detailed in section 6.2.3.2.

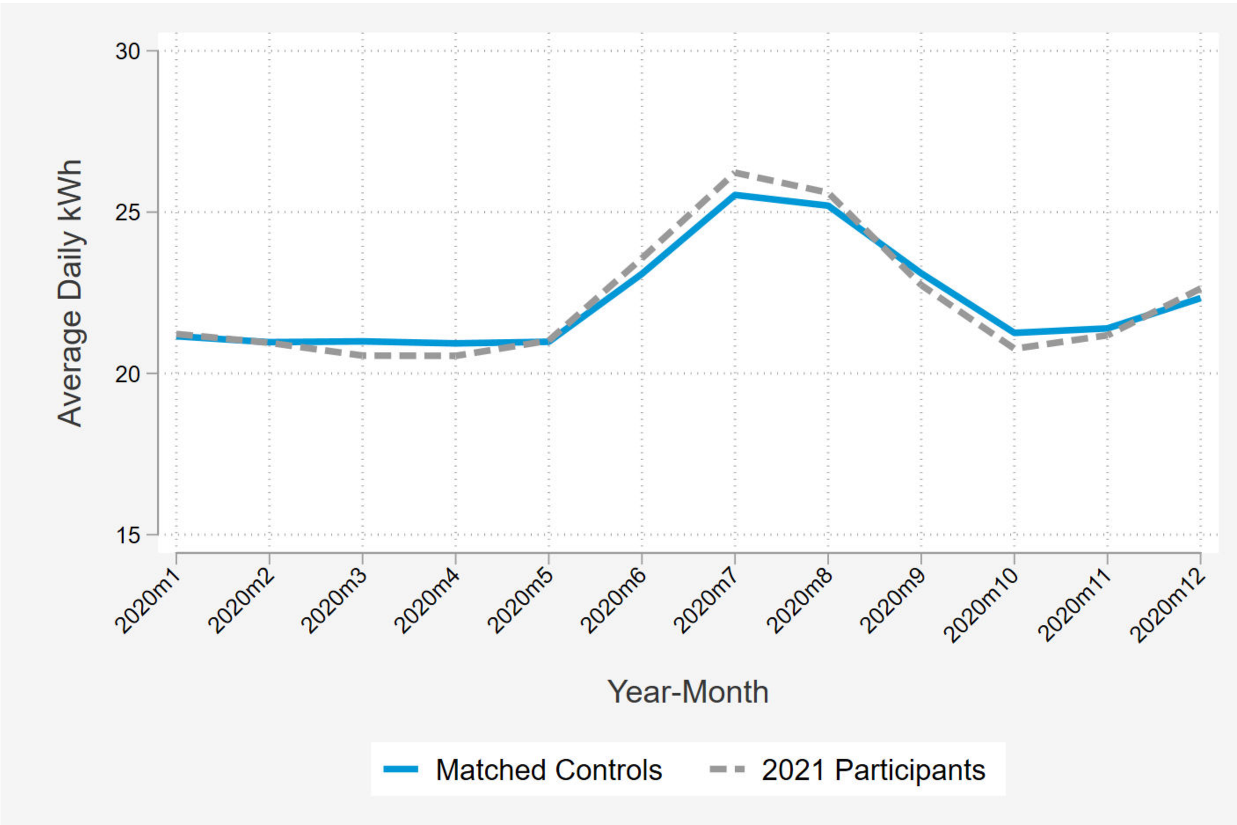
6.2.2 Analysis Approach and Detailed Results

The Evaluation Team used both engineering and consumption analysis to estimate savings for the REAP program in 2022. 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. 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

Because the consumption analysis requires post-installation electricity usage data for approximately one year after treatment, our analysis uses 2021 participants as the treatment group. We used the pre-participation period of the 2022 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 (2021 participants) in their post-installation period. 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 6-1 compares average daily consumption between treatment group homes and their matched comparison homes. Usage between the two groups shows good alignment and the remaining differences are netted out via the modeling procedure. Another benefit to using 2022 participants as a comparison group is that this accounts for the self-selection of program participation.

Figure 6-1: 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 2022) are excluded from the analysis. The transition from the pre-period to post-period is based on the project completion date over the course of 2021, the status the participant group in aggregate gradually shifts as projects are completed. An additional filter was applied to remove customers who installed air purifiers or dehumidifiers through the REAP program. The goal is to remove any load-adding measures. Since these measures could be installed as new, or in homes that did not have an existing air purifier, then these units would add load rather than provide energy savings.

The consumption analysis model is a weather normalized 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 A, Subsection H. Several different model specifications were tested to assess the robustness of the results, and the results were consistent across models.

6.2.2.2 Consumption Analysis – Results

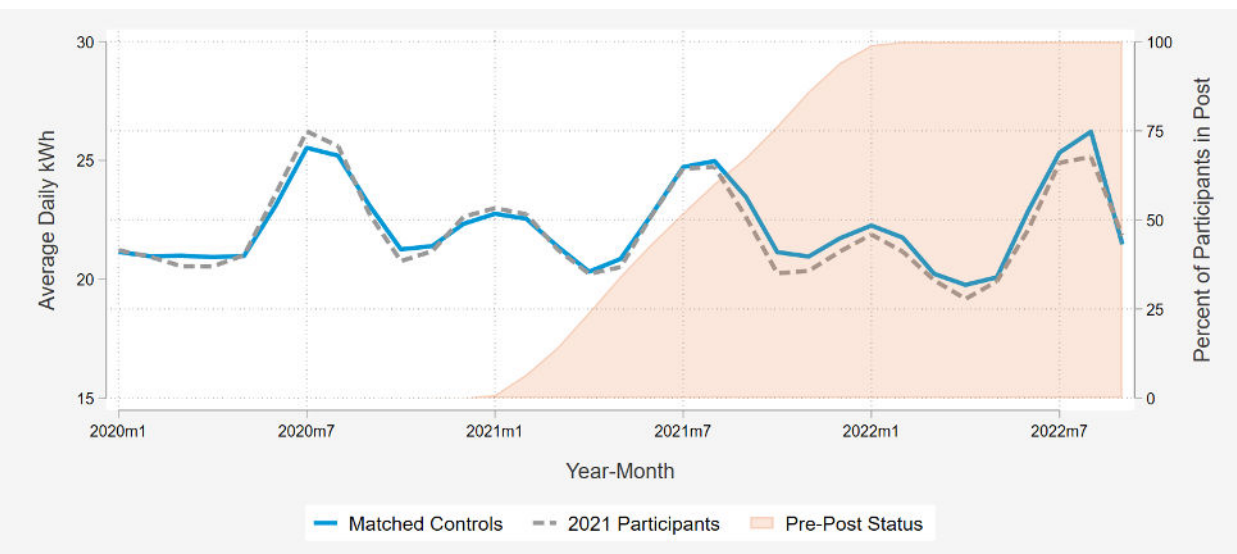
In Table 6-5, we use the results of the REAP consumption model to estimate average savings for 2021 participants and compare the estimated impact to the ex-ante gross kWh savings claimed by the implementer. There were 870 Long Island homes included in the regression model. There were more than 870 REAP participants in 2021. However, only participants with at least one year of pre-participation data and one year of post-participation data were included in the modeling. Additionally, participants that installed potentially load-adding measures were removed from the modeling. Across the homes included in the model, the average annualized savings was 264.4 kWh, which represents a 3.3% reduction in annual electric consumption. This equals 31.9% of the average ex-ante gross kWh savings claim for the same homes. We applied this 31.9% realization rate to the ex-ante gross kWh savings claim of 2022 participants to estimate ex-post gross kWh savings for REAP. Potential drivers of this realization rate are further discussed in section 6.2.3.2.

Table 6-5: REAP Consumption Analysis Results (n=870)

Parameter	Estimate	Lower Bound of 95% CI	Upper Bound of 95% CI
Daily Treatment Effect (kWh Saved)	0.72	0.02	1.43
Daily Treatment Effect (% Savings)	3.34%	0.08%	6.61%
Annual Savings	264.4	6.2	522.6
Ex-Ante Gross kWh	828.7		
Realization Rate	31.9%	0.8%	63.1%

Figure 6-2 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 departure is the effect of interest.

Figure 6-2: REAP Consumption Analysis Results Visualized



6.2.2.3 Engineering Analysis – Results

Program tracking data and engineering analysis are used to estimate gross kWh and kW savings achieved by each measure installed through the 2022 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 6-6, Table 6-7, and Table 6-8 show the ex-post gross MMBtu, MWh, and kW savings as determined by the engineering analysis for each measure category.

Table 6-6. 2022 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	%
REAP Lighting	26,361	2,641.6	2,030.7	76.9%
Energy Star Refrigerators	155	116.4	116.7	100.3%
Power Strips	1,852	1,004.1	1,004.1	100.0%
Aerators	345	68.0	67.2	98.9%
DHW Pipe Insulation	219	54.3	53.7	98.8%
DHW Temperature Turndown	20	4.9	4.9	100.0%
Energy Star Dehumidifier	286	86.3	86.4	100.1%
Low Flow Showerhead	181	269.7	293.8	108.9%
Room Air Conditioners	800	145.9	146.1	100.1%
Thermostatic Valve	800	74.1	74.1	100.0%
Room Air Purifier	298	1,105.5	510.7	46.2%
Smart Thermostat	75	436.6	430.1	98.5%
Total	**31,392**	**6,007**	**4,818**	**80.2%**

Table 6-7. 2022 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	%
REAP Lighting	26,361	1,365.0	951.4	69.7%
Energy Star Refrigerators	155	89.8	89.8	100.0%
Power Strips	1,852	294.3	294.3	100.0%
Aerators	345	2.0	1.9	98.8%
DHW Pipe Insulation	219	1.9	1.9	100.0%
DHW Temperature Turndown	20	0.2	0.2	100.0%
Energy Star Dehumidifier	286	25.3	25.3	100.0%
Low Flow Showerhead	181	7.8	8.5	109.0%
Room Air Conditioners	800	42.8	42.9	100.2%
Thermostatic Valve	800	2.1	2.1	100.0%
Room Air Purifier	298	324.0	149.7	46.2%
Smart Thermostat	75	12.9	13.8	107.0%
Total	**31,392**	**2,168**	**1,582**	**73.0%**

Table 6-8. 2022 REAP Program Measure-Specific kW Gross Impacts: Engineering Analysis

Category	N	Ex-Ante Gross Savings (Claimed)	Engineering Analysis Ex-Post Gross Savings	Engineering Analysis Realization Rate
		kW	kW	%
REAP Lighting	26,361	283.2	142.0	50.1%
Energy Star Refrigerators	155	10.7	10.7	100.0%
Power Strips	1,852	29.3	29.3	100.0%
Aerators	345	0	0	--
DHW Pipe Insulation	219	0.21	0.21	0.0%
DHW Temperature Turndown	20	0.02	0.02	100.0%
Energy Star Dehumidifier	286	4.5	4.5	100.0%
Low Flow Showerhead	181	0.0	0.0	--
Room Air Conditioners	800	35.2	35.2	100.0%
Thermostatic Valve	800	0.0	0.0	--
Room Air Purifier	298	37.2	17.2	46.2%
Smart Thermostat	75	0.0	0.0	--
Total	**31,392**	**400**	**239**	**59.7%**

6.2.3 Key Drivers for Differences in Impacts

6.2.3.1 Reasons for Differences in Engineering Impacts

Measure-level savings estimates were less than the ex-ante gross savings which resulted in realization rates of 80.2% for MMBtu, 73.0% for MWh, and 59.8% for kW as shown in Table 6-9, Table 6-10, and Table 6-11. The lighting measure category was the largest contributor to the REAP program gross savings discrepancy. Lighting comprised 60% of REAP program MWh savings. Realization rates are 76.9% for MMBtu, 69.7% for MWh and 50.1% for kW for this measure category.

Differences in algorithm parameter values were ruled out as the cause of the discrepancy because coincidence factor, hours of use and interactive effects were found to be largely the same for ex-ante and ex-post as shown in Table 6-9.

Table 6-9: REAP Interior Lighting, Comparison of Parameters, Ex-Post vs. Ex-Ante

Parameter	REAP Interior Lighting		REAP Night Lights	
	Ex-Ante 2022 TRC Workbook	Ex-Post 2024 TRM	Ex-Ante 2022 TRC Workbook	Ex-Post 2024 TRM
Coincidence Factor	0.08	0.16	0.08	0
HOU Interior	2.7	2.7	12	12
HOU Exterior	5.8	5.7	0	0
Interactive Factors:				
$HVAC_e$	0.0159	0.0159	0.0159	0.0159
$HVAC_d$	0.1423	0.1423	0.1423	0.0000
$HVAC_g$	(0.0075)	(0.0007)	(0.0075)	(0.0007)
$HVAC_o$	(0.0007)	(0.0007)	(0.0007)	(0.0007)
$HVAC_p$	(0.0000)	(0.0002)	(0.0000)	(0.0002)

Significant baseline wattage discrepancies were found for several lamp types as summarized in Table 6-10 and Table 6-11. Ex-ante standard and specialty lamp baseline watts were 63 watts and 53 watts respectively. Ex-post baseline wattages exhibited greater variation among lamp types. Negative wattage variances generally corresponded with realization rates less than 100% for interior lamps. Realization rates over 100% for exterior lamps result from lower ex-ante hours of use than were used for ex-post analysis.

Table 6-10: REAP Lighting, Common Lamps, Baseline Watts Comparison, Ex-Post vs. Ex-Ante

	10 Watt "A" Bulb	5 watt Globe	Exterior 10 Watt "A"Bulb	0.3 Watt Night Light
Ex-Post Baseline Wattage	43	29	43	5.7
Ex-Ante Baseline Wattage	63	63	63	5.5
Baseline Wattage Discrepancy	(20)	(34)	(20)	0.2
Realization Rate	59%	43%	123%	105%

Table 6-11: REAP Lighting, Specialty Lamps, Baseline Watts Comparison, Ex-Post vs. Ex-Ante

	14 Watt "A" Bulb (3-way)	4.7 Watt Candelabra B10	6.5 Watt Candelabra BA13	9 Watt Reflector R-30	9 Watt Reflector R-40	Exterior 9 Watt Reflector R-30	Exterior 9 Watt Reflector R-40
Ex-Post Baseline Wattage	100	25	40	60	60	60	60
Ex-Ante Baseline Wattage	53	53	53	53	53	53	53
Baseline Wattage Discrepancy	47	(28)	(13)	7.2	7.2	7.2	7.2
Realization Rate	169%	40%	66%	100%	100%	206%	207%

Reasons for discrepancies between the ex-ante assumptions and measure-level engineering results are summarized in Table 6-12. In most cases, our recommendations apply to the 2024 program year. Planning for the 2023 program year was finalized a year ago, and program delivery is almost half complete. These types of changes are often most efficient to implement at the beginning of a new program year.

Table 6-12: Realization Rate Drivers

Component	Summary of Contributing Factors	Recommendations
Lighting	▪ The 69.7% realization rate was largely the result of discrepancies between ex-ante and ex-post and baseline lamp wattage assumptions. ▪ The ex-ante exterior lamp savings algorithms used 2.7 HOU for interior lamps versus the correct value of 5.8 HOU used for ex-post savings. This resulted in realization rates ranging from 123% to 207% for 1,371 exterior lamps out of 26,361 lamps installed in the REAP Program.	▪ Since the program controls the exact specification of lamps installed and the roster is relatively short, rely on dedicated measure characterization for each program-supported LED product. The 2024 PSEG Long Island TRM provides separate savings values for each of the LED lighting products distributed in 2022.

Component	Summary of Contributing Factors	Recommendations
Air Purifiers	▪ Efficient unit specs (standby power, cfm/W, and CADR) were updated based on actual installs. ▪ Baseline efficiency standard (CFM/Watt) was updated to reference updated market baseline values using Version 11 of the Illinois TRM instead of the blanket assumption of 1.0 CFM/W for all size tiers.	▪ Include an indicator in the program tracking system for "load building" measures when appliances are added to homes rather than replaced. While these installations have health benefits, they do not save energy. Flagging such installations in the program tracking data and reporting negative savings (kWh_{be}) will allow them to be reported more clearly or removed from future billing analyses.

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

The 2022 consumption analysis resulted in much lower overall ex-post gross savings than ex-ante gross savings, as shown by the 31.9% 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 0.8% to 63.1%. There are a few factors that could be driving the realization rate.

6.2.3.2.1 2020-2022 TRENDS

To start, the average per-customer claimed savings has increased steadily from year to year, from about 700 kWh/customer in 2020 to almost 1,100 kWh/customer in 2022. Meanwhile, the results of the billing analyses show variable average customer impacts from year to year, driving down realization rates. While the billing impacts this year were lower than previous years, the realization rate was driven even lower by the increase in per/customer claimed impacts.

Figure 6-3: kWh Impacts per Customer from 2020 to 2022

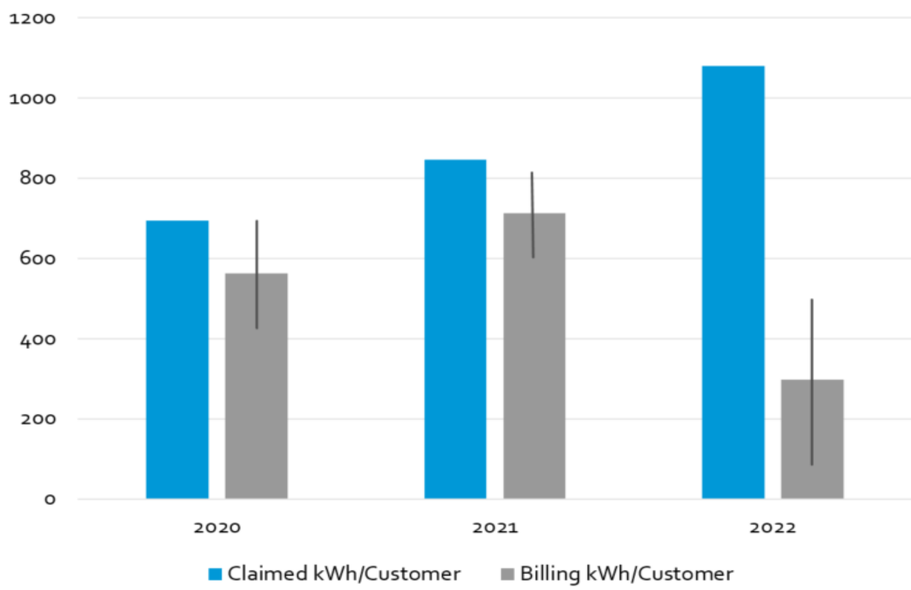
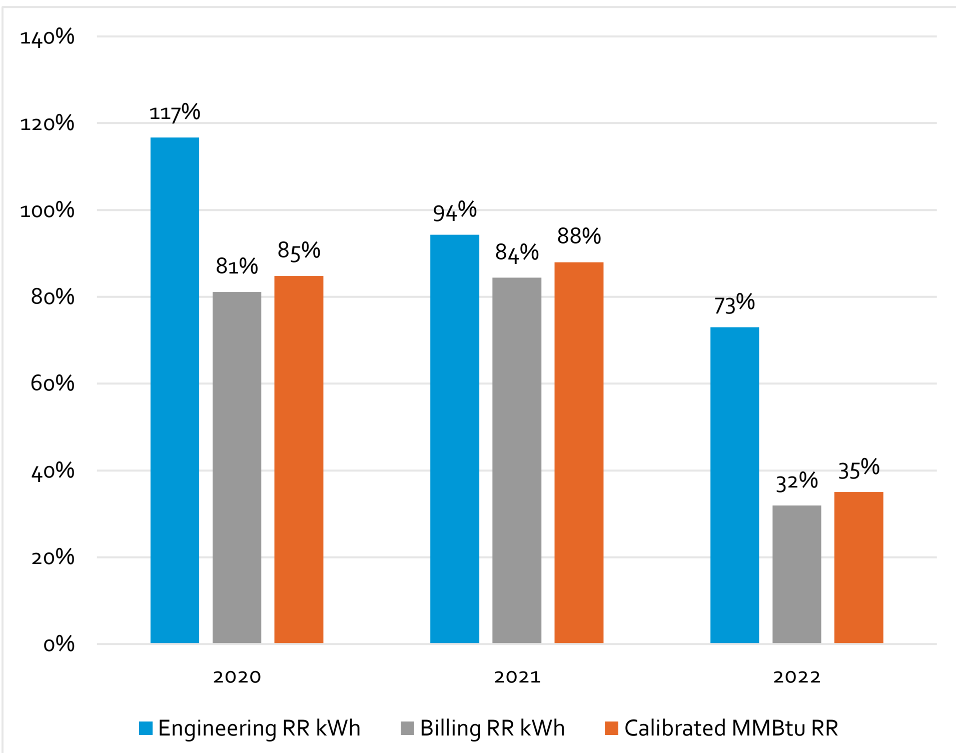


Figure 6-4 shows that while the claimed savings are increasing year to year, the engineering realization rate is consistently decreasing year to year.

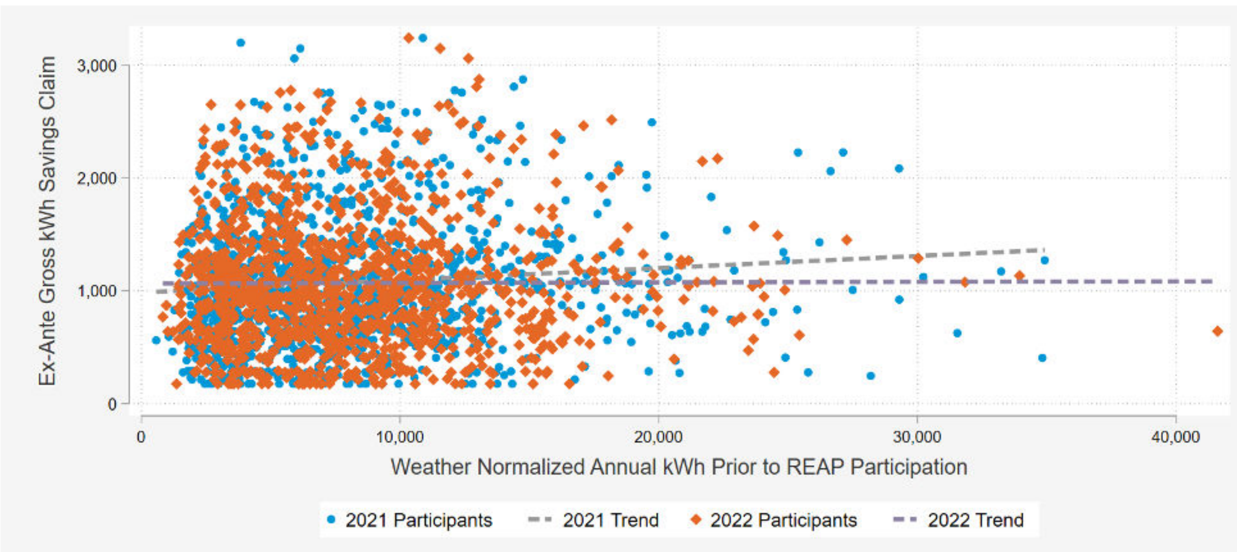
Figure 6-4: Engineering, Consumption, and Calibrated Realization Rates 2020-2022



6.2.3.2.2 ENGINEERING CALCULATIONS VS. ANNUAL HOUSEHOLD USAGE PATTERNS

One potential explanation for the results is that ex-ante kWh savings claims are decoupled from the usage patterns of the home while the consumption analysis is intrinsically linked to actual billed kWh. Figure 6-5 compares the ex-ante gross kWh savings claim (y-axis) to the weather-normalized annual kWh consumption (x-axis) for each participant in 2021 and 2022. The trend line is effectively flat for both years. This is expected with deemed savings as the parameters and estimated energy savings are "averages of averages" and as a result are high for some homes and low for others. The homes with high ex ante claims and relatively low annual kWh, located in the upper left portion of Figure 6-5, are likely pulling the REAP realization rate below 100%. It is unlikely any set of EE measures will save over 2,000 kWh in household that only uses less than 5,000 kWh per year. PSEG Long Island and TRC might consider creating a flag in Captures that is tripped by projects claiming kWh savings equal to or greater than half of their last 12 months of billed consumption.

Figure 6-5: Comparison of Ex-Ante Gross kWh Savings and Pre-Retrofit Annualized Consumption



6.2.3.2.3 LOAD ADDING MEASURES

A second explanation could lie with non-replacement measures, like the Room Air Purifiers, that have potential to add electric load to a household's annual consumption if the home did not have an air purifier previously. The engineering estimates for the Room Air Purifier measure assume an ENERGY STAR unit is replacing a standard efficiency air purifier. If a participating household did not own an air purifier prior to participating in REAP, the ENERGY STAR purifier would lead to increased electric consumption compared to no air purifier at all. The baseline expectation outlined in the TRM is that each home will replace an existing Air Purifier, however under the Healthy Homes Initiative[10], customers with breathing issues or allergies will be provided an air purifier regardless of whether one currently exists in the home. These homes will have claimed electric savings under current TRM

[10] NYS Healthy Neighborhoods Program: https://www.health.ny.gov/environmental/indoors/healthy_neighborhoods/#:~:text=The%20New%20York%20State%20Healthy%20Neighborhoods%20Program%20%28HNP%29,and%20injury%20through%20a%20holistic%2C%20healthy%20homes%20approach.

specifications, however in a billing analysis they may see increased electric load driving down the realization rate. To account for this in this year's billing analysis, homes with suspected load adding measures were removed from the model. Even though these measures have potential to add load, they can be associated with other, non-energy benefits to the customer. Installing air purifiers can help alleviate symptoms and additional stress from breathing issues and illnesses, such as asthma, or allergies experienced in the home, improving the health of the customer. For customers with asthma, this can lead to a reduction in the number of doctor's visits or hours of missed work.

6.2.3.2.4 COVID19 INFLUENCE ON PROGRAM IMPLEMENTATION

Finally, it is important to consider the impacts COVID-19 may have had on implementation practices within the REAP program. The implementation contractor, TRC, confirmed that the REAP Program pivoted to Remote Energy Assessments (REAs) during the height of COVID, and they continue to offer REAs as needed. Through a Remote Energy Assessment, a customer receives 1) General Energy Education, 2) Virtual Assessment, and 3) a Measure Package. The General Energy Education portion included specific tips on energy saving options for each customer. During the Virtual Assessment, a representative from the implementation contractor, a REAP Tech, would walk the participant through the REAP participation agreement application. During this portion, the participant would walk through the home to review needs covered by the program. Finally, based on the virtual assessment, a Customized Energy Reduction Package (CERP) is compiled and delivered to the participant's home with self-install instructions. It's difficult to know if the measures from the CERPs were installed in participant homes. In instances where the measures were not installed, savings may have been claimed where none would have showed up in the billing analysis.

6.3 CONCLUSIONS AND RECOMMENDATIONS

Our key findings and recommendations based on this evaluation are shown in Table 6-13. In most cases, our recommendations apply to the 2024 program year. Planning for the 2023 program year was finalized a year ago, and program delivery is almost half complete. These types of changes are often most efficient to implement at the beginning of a new program year. Most of our recommendations are also reflected in the recently completed 2024 PSEG Long Island TRM.

Table 6-13: REAP Findings and Recommendations

Finding	Recommendation
▪ Claimed savings are rooted in deemed assumptions and calculations that are independent from actual customer consumption. In some cases, this can lead to claimed savings that are too high for the household's annual kWh.	▪ Create a flag in Captures that indicates if claimed savings are more than half of the customer's last 12 months of billing consumption.

Finding	Recommendation
REAP engineering realization rates were low in 2022 due to differences between the assumed and actual mix of LED lamps.	Each lighting product is tracked separately in REAP so there is no need to assume a mix of lamps and claim savings using averages. The 2024 PSEG Long Island TRM provides product-specific measure characterizations, which if implemented, would eliminate differences between ex-ante savings claims and ex-post engineering calculations.
Under some circumstances, measures are installed differently from TRM assumptions, such as: ➢ Air purifiers installed where one did not exist before. TRM assumes air purifiers are installed as a replacement to a market baseline efficiency unit. ➢ Remote assessment and self-install measure packages. Claimed savings will assume all measures are installed while it is possible self-install measures were not installed correctly, or at all.	If possible, better track these the nuances in program delivery in the measure records. This would allow evaluators to extract data that informs savings for all projects rather than refer to project workbooks one by one. Most notably for the following data fields: ➢ Indicator for if the air purifier was installed new or as a replacement. ➢ Standardized indicator for type of program implementation: home visit vs. remote audit.
The mix of REAP offerings has remained relatively consistent year-to-year. LED bulbs and power strips are the most consistently implemented measures and make up the largest portion of claimed savings. As a result of the lighting phasing out of energy efficiency programs, there is a statewide policy push towards expanding building efficiency and electrification in LMI. It will be necessary to think about what the next iteration of the REAP program includes. We expect that REAP program offerings will start to include more measures that fall under the Home Performance Program.	As the REAP program evolves to meet state policy objectives around equity it would be beneficial to explore identifying additional REAP program benefits. Many jurisdictions have additional SCT benefit streams for low income programs such as: decrease in health issues, reduced bill assistance, fewer sick days taken, etc.

7 HOME ENERGY MANAGEMENT (HEM) PROGRAM

PSEG Long Island's Home Energy Management (HEM) program currently delivers paper and electronic home energy reports (HERs) to over 386,000 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 2022 (PY2022) 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 considerable 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 introduction of the HERs?
- What is the magnitude of annual electricity savings?
- Is there an overlap with other energy efficiency programs (to avoid double-counting)?
- 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:

- Reduce energy usage,
- Increase peak hour energy savings,
- Increase awareness of and participation in energy efficiency programs,
- Consider renewable energy/energy storage and demand response programs, and
- Increase customer 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 program launched 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 2022 was to achieve 29,881 MWh in energy savings across both cohorts. Due to attrition (mostly move-outs), 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 2022 onward, PSEG Long Island anticipates sending HERs to treatment customers in both Cohorts 1 and 2. Two more Cohorts were launched in February 2023, adding 130,000 customers to the HEM program. The impacts from this additional cohort will be evaluated as part of the 2023 program year.

7.2 2022 PROGRAM ENROLLMENT AND REPORT COUNTS

Table 7-1 presents HEM program participation in Cohorts 1 and 2. Cohort 1 contained 262,763 treatment customers and Cohort 2 contained 123,821 treatment customers, which represents an attrition rate of 6% from PY2021. The evaluation method used requires before and after data for each participant and control. Thus, we only analyze sites with a full year of data before they receive the behavioral intervention and a full year of 2022 billing data, which are approximately 98% of the evaluation, and apply the results to the full population.

Table 7-1: 2022 HEM Program Participation Summary[11]

Cohort	Number of Treatment Customers	Number of Control Customers	Number of Customers per Cohort
Cohort 1	262,763	32,005	294,768
Cohort 2	123,821	27,117	150,938
Total	**386,584**	**59,122**	**445,705**

Each treatment group household is sent approximately five reports over the course of the year. Based on the program tracking data, the verified count of paper reports sent was 2,446,214 with each participant receiving multiple reports throughout the year. The verified number of paper reports sent each month and the total for 2022 are presented in Table .

Table 7-2: HEM Program Paper HERs Sent by Month in 2022

Month	Verified Report Count
January	363,287
February	60,166
March	246,800
April	164,209
May	170,039
June	451,151
July	273,143
August	263,048
September	-
October	364,691
November	15,649
December	74,031
Total	**2,446,214**

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.

[11] Counts represent the average number of customers with active billing data in 2022. Savings were calculated for each month separately based on the number of customers with active billing data that month.

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

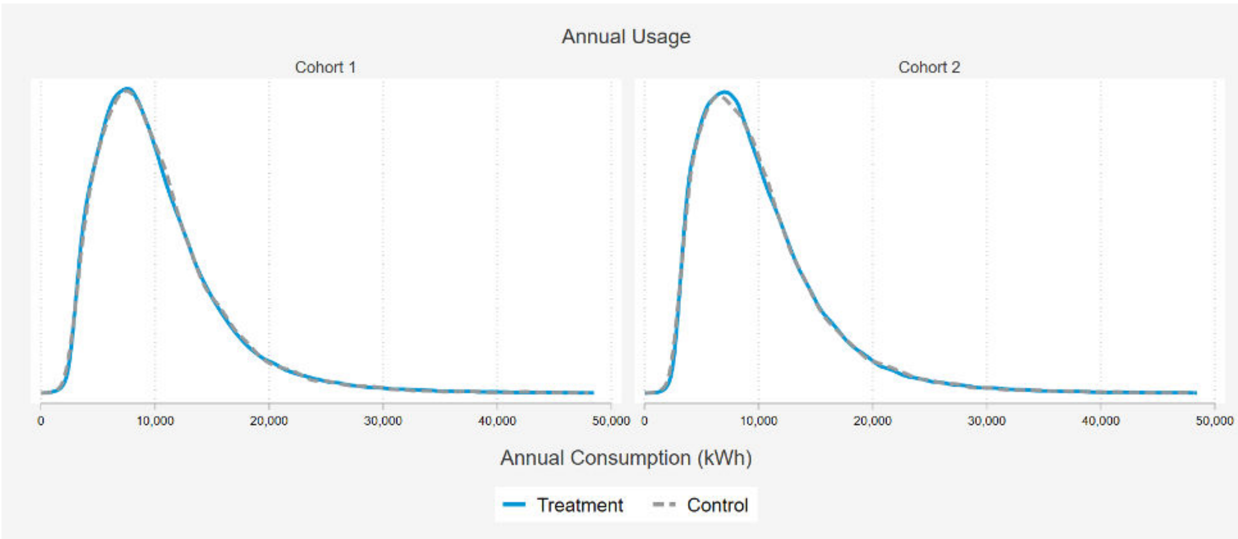


Table shows the average annual usage between treatment and control groups by cohort. On average, the annual usage is 0.06% different between the groups, and neither wave shows a statistically significant difference between the two groups. The minor pre-existing difference is netted out in the statistical analysis.

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

Wave	Start Date	Number of Homes Analyzed[1]		Annual Use (kWh)		Difference in Annual Use		
		Control	Treated	Control	Treated	kWh	%	95% Conf. Interval
Cohort 1	10/1/2017	30,370	249,521	10,329.0	10,307.2	-21.8	-0.21%	(-96.3,52.8)
Cohort 2	8/27/2018	25,574	116,934	10,214.3	10,192.4	-21.9	-0.21%	(-115.9,72.1)
Total		**55,944**	**366,455**	**10,276.5**	**10,270.6**	**-6.0**	**-0.06%**	**(-96.1,84.2)**

[1] The estimating sample is limited to participants and control with a full year of pre-intervention data and are roughly 98% of the total participants

7.4 ELECTRIC EX-POST SAVINGS SUMMARY

Table depicts the ex-post savings results for HEM in MMBtu and MWh. A total of 386,584 customers participated in the program in PY2022, on average saving 90 kWh per participant annually for total annual savings of 34,630 MWh, or 118,157 MMBtu before accounting for any dual enrollment in other programs, referred to here as uplift. The uplift refers to energy savings due to the boost in energy efficiency program participation delivered by HERs. The savings are backed out to avoid double-counting since they are already accounted for in the other programs. Once we account for uplift, the average participant saved 86 kWh annually for total annual savings of 33,183 MWh and 113,219 MMBtu.

The HEM realization rate is the ratio between claimed ex-post savings and claimed ex-ante savings. In 2022, the realization rate for electric savings was 99.9%. The ex-post savings were 111.1% of the HEM goal for 2022.

Table 7-4: 2022 HEM Program Ex-Post Gross Impacts

Metric	Participation	kWh per participant	Energy Savings	
			MMBtu	MWh
Goal	440,000	68	101,952	29,881
Claimed Ex-Ante	489,249	68	113,362	33,225
Verified Ex-Ante	489,243	68	113,362	33,225
Unadjusted Ex-Post	386,584	90	118,157	34,630
Uplift Adjustment[1]	386,646	4	4,938	1,447
Adjusted Ex-Post After Accounting for Uplift	386,584	86	113,219	33,183
Realization Rate of Ex-Post to Claimed Ex-Ante	79.0%	126.5%	99.9%	99.9%
Ex-Post as Percent of Goal	87.9%	126.5%	111.1%	111.1%

Table summarizes the demand savings in kW for the HEM program for 2022. The HEM population was able to reduce demand by 9.0 MW between 4 and 5 PM during summer 2022. While no kW demand savings were claimed for HEM during the program year, we did assess the kW demand reduction for the program as a part of the ex-post analysis and included the demand savings as a part of the cost-effectiveness assessment. The kW impacts were estimated for sites that had AMI data in 2022 and scaled for the full population of participants. Detailed methodology in Appendix A, Subsection G provides additional details on the peak demand savings calculations.

Table 7-5: HEM Peak Demand Reduction

Wave	MW Impact
Cohort 1	8.77
Cohort 2	0.14
Total	**8.91**

7.5 ELECTRIC EX-POST SAVINGS DETAIL

Table depicts the unadjusted ex-post savings from the analysis. On average, participants saved approximately 89.6 kWh ± 10 kWh annually (95% confidence), or approximately 0.89% of their annual consumption. On an aggregate basis, HEM reduced electricity use by 118,157 MMBtu.

Table 7-6: 2022 HEM Unadjusted Ex-Post Per-Household and Program Energy Savings

Cohort	Number of Customers Treated in 2021	Unadjusted Savings (% per household)	Unadjusted Energy Savings (kWh per household)	Lower Bound	Upper Bound	Unadjusted Program Savings (MMBtu)
Cohort 1	262,763	0.93%	94.28	74.51	106.67	84,499
Cohort 2	123,821	0.79%	79.73	60.49	100.79	33,657
Total	**386,584**	**0.89%**	**89.62**	**74.91**	**99.91**	**118,157**

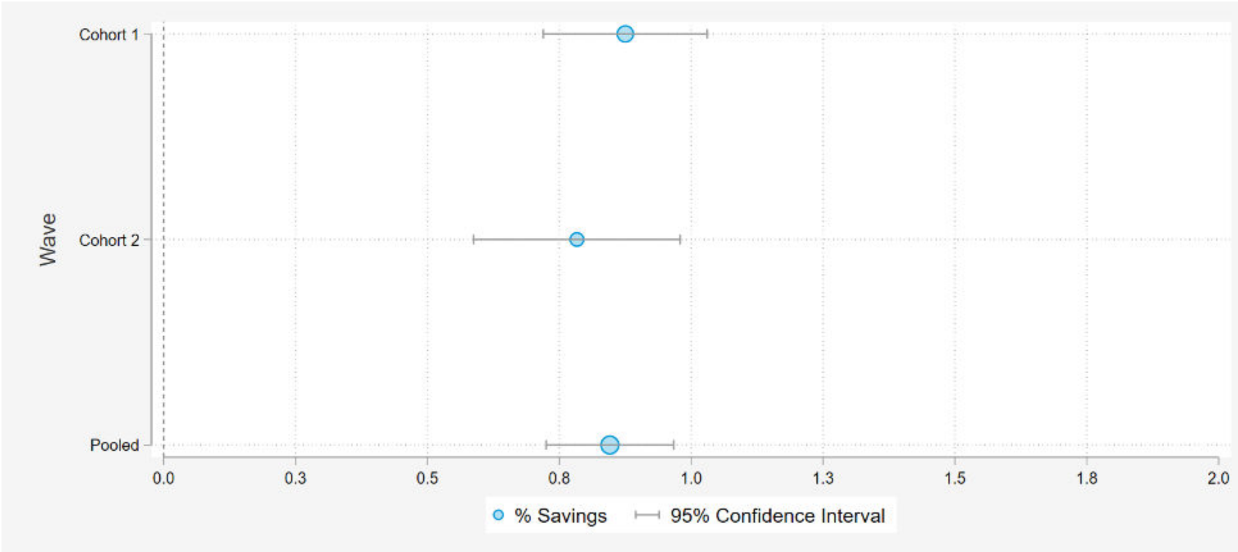
Table depicts the percent savings for each cohort by month. We see that the highest percent savings generally occur in the winter, with over 1.1% savings in January, February, November, and December on average across both cohorts.

Table 7-7: 2021 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	1.21%	1.12%	1.18%
February	1.19%	0.98%	1.12%
March	0.83%	1.01%	0.89%
April	0.78%	0.72%	0.76%
May	0.61%	0.28%	0.50%
June	0.69%	0.68%	0.69%
July	0.67%	0.73%	0.69%
August	0.83%	0.81%	0.82%
September	0.74%	0.81%	0.76%
October	1.08%	0.93%	1.03%
November	1.34%	0.90%	1.20%
December	1.48%	0.39%	1.13%
Annual	**0.93%**	**0.79%**	**0.89%**

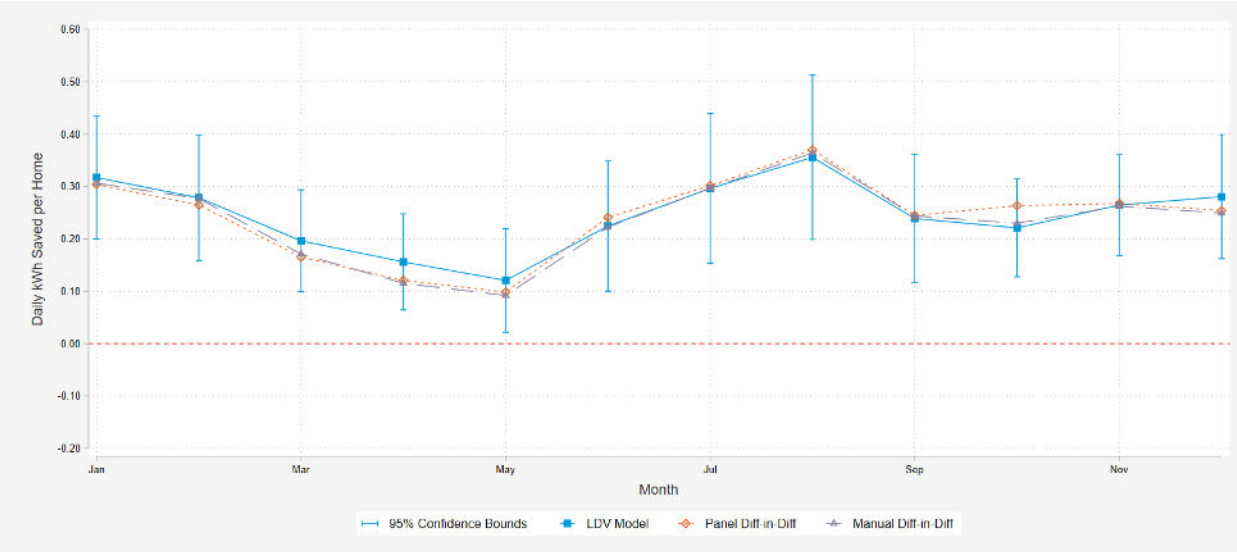
Figure 7-2 shows the percent savings by cohort and for all cohorts pooled. The size of the marker indicates the relative participant population size for each wave. The savings for individual cohorts are statistically significant, and there are 0.89% annual savings for the pooled analysis. The magnitude of savings is also similar between the two cohorts.

Figure 7-2: Electric Percent Savings by Wave



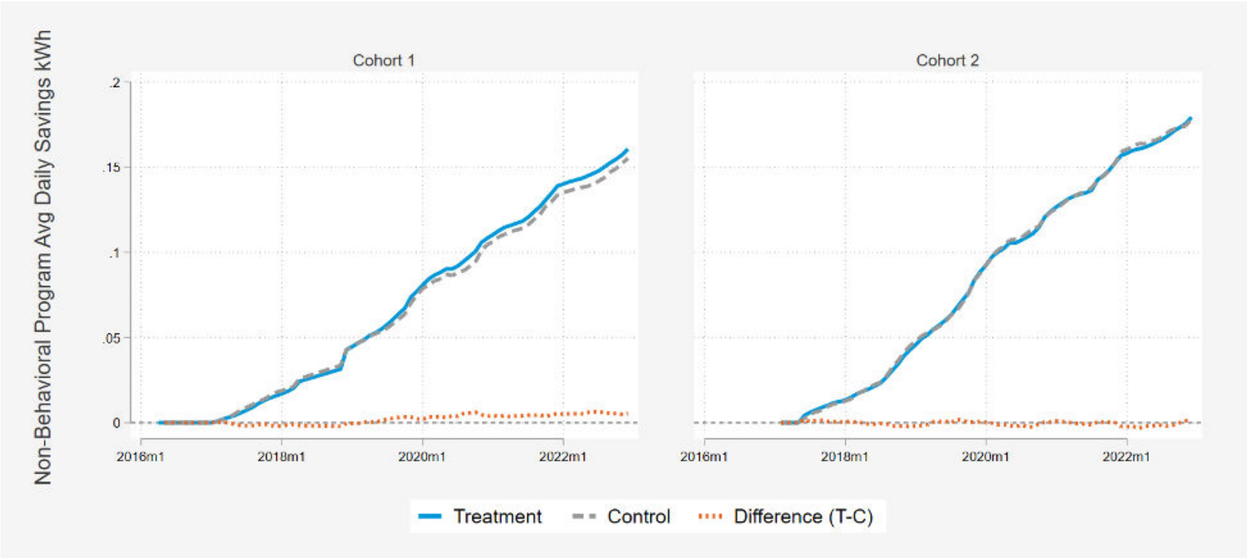
The evaluation team tested the robustness of the impacts by implementing two other common methods for estimating behavioral impacts: a panel difference-in-difference model and a classic difference-in-difference calculation. The panel difference-in-difference model uses data from both the pre and post periods and analyzed impacts via a regression model. The classic difference-in-difference approach examines differences in raw averages using the same data. It compares the change observed among participants over between the before and after period and nets out the change observed among controls in the before and after period. 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. The pooled savings are also statistically significant for each month.

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



As noted earlier, HERs boost participation in energy efficiency programs (uplift), which can lead to double-counting. 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. We see separation over time, particularly for Cohort 1, indicating higher participation in energy efficiency programs for the treatment group. The calculated adjustment for downstream savings netted out approximately 2%, or 1.6 kWh per participant. The calculated adjustment for upstream savings netted out approximately 2.2% of the program savings, or 1.7 kWh per participant. In total this led to an adjustment equivalent to 4% of the total savings, or 3.3 kWh per participant. While the savings are due to the HERs, they are netted out since they are already accounted for in other program totals. For more detail on how dual participation analysis was calculated, please see Detailed Methodology.

Figure 7-4: Downstream Dual Participation Analysis Output



7.6 COMPARISON TO PY2021

Table compares per-customer savings from PY2021 and PY2022. In PY2022, the per-customer and percent savings were higher for Cohort 1. Cohort 2 saw slightly lower per customer savings and percent savings. Overall, the HEM program saw higher per customer impacts. This aligns with the expectation that customers savings increase over the first few years of HEM program participation.

Table 7-8: Unadjusted Ex-Post Savings by Cohort and Evaluation Year

Cohort	2021 Energy Impact Per account		2022 Energy Impact Per account	
	kWh Impact	% Impact	kWh Impact	% Impact
Cohort 1	75.29	0.73%	94.28	0.93%
Cohort 2	87.35	0.86%	79.73	0.79%

7.7 CONCLUSIONS AND RECOMMENDATIONS

PSEG Long Island's HEM program remains a significant component of PSEG LI's portfolio, currently reaching over 386,000 electric accounts and additional accounts being added in 2023. While home energy reports deliver small percentage changes in energy use, they typically yield large aggregate savings because they reach a considerable number of customers and do not require rebates or installations. In PSEG LI, the program yielded 33.1 GWh (or 113,219 MMBtu) of electric savings. With the adjusted expectations for per customer savings, the realization rate for the program is also substantially higher than the previous program year. Some key findings and recommendations are provided in Table 7-9.

Table 7-9: HEM Findings and Recommendations

Finding	Recommendation
▪ HEM's percent savings (0.89%) are generally lower than other HER programs.	▪ As the program continues to mature, we recommend investigating potential drivers for the lower-than-anticipated savings. In specific, we would continue to recommend coordination of the evaluation with National Grid, which provides natural gas delivery to customers. It is likely that some of the customers in the HEM control group are receiving behavioral energy reports from National Grid, diluting the energy savings estimate.
▪ PSEG Long Island does not claim peak demand savings for HEM.	▪ The 2022 evaluation used AMI data to estimate peak demand savings. We recommend that PSEG Long Island use an assumption of 0.02 kW/household to claim ex-ante peak demand savings in 2023. 0.02 kW/household is equal to the total kW impact/average number of customers treated in 2022. In the 2022 program year, this would have translated to 7.7MW in claimed peak reduction.

8 ALL ELECTRIC HOMES

PSEG Long Island's All Electric Homes Program provides approved developers and contractors rebates for building new single-family all-electric homes or for converting existing single-family homes to all-electric appliances and HVAC units. The All Electric Homes program was designed and launched in 2021, but saw its first completed projects in 2022, so this is the first evaluation cycle for the program.

8.1 ALL ELECTRIC HOMES PROGRAM DESIGN AND PARTICIPATION

The following sections detail the program design, implementation strategies, and PY2022's participation and performance for the All Electric Homes program.

8.1.1 PROGRAM DESIGN AND IMPLEMENTATION

The All Electric Homes program is an extension of New York state policy goals to reduce reliance on fossil fuel combustion appliances in homes. As the electric grid in New York becomes decarbonized, this transition from fossil fuel space heating, domestic hot water, and appliances to electricity will lower greenhouse gas emissions. New construction participants are not allowed to have fossil fuel connections in the home other than an emergency backup generator and existing home participants must disconnect their natural gas service and remove any equipment that relies on delivered fuel. The All Electric Homes program offers two participation pathways, or tiers:

- **Tier 1 Pathway**: includes cold climate air source heat pumps, tankless water heaters, and ENERGY STAR appliances and a 10% bonus on all required rebated measures.
- **Tier 2 Pathway**: includes cold climate air source heat pumps, geothermal heat pumps, heat pump water heaters, and ENERGY STAR Most Efficient appliances and a 25% bonus on all required rebated measures.

Both pathways included a $2,000 contractor bonus to stimulate the market. Electric cooking equipment like induction stoves are encouraged, but not required and PSEG Long Island does not claim savings from cooking equipment.

TRC implements the All Electric Homes program and leverages its existing relationships with Home Comfort Partners, Home Performance Partners, and Multi-Family Partners and Developers to drive participation. All partners who participate in All Electric Homes have already been trained and vetted by others PSEG Long Island program to ensure customers will have a positive "All Electric" participation experience.

8.1.2 PROGRAM PARTICIPATION AND PERFORMANCE

The All Electric Homes program recorded just one completed project in 2022 from a single participant. There are additional active projects in the program that will be closed and reported on for 2023. Based on verified ex-ante estimates, the All Electric Homes program reached 14% of its energy savings goal in

2022. Table 8-1 presents 2022 All Electric Homes programs verified ex-ante gross MMBtu savings compared to goal.

Table 8-1: All Electric Homes Program Verified Ex-Ante Gross MMBtu Savings versus Goals

Metric	MMBtu
Goal	560
Verified Ex-Ante Gross Savings	79
% of Goal	14%

8.2 ALL ELECTRIC HOMES PROGRAM IMPACTS

The following sections provide the results of the impact analysis for the All Electric Homes program.

8.2.1 OVERVIEW OF IMPACTS BY RESOURCE TYPE

Table 8-2 shows ex-post gross MMBtu impacts by measure category. Table 8-3 and Table 8-4 show the ex-post kWh and kW impacts, respectively. Realization rates are calculated by dividing ex-post gross savings values by ex-ante gross savings values. Overall, the All Electric Homes program realized 107% of its ex-ante gross MMBtu energy savings claims and 104% of kW savings claims. The electric energy realization rate of 12,393% appears more volatile than it actually is. Because the program includes a mix of energy efficiency (kWh saving) and beneficial electrification (kWh increasing) measures the ex-ante claimed savings was very close to zero. Our evaluation estimated more beneficial electrification savings than claimed and this led to a much larger number in the numerator of the realization rate than the denominator. Section 8.2.1.1 explores the beneficial electrification impacts of the All Electric Homes program results in more detail.

Table 8-2: 2022 All Electric Homes Program Ex-Post Gross MMBtu Impacts

Measure	N	Ex-Ante Gross Savings (Claimed)	Ex-Post Gross Savings	Realization Rate
		MMBtu	MMBtu	%
Geothermal Heat Pump	1	50.0	67.4	135%
Heat Pump Water Heater	1	8.2	10.0	122%
ENERGY STAR Appliances	5	15.1	1.2	8%
Connected Thermostat	2	1.3	1.4	106%
LED Lighting	42	4.9	5.4	109%
Totals[1]	**51**	**79.6**	**85.3**	**107%**

[1] Totals may not sum due to rounding.

Table 8-3: 2022 All Electric Homes Program Ex-Post Gross kWh Impacts

Measure	N	Ex-Ante Gross Savings (Claimed)	Ex-Post Gross Savings	Realization Rate
		kWh [2]	kWh [2]	%
Geothermal Heat Pump	1	-1,551	-2,439	157%
Heat Pump Water Heater	1	-421	-685	163%
ENERGY STAR Appliances	5	135	107	80%
Connected Thermostat	2	383	408	106%
LED Lighting	42	1,446	1,580	109%
Totals[1]	**51**	**-8**	**-1,029**	**12,393%**

[1] Totals may not sum due to rounding.
[2] These kWh impacts include both energy efficiency (EE) and beneficial electrification (BE) components. The kWh impacts are negative for heat pump and water heater measures due to the displacement of fossil fuel heating with electricity

Table 8-4: 2022 All Electric Homes Program Ex-Post Gross kW Impacts

Measure	N	Ex-Ante Gross Savings (Claimed)	Ex-Post Gross Savings	Realization Rate
		kW	kW	%
Geothermal Heat Pump	1	1.25	1.34	107%
Heat Pump Water Heater	1	-0.05	-0.08	163%
ENERGY STAR Appliances	5	0.04	0.03	84%
Connected Thermostat	2	0.00	0.00	N/A
LED Lighting	42	0.36	0.36	101%
Totals[1]	**51**	**1.59**	**1.65**	**104%**

[1] Totals may not sum due to rounding.

8.2.1.1 Beneficial Electrification Impacts

Table 8-5 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 Geothermal Heat Pump, HPWH, and some ENERGY STAR Appliance measures include a mixture of electric energy efficiency and beneficial electrification impacts.

Table 8-5: Breakdown of Ex-Post Gross Impacts by EE and BE Components

Measure	kWh_{ee}	kWh_{be}	kWh Total (EE - BE)	$MMBtu_{ee}$	$MMBtu_{be}$	MMBtu Total (EE + BE)
Geothermal Heat Pump	1,152	3,591	-2,439	3.9	63.5	67.4
Heat Pump Water Heater	164	849	-685	0.6	9.4	10.0
ENERGY STAR Appliances	306	199	107	1.0	0.2	1.2
Total	**1,622**	**4,639**	**-3,017**	**5.5**	**73.0**	**78.5**

8.2.2 Key Drivers for Differences in Impacts

Table 8-6 discusses the factors which led to realization rates above or below 100% and offers recommendations for program delivery and savings claims in 2023 and beyond.

Table 8-6: Key Contributors to Home Comfort Realization Rates and Recommended Adjustments

Component	Summary of Contributing Factors	Recommendation
Lighting	▪ The LEDs installed in the home were recessed downlight fixtures, not A19 lamps. This led to slightly larger Wattage differential between the baseline and efficient case and a realization rate greater than 100%.	▪ With the EISA standards taking full effect mid-2023, PSEG Long Island and TRC will need to remove the LED lighting component from the claimed savings procedures for all New Construction projects as soon as possible.
Geothermal Heat Pump	▪ The ex-ante claimed savings for this measure were based on a placeholder value of 3 tons. A later version of the workbook updated the calculations to rely on Manual J calculations by the contractor. The Manual J heating and cooling loads for the home were larger than the placeholder value, which led to a realization rate greater than 100%.	▪ Where contractors are required to complete Manual J calculations, PSEG Long Island should make sure to use those values as inputs to the claimed savings. Heuristics are helpful for giving contractors and participants an estimated rebate amount, but should be classified as "interim" or "draft".
ENERGY STAR Appliances	▪ A workbook configuration error led to significantly over claimed MMBtu savings for the ENERGY STAR Refrigerator measure. The project workbook recorded 14.0 MMBtu for the measure. The PSEG Long Island TRM value this measure is less than 1 MMBtu. The kWh and kW savings claims for the measure were unaffected by this issue.	▪ Review projects in the AEH pipeline ENERGY STAR refrigerators and correct the measure-level MMBtu savings assumption before ingesting the workbook values into Captures.

Component	Summary of Contributing Factors	Recommendation
Smart Thermostats	▪ This home installed two smart thermostats connected to a single ground source heat pump (e.g. a zoned system). The claimed savings effectively double-count the heating and cooling capacity controlled in the home. This issue is offset by use of a heating EFLH (786) assumption for fossil fuel equipment instead of heat pump EFLH (1329).	▪ Create an indicator for zone systems and configure all connected thermostat calculations to key off of heat pump EFLH in the AEH program since fossil fuel heating systems are not allowed.

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 • 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)	• Lighting & Multifamily Categories: Census of all measure installs for measures where Captures data includes all parameters • Standard, Custom & HVAC Categories: Measure installs that constituted 95% of savings • Stratified random sample of projects where the parameters and calculations are housed in supporting workbooks
Primary Data	• Captures install tracking data for PY2022 CEP measures • Project specific pre- and post-inspection details • Custom measure inputs and calculations • Updated lighting waste heat factors developed by the evaluation team
Secondary Sources	• New York State TRM and PSEG Long Island TRM • 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	• Net-to-gross factors for CEP lighting are based on the results of 2022 CEP participant survey efforts.
Other Evaluation Techniques	• Engineering Calculations
Opportunities for Refinement	• **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 • **Align with PSEG Long Island TRM** on full load heating and cooling hours, lighting operating hours and coincidence factors based on building type, savings algorithms, and savings estimation methods

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 are highly skewed to three measure categories: Lighting (76%), Thermostats (12%), and Heat Pump Pool Heaters (7%).
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 PY2022 EEP measures
Secondary Sources	• PSEG LI Technical Reference Manuals 2022-2024 • New York State TRM v10 • 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 is available • Assumed baseline is federal standard for end-of-life replacement measures
Opportunities for Refinement	• **Inform savings estimates with supplemental research:** Research assumptions around baseline condition, capacity, namely for heat pump pool heaters. • **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 MWh savings for those measures.
General Approach (Ex-post gross)	• Engineering calculations are rooted in the 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 PY2022 Home Comfort measures
Secondary Sources	• New York State TRM and PSEG Long Island TRM • 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	• Net-to-gross factors for heat pumps and HPWH are based on the results of 2022 EEP and Home Comfort participant survey efforts.
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 2021 and 2022 customers using pre-participation data from 2022 customers as a baseline and post-participation data from 2021 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)	• Engineering Calculations: Census of all projects from the measure categories that comprised 95% of program savings • Consumption Analysis: Matched participants provided in billing data
Primary Data	• Captures install tracking data for PY2021 EEP measures • Billing data from 2020 and 2021 REAP participants
Secondary Sources	• PSEG LI Technical Reference Manuals 2019-2021 • New York State and PSEG LI Technical Reference Manuals • 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 baseline and installed wattage values with the assumptions in the PSEG-LI TRM

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 and kW 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 derived from the consumption analysis
Sampling Method(s)	• Census of all measure installs from Captures • Matched participants provided in billing data
Primary Data	• Captures install tracking data for PY2022 Home Performance measures • Billing data from 2021 and 2022 Home Performance participants
Secondary Sources	• New York State and PSEG LI Technical Reference Manuals • Department of Energy Codes and Standards • Other manufacturer equipment specifications • PSEG LI Planning documents and workbooks
Net-to-Gross Approach	• Heat Pump NTG developed in the 2022 EEP and Home Comfort participant survey efforts. • Stipulated NTG ratios for all other measures
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 air and duct

Evaluation Methodology: Home Performance	
	sealing projects; HVAC system type and fuel type; pre-installation wattages and quantities for direct-install lighting

F. ALL ELECTRIC HOMES METHODOLOGY

Evaluation Methodology: All Electric Homes	
Key Considerations	• Heating and cooling load of the home as specified in the contractor's Manual J calculations and efficiency of installed heat pump system. • HVAC interactive effects on LED lighting and heat pump water heater measures given the all-electric home construction.
General Approach (Ex-post gross)	• Engineering analysis similar to other residential programs. Ground source heat pump calculations mirror Home Comfort. The LED lighting, appliance, connected thermostat, and HPWH measure calculations mirror their EEP counterparts.
Sampling Method(s)	• No sampling required. Detailed review of the lone AEH project completed during the 2022 program year.
Primary Data	• Program tracking data from the Captures system • TRC measure workbook • Contractor invoices and Manual J calculations • Manufacturer specification sheets
Secondary Sources	• ENERGY STAR Qualified Products List • New York State TRM and PSEG Long Island TRM
Net-to-Gross Approach	• Net-to-gross factors for heat pumps and HPWH are based on the results of 2022 EEP and Home Comfort participant survey efforts. ENERGY STAR appliances, connected thermostats, and LED lighting NTG factors come from previous EEP program analysis.
Other Evaluation Techniques	• Long Island market baseline blend of space heating and domestic water heating assumed for baseline fuel and efficiency blend.
Opportunities for Refinement	• Inclusion of savings for electric induction cooktop • Include a flag for zoned HVAC systems to allow for multiple thermostats controlling a single condensing unit without double-counting the capacity.

G. 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.

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.

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.

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.

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.

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.

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

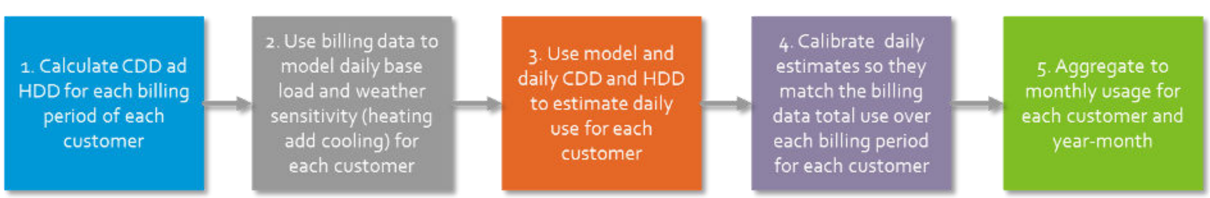
Table A- 1: Lagged Dependent Variable Model Definition of Terms

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

Upstream programs present a unique challenge for dual participation analysis because participation is not tracked at the customer level and therefore cannot be tied back to treatment and control group homes for comparison. While incremental uptake of upstream measures by the treatment group has been observed in multiple studies, the size of the effects that are typically subtracted is disproportionate to the evaluation resources required to estimate it. Table A- 2 provides default values that can be used to calculate a dual participation adjustment factor for upstream offerings. To account for the growing separation between the treatment and control groups over time, Table A- 2 relies on a conditional lookup based on the number of years since cohort inception to calculate the reduction factor.

Table A- 2: Default Upstream Adjustment Factors[12]

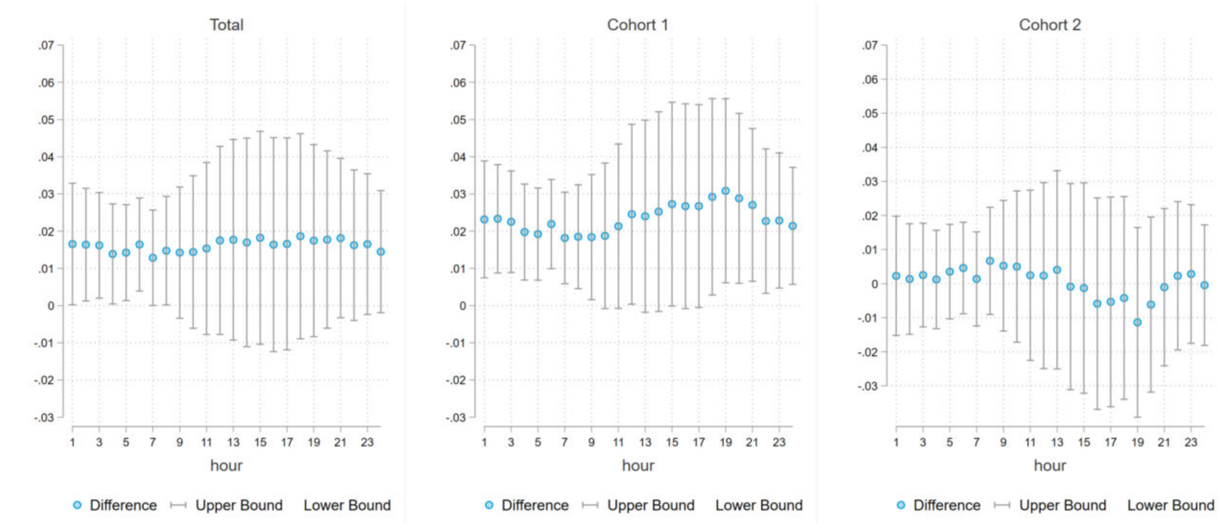
Years Since Cohort Inception	Default Upstream Reduction Factor
1	0.75%
2	1.5%
3	2.25%
4 and beyond	3.0%

PEAK DEMAND REDUCTION ANALYSIS

While no kW demand savings were claimed for HEM during the program year, we did assess the kW demand reduction for the program as a part of the ex-post analysis. The demand reduction analysis utilized hourly metered household data (referred to here as advanced metering infrastructure or AMI data) to estimate demand reduction for HEM customers at the hourly level. As no pre-treatment AMI data was available, we utilized a manual difference approach which examined differences in raw averages between the treatment and control groups for each hour. For the purpose of this analysis, we defined peak demand as hour-ending 4-5 PM and looked at customer demand reductions for the top 20 system load days in 2022. Figure A- 2 depicts the average raw differences between the treatment and control group for each hour and each wave on the top 20 system load days from 2022. While there is a clear directionality in the difference between the treatment and control group, the differences overall are very small and not statistically significant. We can also see that the shape of the savings differs for each wave. Cohort 2 savings are flatter, with slightly higher savings in the morning and evening while Cohort 2 savings are higher overall and concentrated in the middle of the day.

[12] Default values were developed via a review of two studies that used primary data collection with large sample sizes to estimate a dual participation adjustment for upstream lighting. A 2012 PG&E evaluation found values larger than those in this table. http://www.calmac.org/publications/2012_PGE_OPOWER_Home_Energy_Reports__4-25-2013_CALMAC_ID_PGE0329.01.pdf A 2014 Puget Sound evaluation found values lower than those in this table. https://conduitnw.org/_layouts/Conduit/FileHandler.ashx?RID=2963.

Figure A- 2: HEM Hourly Demand Reduction on Peak Summer Days



The raw differences approach does not account for any pre-treatment differences that may exist between the treatment and control groups, as no pre-treatment interval data was available for analysis. To account for any pre-existing differences between the treatment and control groups we adjusted the control group reference load based on the observed pre-treatment percent difference between treatment and controls in the billing analysis. For both Cohorts this pre-treatment difference was 0.261%. Once we adjusted for the pre-treatment difference, we found that the HEM population was able to reduce demand by 8.91 MW between 4 and 5 PM during the summer. Table A- 3 summarizes the peak demand reduction for each wave.

Table A- 3: HEM Peak Demand Reduction

Wave	MW Impact
Cohort 1	8.77
Cohort 2	0.14
Total	8.91

H. 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 2022, the consumption analysis leveraged a matched control design. To control for selection effects, we select matches from future participants rather than Long Island households with no energy efficiency participation. Participants from 2021 acted as the "treatment" group and participants from 2022 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 17% of the billing records in both our REAP and Home Performance data sets 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- 4 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- 4: Estimated Reads

Meter Read Date	Days in Cycle	Estimated or Actual	Billed kWh	Average Daily kWh
2/15/2021	30	Actual	540	18.0
3/15/2021	28	Estimated	462	
4/15/2021	31	Estimated	481	17.7
5/15/2021	30	Actual	630	

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- 5 contains four months of simulated billing data. The consumption values and time periods are hypothetical and not from an actual customer.

Table A- 5: Simulated Billing Data

Billing Period	Nov 12th – Dec 11th	Dec 12th – Jan 11th	Jan 12th – Feb 11th	Feb 12th – Mar 11th
Usage (kWh)	540	577	520	455
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- 6 shows estimated daily usage for each day in December.[13] 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- 6: 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 18.6
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- 7 for December, January, and February.

Table A- 7: Calendarized Billing Data

Value	December 2021	January 2022	February 2022
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

[13] 2021 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 2022 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.

   a. For Home Performance only, create an additional set of indicator variables denoting which program component the household participated in (HPwES, HPDI, and HEA).

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. For the 2022 analysis, the best-performing matching model was slightly different for REAP and Home Performance

Figure A- 3 shows the distribution of weather-normalized consumption for the REAP treatment and control group pools prior to matching. Without any matching, participating households from the 2021 and 2022 show similar distributions and central tendency. Figure A- 4 compares average daily consumption in the REAP treatment and matched control groups across 2020 after the propensity score matching procedure. Although not perfect, there is clearly strong alignment between the two groups.

Figure A- 3: Distribution of Annual Consumption Prior to Matching, REAP

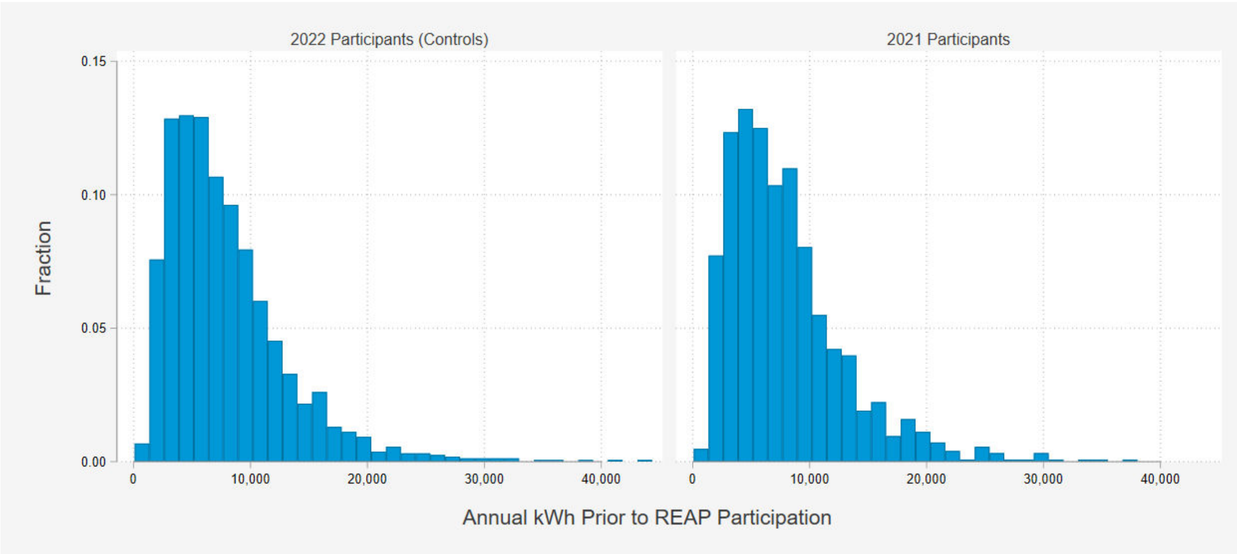


Figure A- 4: Average Daily Usage of Treatment and Comparison Groups (kWh), REAP

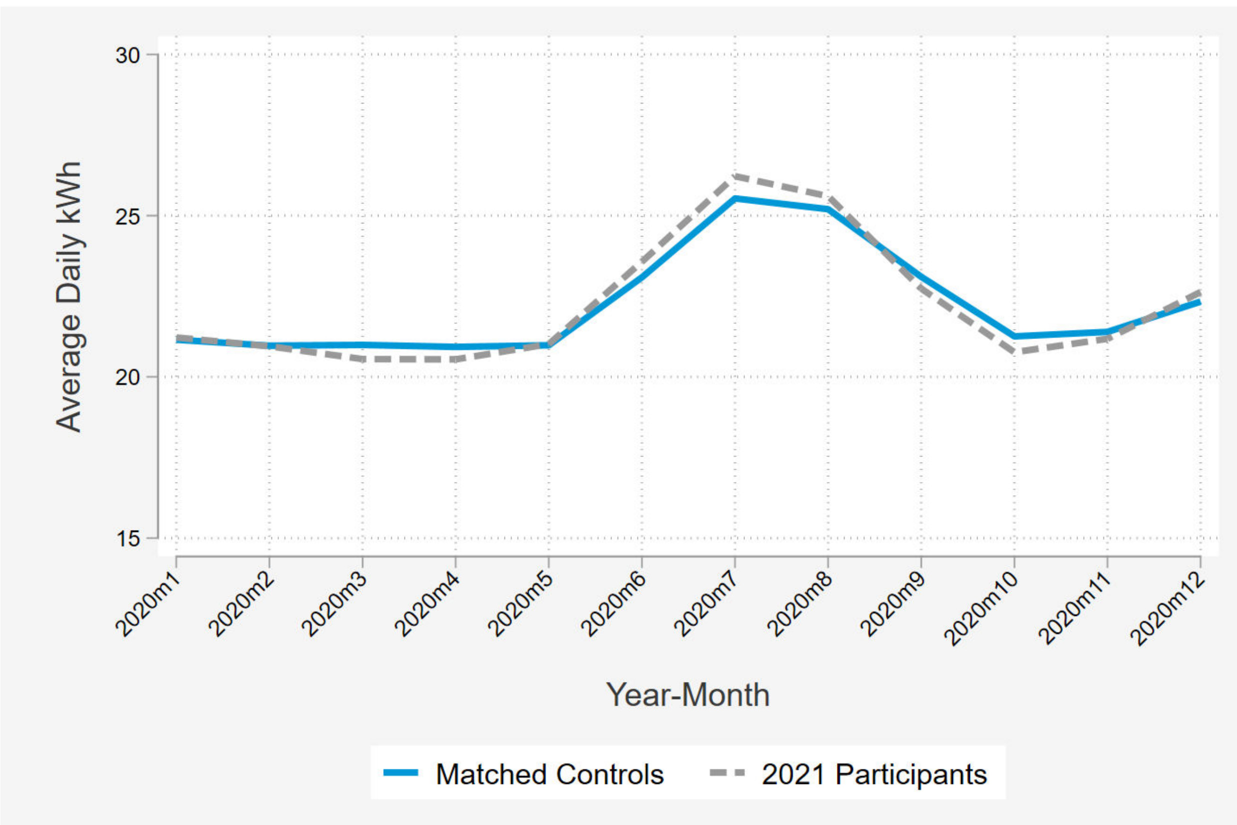


Figure A- 5 and Figure A- 6 are similar to Figure A- 3 and Figure A- 4 but represent Home Performance treatment and comparison group rather than REAP. The takeaways for Home Performance are the same as REAP – the participant group and the matched control groups are well-aligned in their annual consumption and the seasonality of their consumption trends.

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

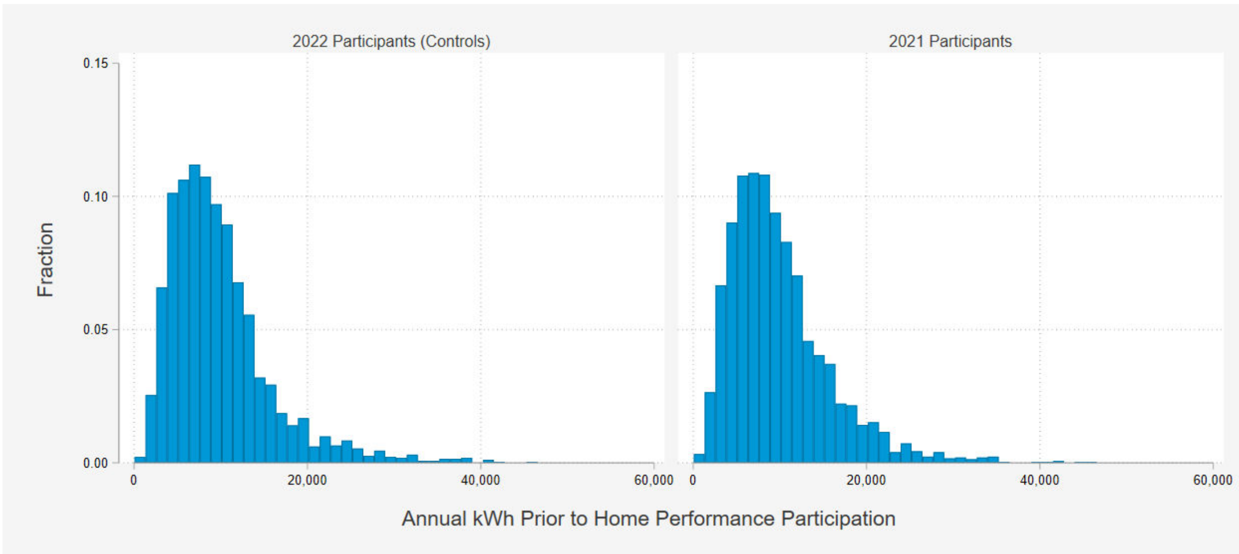
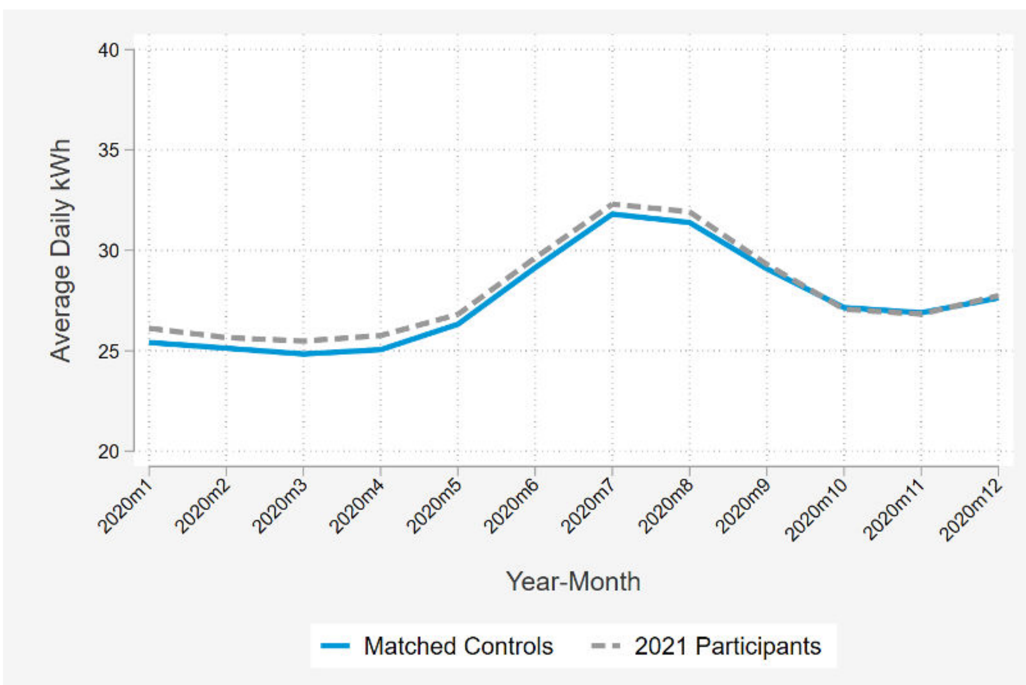


Figure A- 6: Average Daily Usage of Treatment and Comparison Groups (kWh), Home Performance



IMPACT ANALYSIS

The consumption analysis model is a weather-normalized 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. Table A- 8 shows the full model specification. 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 normalized for weather by modeling the interaction of the treat-post variable with the HDD and CDD variables. We then multiply the interaction coefficient of the treat-post and CDD estimates by the expected number of CDD for the McArthur Airport. CDD was calculated using 1991-2020 NOAA climate normals. The same calculations are done using HDD. We then multiply the treatment effect by the number of days in a year to annualize the savings.

Equation 1: Linear Fixed Effects Regression Model Specification

$$\mathrm{kWh}_{\mathrm{imy}} = \beta_0 + \beta_1 * Post_{imy} + \beta_2 * CDD_{my} + \beta_3 * TreatPost_{imy} * CDD_{my} + \beta_4 * HDD_{my} + \beta_5 * TreatPost_{imy} * HDD_{my} + \beta_6 * TreatPost_{imy} + \varepsilon_{\mathrm{imy}}$$

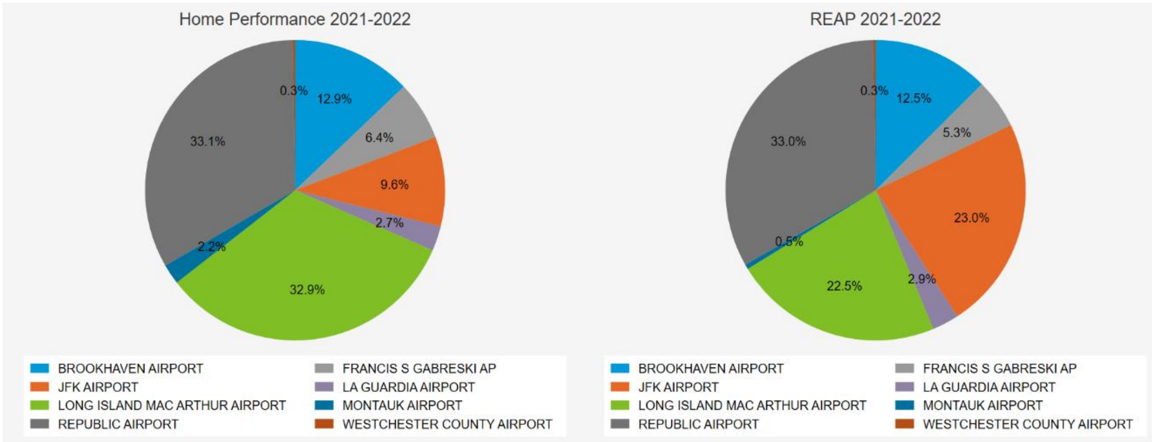
Table A- 8 defines the model terms and coefficients in Equation 1. The impacts are calculated by summing the following terms, 1) the coefficient of the treatpost term (β_6) multiplied by the number of days in a year, 2) the coefficient of treatpost by CDD (β_3) multiplied by the number of cooling degree days in a year, and 3) the coefficient of the treatpost by HDD (β_4) multiplied by the number of heating degree days in a year.

Table A- 8: Regression Model Parameter Definitions

Variable	Definition
kWh_{imy}	Customer i's average daily electric usage in month m of year y.
β_0	The intercept term for customer i, or the "fixed effect" term. Equal to the mean daily energy use for each customer.
$Post_{imy}$	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_1	The coefficient on the post indicator variable. This variable captures the change in consumption in the matched control group during the post-period due to exogenous factors such as the COVID-19 pandemic.
CDD_{my}	The average daily cooling degree days at base 60 degrees (F) for the nearest weather station in month m of year y
β_2	The coefficient on the cooling degree day variable.
β_3	The coefficient on the interaction between cooling degreed day and the post indicator. This captures weather-related factors driving customer consumption behavior during the summer months.
HDD_{my}	The average daily heating degree days at base 60 degrees (F) for the nearest weather station in month m of year y
β_4	The coefficient on the heating degree day variable.
β_5	The coefficient on the interaction between cooling degreed day and the post indicator. This captures weather-related factors driving customer consumption behavior during the winter months.
$TreatPost_{imy}$	The indicator variable for post-period of treatment customers. Equal to one for the participant group in the post period, zero for the participant group in the pre-period, and zero for the matched control group.
β_6	The estimated treatment effect in kWh per day; the main parameter of interest. The change in daily kWh consumption attributable to program participation.
ε_{imy}	The error term.

The Evaluation Team used service zip code to map each participating household to one of eight weather stations. Figure A- 7 shows the distribution of participants across the weather stations, by program. REAP participants are more likely to live in the western portion of PSEG Long Island service territory near Brooklyn and Queens, while Home Performance participants tend to live further east.

Figure A- 7: Weather Station Mapping by Program



The REAP consumption analysis returned an annual savings estimate of 264.4 kWh (95% confidence interval: 6.2 kWh/year, 522.6 kWh/year), and the Home Performance analysis returned an annual savings estimate of 434.2 kWh (95% confidence interval: 284.8 kWh/year, 583.7 kWh/year). Savings for REAP and Home Performance are visualized in Figure A- 8 and Figure A- 9, respectively. Statistical regression output for the REAP and Home Performance models is shown in Figure A- 10 and Figure A- 11, respectively. The key terms in the regression output are, 1) the coefficient for the "treatpost" term, which represents the change in average daily consumption for the treatment group in the post period, 2) the coefficient for the treatpost by cooling degree days, which represents the relationship between the change in daily consumption and summer weather, and 3) the coefficient for the treatpost by heating degree days, which represents the relationship between the change in daily consumption and winter weather. The HDD and CDD coefficients weather normalize the regression results.

Figure A- 8: REAP Consumption Analysis Results Visualized

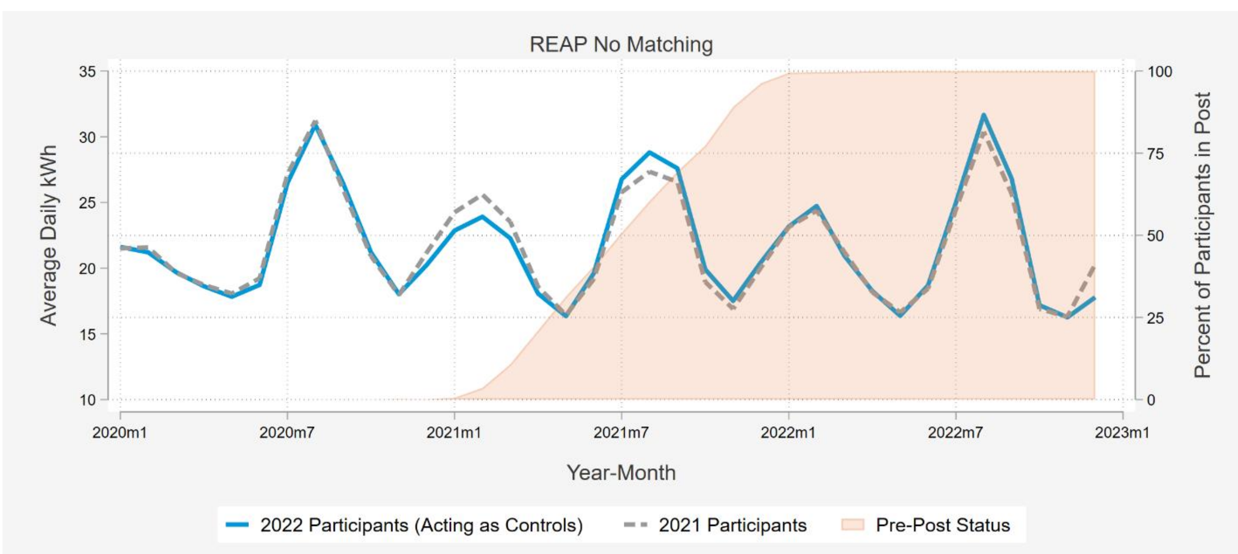


Figure A- 9: Home Performance Consumption Analysis Results Visualized

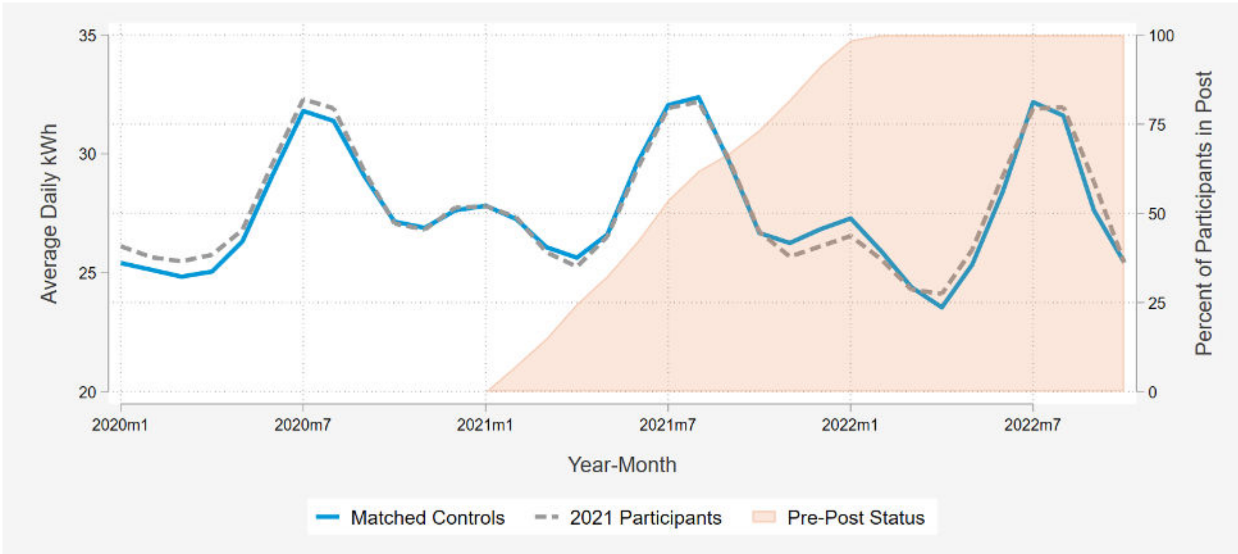


Figure A- 10: Regression Output – REAP

Linear regression, absorbing indicators
Absorbed variable: **account**

Number of obs	=	**53,156**
No. of categories	=	**1,468**
F(**6**, **1739**)	=	**97.63**
Prob > F	=	**0.0000**
R-squared	=	**0.7479**
Adj R-squared	=	**0.7408**
Root MSE	=	**8.6071**

(Std. Err. adjusted for **1,740** clusters in id)

daily_kwh	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
post	**-.3763652**	**.204469**	**-1.84**	**0.066**	**-.7773962**	**.0246658**
1.treatpost	**-1.038811**	**.3912026**	**-2.66**	**0.008**	**-1.806088**	**-.2715337**
daily_cdd60	**.3579706**	**.0176325**	**20.30**	**0.000**	**.3233875**	**.3925537**
treatpost#c.daily_cdd60						
1	**.0434498**	**.0251167**	**1.73**	**0.084**	**-.0058123**	**.0927118**
daily_hdd60	**.1119003**	**.0111877**	**10.00**	**0.000**	**.0899575**	**.1338432**
treatpost#c.daily_hdd60						
1	**.013973**	**.014866**	**0.94**	**0.347**	**-.0151841**	**.04313**
_cons	**19.78068**	**.1614632**	**122.51**	**0.000**	**19.46399**	**20.09736**

Figure A- 11: Regression Output – Home Performance

```
Linear regression, absorbing indicators         Number of obs     =    175,558
Absorbed variable: account                      No. of categories =      4,430
                                                F(   6,    5757)  =     272.48
                                                Prob > F          =     0.0000
                                                R-squared         =     0.7510
                                                Adj R-squared     =     0.7445
                                                Root MSE          =    10.0420

                              (Std. Err. adjusted for 5,758 clusters in id)
```

daily_kwh	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
post	.1797894	.158134	1.14	0.256	-.1302128	.4897916
1.treatpost	-1.329018	.2384505	-5.57	0.000	-1.796471	-.8615655
daily_cdd60	.4239465	.0114273	37.10	0.000	.4015447	.4463483
treatpost#c.daily_cdd60						
1	.0482828	.016981	2.84	0.004	.0149936	.081572
daily_hdd60	.0523128	.0075687	6.91	0.000	.0374753	.0671503
treatpost#c.daily_hdd60						
1	-.0042435	.010399	-0.41	0.683	-.0246294	.0161424
_cons	25.36794	.1071836	236.68	0.000	25.15782	25.57806

APPENDIX B VERIFIED EX-ANTE MEMO

MEMORANDUM 2022 VERIFIED EX-ANTE SAVINGS

Date: February 2, 2023

To: Dan Zaweski, Joseph Fritz-Mauer, Ronan Murphy, and Gabrielle Scibelli (PSEG Long Island)

From: 2022 Evaluation Team (Demand Side Analytics, DNV, Mondre Energy, and BrightLine Group)

Re: 2022 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 energy savings as part of its evaluation of PSEG Long Island's 2022 energy efficiency and beneficial electrification programs. This memorandum defines "verified ex-ante" (VEA) savings and presents the 2022 verified ex-ante savings for each program.

Definition of Verified Ex-Ante

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, we 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 contractors (TRC and Uplight). 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 are assigned static per-unit impacts in the planning 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. PSEG Long Island generally uses a static set of algorithms and assumptions for a given calendar year. However, projects have varying lead times and processing lag so it is not uncommon for a project to begin in one year and complete in the following calendar year. In practice, this means a subset of 2022 projects were completed on 2021 application workbooks with 2021 savings assumptions. For the purposes of VEA, we consider these "carryover" projects verified as long as 2021 algorithms and assumptions were correctly implemented.

The verified ex-ante savings are the first milestone of the 2022 evaluation. They are a separate and distinct performance metric from the evaluated ex-post savings, which will be delivered later this spring. Both the claimed ex-ante and verified ex-ante savings are expressed on a gross basis – meaning they do not reflect adjustments for net-to-gross factors or line losses.

Results

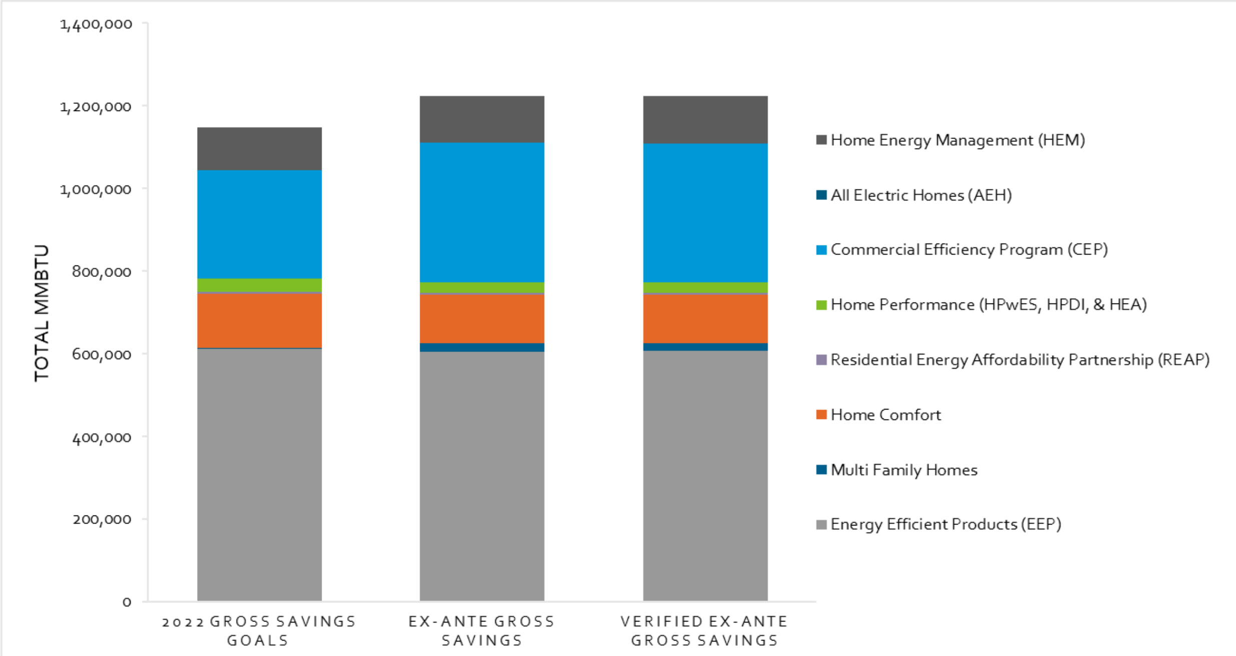
Table 1 summarizes the 2022 verified ex-ante savings for MMBtu. The verified ex-ante savings were 99.9% of the claimed ex-ante gross savings. The evaluation team's independent measure counts were nearly identical to the claimed measure counts. Per-unit MMBtu savings calculations and assumptions matched the approved values almost perfectly for nearly all measures.

TABLE 1: SUMMARY OF 2022 VERIFIED EX-ANTE MMBTU SAVINGS AND GOALS

Program		2022 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)	262,559	337,244	336,381	99.7%	128%
	Multi-Family Homes Rebate	2,423	18,763	18,763	100.0%	774%
Residential	Energy Efficient Products (EEP)	612,027	605,812	605,943	100.0%	99%
	Home Comfort	129,673	117,803	117,803	100.0%	91%
	Residential Energy Affordability Partnership (REAP)	5,953	6,007	5,967	99.3%	100%
	Home Performance (HPwES, HPDI, & HEA)	31,917	25,113	24,783	98.7%	78%
	All Electric Homes (AEH)	560	80	79	99.2%	14%
	Home Energy Management (HEM)	101,952	113,362	113,362	100.0%	111%
Total Commercial:		**264,982**	**356,008**	**355,144**	**99.8%**	**134%**
Total Residential:		**882,082**	**868,177**	**867,938**	**100.0%**	**98%**
Total Energy Efficiency:		**1,147,064**	**1,224,185**	**1,223,083**	**99.9%**	**106.6%**

Figure 1 below shows that the Energy Efficiency Program, Commercial Efficiency Program, and Home Comfort programs were the top three contributing programs, together comprising 87% of verified ex-ante savings in 2022.

FIGURE 1: MMBTU CONTRIBUTIONS BY PROGRAM



Additionally, we developed a metric comparing verified ex-ante savings metric with the established annual savings goals. The portfolio verified ex-ante gross savings were 106.6% of the 2022 savings goals, exceeding PSEG Long Island's goals by 76,019 MMBtu.

In addition to energy conservation goals, PSEG Long Island set goals related to uptake of specific technologies and enrollment in new programs. In the 2022 program year, goals were specifically set for total number of heat pumps installed, total number of homes enrolled in the All Electric Homes Program, and number of distinct buildings enrolled in the Multi-Family Homes Rebate Program. Table 2 below shows that both the claimed number of heat pump installations and enrolled All Electric Homes line up with the verified counts. The verified count of enrolled buildings in the Multi-Family Homes Rebate looked at the total number of distinct buildings associated with customer accounts on all projects enrolled in 2022. The verified count of enrolled multi-family buildings was 70, far exceeding the planning goal of 10 buildings, while 109 enrolled buildings were reported. Further detail on what drives the differences between the claimed and verified MF enrollment counts can be found in Appendix B: Supplemental Detail.

TABLE 2: SUMMARY OF VERIFIED EX-ANTE COUNTS AND ENROLLMENTS

Tracked Installation and Enrollment Counts	Goal	Claimed	Verified
Heat Pump Installations (including LMI)	6,000	7,385	7,385
All Electric Homes - Enrolled Homes	20	4	4
Multi-Family Homes Rebate - Enrolled Buildings	10	109	70

Appendix A: MWh and MW VEA Results

Both the claimed ex-ante and verified ex-ante savings are expressed on a gross basis. This means they do not reflect adjustments for net-to-gross factors or line losses. The primary reporting metric for 2022 VEA is Gross MMBtu savings. Gross MMBtu is the sum of MMBtu Beneficial Electrification ($MMBtu_{be}$) savings and MMBtu Energy Efficiency ($MMBtu_{ee}$) savings.

In Table 3 below we report the claimed ex-ante and verified ex-ante MWh savings. Gross MWh savings in this context, is just the MWh Energy Efficiency (MWh_{ee}) value. Increased MWh consumption from Beneficial Electrification (MWh_{be}) are not considered in the ex-ante savings. This is different from the ex-post evaluation where we will report delta MWh impacts. Delta MWh is the difference between MWh_{ee} and MWh_{be}.

TABLE 3: SUMMARY OF 2022 VERIFIED EX-ANTE MWH SAVINGS

Program		Claimed Ex-Ante Gross Savings	Verified Ex-Ante Gross Savings	Verified Ex-Ante Realization Rate
		MWh_{ee}	MWh_{ee}	%
Commercial	Commercial Efficiency Program (CEP)	67,963	67,713	100%
	Multi-Family Homes Rebate	2,409	2,409	100%
Residential	Energy Efficient Products (EEP)	219,089	219,399	100%
	Home Comfort	2,073	2,073	100%
	Residential Energy Affordability Partnership (REAP)	2,168	2,162	100%
	Home Performance (HPwES, HPDI, & HEA)	1,794	1,718	96%
	All Electric Homes	3.5	3.3	95%
	Home Energy Management (HEM)	33,225	33,225	100%
	Total Commercial:	**70,373**	**70,122**	**100%**
	Total Residential:	**258,352**	**258,579**	**100%**
	Total Energy Efficiency:	**328,725**	**328,701**	**100%**

Table 4 below reports claimed ex-ante and verified ex-ante peak demand (MW) values. PSEG-LI does not claim MW savings for HEM, so we did not calculate ex-ante MW savings for this program. MW savings will be provided in the ex-post evaluation. Ex-Ante MW savings are not adjusted for net-to-gross factors or line losses.

TABLE 4: SUMMARY OF 2022 VERIFIED EX-ANTE MW SAVINGS

Program		Claimed Ex-Ante Gross Savings	Verified Ex-Ante Gross Savings	Verified Ex-Ante Realization Rate
		MW	MW	%
Commercial	Commercial Efficiency Program (CEP)	12.18	11.73	96%
	Multi-Family Homes Rebate	0.33	0.40	121%
Residential	Energy Efficient Products (EEP)	16.26	16.29	100%
	Home Comfort	0.47	0.47	100%
	Residential Energy Affordability Partnership (REAP)	0.40	0.40	100%
	Home Performance (HPwES, HPDI, & HEA)	0.53	0.53	99%
	All Electric Homes	0.00	0.00	100%
	Home Energy Management (HEM)[b]	n/a	n/a	n/a
Total Commercial:		**12.51**	**12.13**	**97%**
Total Residential:		**17.66**	**17.69**	**100%**
Total Energy Efficiency:		**30.17**	**29.81**	**99%**

Appendix B: Supplemental Detail

The evaluation team verified the calculations and inputs for hundreds of measures and inputs. The below table includes additional detail on nuances observed in the Captures data as well as the calculations and assumptions used.

Program	Sub-Component	Description	Implications
Commercial Efficiency Program	Comprehensive, Fast Track and Multi-Family Lighting	▪ We calculated verified ex-ante MW savings using the building type-based coincidence factors (CF) from 2022 PSEG Long Island TRM, whereas the program used a legacy CF of 0.75 for all interior lighting projects.	▪ A 91% MW realization rate for comprehensive, 108% MW realization rate for fast track, and 131% MW realization rate for multi-family lighting measures.
	Refrigerated Case Lighting	▪ TRC applied PSEG 2010 assumptions, based on the 2010 NYS Tech Manual. Planning spreadsheet recommended an algorithm based on NYS TRM v8.	▪ Refrigerated Case Lighting constituted 2% of overall CEP lighting savings.
	Multi-Family Homes Rebate: Building Enrollment Counts	▪ Multi-Family Homes Rebate program enrollments were first tracked for the 2022 program year. An enrolled building is counted using the following criteria: ▪ The building was committed to the program 2022. ▪ The building is new to the Multi-Family Program. For example, if a building enrolls a lighting project in January, then enrolls an HVAC project in February, it will not be counted a second time. ▪ During the verification process, we found that these criteria were not applied consistently month-to-month. This lead to double-counting and a misallocation of building enrollments. ▪ 25 buildings were double-counted. This means that buildings involved in multiple projects, committed across different months were counted again with each new project.	▪ Under the described criteria, the verified counts of enrolled multi-family buildings is 70, while 109 were claimed. This still far exceeds the 2022 goal of 10 buildings enrolled. ▪ This has no impact on VEA MMBtu savings. The Realization Rate for the Multi-Family Rebate program is 100%.

Program	Sub-Component	Description	Implications
		▪ 14 buildings were misallocated to the 2022 program year. These buildings were enrolled in December 2021, but were counted towards enrollment counts for December 2022.	
Home Performance with ENERGY STAR	Air Sealing	▪ For a subset of projects, the TRC workbooks incorrectly defaults the associated HVAC system to 'AC with Electric Heat' when the system was an air source heat pump. This applied a savings factor based on electric resistance heat and overstated measure savings. TRC identified this issue in May 2022 and air sealing projects in the second half of 2022 did not have this issue.	▪ Projects closed before the adjustment claimed impacts based on incorrect assumptions. As a result, the Verified Ex Ante impacts for this measure were slightly lower than claimed resulting in an MMBtu realization rate of 92% for air sealing measures.
	Smart Thermostats	▪ For a small subset of homes, two smart thermostats were installed resulting in two types of workbook calculation errors: ▪ 1) If the thermostats controlled the same HVAC system, then the calculation double counted the HVAC capacity inflating impacts. ▪ 2) If the thermostats controlled two separate HVAC systems, the calculation tied both thermostats back to one system, sometimes applying the incorrect capacity of the heating and cooling being controlled. This pushed impacts in both directions.	▪ Adjustments were made for these measures in the Verified Ex Ante. The VEA MMBtu realization rate for Smart Thermostats was 99%.
All Electric Homes	Smart Thermostats	▪ The All Electric Homes program had one closed project in the 2022 program year. At this home, two smart thermostats were installed and controlled the same HVAC system. The workbook calculation double counted the HVAC capacity, inflating impacts.	▪ The MMBtu VEA realization rate for the All Electric Homes program was 99.2%.

Appendix C: Ex-Post Drivers

The table below outlines measures that are expected to drive differences in impacts during the Ex-Post evaluation.

Program	Sub-Component	Description	Implications
CEP	**Prescriptive: Non-Road Vehicle Electrification**	▪ PSEG Long Island had significant uptake of electric golf cart rebates in 2022. The projects delivered high MMBtu savings at very low cost, which prompted an internal review of the CEP Standard Non-road Vehicle Electrification measure in the 2022 TRM. This measure had been in the PSEG Long Island TRM for several years, but was rarely used. The mid-year review led to changes in the algorithms and assumptions in the 2023 TRM. A synopsis of the changes is below. The most impactful update being a reduction in estimated baseline annual gasoline consumption from 799 gallons (96 MMBtu equivalent) to 120 gallons (15 MMBtu). ▪ The assumed miles driven per year was reduced from 21,971 to 3,306 reducing MMBtu impact per golf cart from 93 to 10.	▪ **Verified Ex-Ante**: No Impact. We found that TRC correctly applied the 2022 TRM algorithm, and the Verified Ex-Ante results. ▪ **Verified Ex-Post**: The updated 2023 TRM method will be applied. Golf carts represented 121,029 MMBtu, 34% of the claimed MMBtu savings under CEP. The application of the updated methodology is expected to decrease the ex post realization rate for golf carts, likely decreasing the overall CEP realization rate and program performance by approximately 100,000 MMBtu.
EEP	**Linear LEDs**	▪ A mid-year adjustment was implemented in August 2022 that allowed all Indoor ENERGY STAR fixtures to be rebated under the LED Linear category in the EEP program. This adjustment was recommended in a memo from TRC and approved by PSEG Long Island. This change led to increased volume in the linear LED product category, predominantly from retrofit kits and recessed downlights. These product types are not consistent with the planning assumptions for Linear LEDs. Per-unit impacts for Linear LEDs are smaller than these ENERGY STAR LED fixtures on average so the adjustment was conservative with respect to 2022 energy savings.	▪ **Verified Ex-Ante**: No impact. The VEA EEP realization rate was 100%. ▪ **Verified Ex-Post**: DSA will reclassify each program-supported product and apply the appropriate baseline wattage assumptions. Non-linear ENERGY STAR fixtures claimed as Linear LEDs will have a realization rate greater than 100%. We expect this adjustment to add approximately 5,000 MMBtu to EEP's verified ex post savings.

Program	Sub-Component	Description	Implications
		However, this adjustment has important implications for 2023 as many of the products moved under the Linear LED category are ineligible due to new federal standards.	▪ **2023 Planning**: PSEG Long Island should limit the Linear LED product category to Linear LEDs by August 2023 to avoid a potentially significant downward evaluation result in 2023 once new federal standards are in place.

APPENDIX C COST-EFFECTIVENESS EX-POST NET TABLES

Table E- 1: 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	Comprehensive Lighting	123,727	67%	1.00	82,551
		Fast Track Lighting	8,294	67%	1.00	5,534
		Refrigerated Case Lighting	5,083	67%	1.00	3,391
		Lighting Subtotal	137,104			91,476
	Multi-Family	Multi-Family	16,778	100%	1.00	16,778
	Standard	Refrigeration	3,443	72%	1.00	2,464
		Motors & VFDs	4,990	72%	1.00	3,570
		Compressed Air	1,108	72%	1.00	793
		Nonroad Vehicle Electrification	14,302	72%	1.00	10,233
		Other Comm. Equipment	2,142	72%	1.00	1,532
		Standard Subtotal	25,986			18,593
	Custom	Custom	44,383	72%	1.00	31,756
	HVAC	HVAC	1,832	72%	1.00	1,311
		MMBtu Total:	**226,082**			**159,913**
MWh	Lighting	Comprehensive Lighting	44,136	67%	1.06	31,217
		Fast Track Lighting	3,089	67%	1.06	2,185
		Refrigerated Case Lighting	1,490	67%	1.06	1,054
		Lighting Subtotal	48,715			34,456
	Multi-Family	Multi-Family	1,042	100%	1.06	1,105
	Standard	Refrigeration	1,009	72%	1.06	765
		Motors & VFDs	1,463	72%	1.06	1,109

		Compressed Air	325	72%	1.06	246
		Nonroad Vehicle Electrification	-1,752	72%	1.06	(1,329)
		Other Comm. Equipment	571	72%	1.06	433
		Standard Subtotal	1,615			1,225
	Custom	Custom	8,256	72%	1.06	6,262
	HVAC	HVAC	536	72%	1.06	406
		MWh Total:	**60,164**			**43,455**
kW	Lighting	Comprehensive Lighting	10,397	67%	1.08	7,474
		Fast Track Lighting	828	67%	1.08	595
		Refrigerated Case Lighting	350	67%	1.08	252
		Lighting Subtotal	11,575			8,321
	Multi-Family	Multi-Family	355	100%	1.08	383
	Standard	Refrigeration	526	72%	1.08	408
		Motors & VFDs	99	72%	1.08	76
		Compressed Air	54	72%	1.08	42
		Nonroad Vehicle Electrification	-15	72%	1.08	(12)
		Other Comm. Equipment	317	72%	1.08	246
		Standard Subtotal	981			760
	Custom	Custom	445	72%	1.08	345
	HVAC	HVAC	133	72%	1.08	103
		kW Total:	**13,490**			**9,912**

Table E- 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	450,306	55%	1.00	247,669

	Heat Pump Pool Heaters	35,827	97%	1.00	34,673
	Pool Pumps	96	90%	1.00	86
	Thermostats	71,760	77%	1.00	55,255
	Appliances	9,835	90%	1.00	8,851
	Recycling	11,487	57%	1.00	6,547
	Water Heaters	2,062	100%	1.00	2,067
	Lawn Equipment	611	90%	1.00	550
	Advanced Power Strips	374	100%	1.00	374
	MMBtu Total:	**582,358**			**356,073**
MWh	Lighting	200,429	55%	1.06	116,862
	Heat Pump Pool Heaters	1,550	97%	1.06	1,590
	Pool Pumps	28	90%	1.06	27
	Thermostats	2,323	77%	1.06	1,896
	Appliances	2,440	90%	1.06	2,328
	Recycling	3,419	57%	1.06	2,066
	Water Heaters	-131	100%	1.06	-140
	Lawn Equipment	-8	90%	1.06	-8
	Advanced Power Strips	110	100%	1.06	116
	MWh Total:	**210,158**			**124,737**
kW	Lighting	28,361	55%	1.08	16,807
	Heat Pump Pool Heaters	0	97%	1.08	0
	Pool Pumps	0	90%	1.08	0
	Thermostats	0	77%	1.08	0
	Appliances	653	90%	1.08	633
	Recycling	556	57%	1.08	342
	Water Heaters	-14	100%	1.08	-15
	Lawn Equipment	0	90%	1.08	0

	Advanced Power Strips	12	100%	1.08	12
	kW Total:	**29,568**			**17,779**

Table E- 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	Ductless Mini-Splits	61,611	91%	1.00	56,152
	Ducted Air-source Heat Pumps	42,841	91%	1.00	39,046
	Geothermal Heat Pumps	9,546	100%	1.00	9,546
	Smart Thermostats	144	90%	1.00	130
	Heat Pump Water Heaters	642	100%	1.00	643
	MMBtu Total:	**114,784**			**105,517**
MWh	Ductless Mini-Splits	(6,085,131)	91%	1.06	(5,879,347)
	Ducted Air-source Heat Pumps	(3,260,034)	91%	1.06	(3,149,788)
	Geothermal Heat Pumps	(393,799)	100%	1.06	(417,470)
	Smart Thermostats	42,203	90%	1.06	40,265
	Heat Pump Water Heaters	(29,729)	100%	1.06	(31,592)
	MWh Total:	**(9,726,491)**			**(9,437,932)**
kW	Ductless Mini-Splits	(20)	91%	1.08	(19)
	Ducted Air-source Heat Pumps	232	91%	1.08	228
	Geothermal Heat Pumps	191	100%	1.08	206
	Smart Thermostats	-	90%	1.08	-
	Heat Pump Water Heaters	(4)	100%	1.08	(4)
	kW Total:	**400**			**411**

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

Resource	Ex-Post Gross Savings	Net-to-Gross Ratio	Line Loss Factor	Ex-Post Net
MMBtu	2,108	100%	1.00	2,108
MWh	692	100%	1.06	733
kW	105	100%	1.08	113

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

Resource	Ex-Post Gross Savings	Net-to-Gross Ratio	Line Loss Factor	Ex-Post Net
MMBtu	34,049	80%	1.00	27,149
MWh	1,040	77%	1.06	829
kW	684	77%	1.08	566

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

Resource	Ex-Post Gross Savings	Net-to-Gross Ratio	Line Loss Factor	Ex-Post Net
MMBtu	113,219	100%	1.00	113,219
MWh	33,183	100%	1.06	35,177
kW	8,996	100%	1.08	9,693

APPENDIX D MEMO: GOLF CART 2023 TRM UPDATE DETAILS

MEMORANDUM

Date: September 15, 2022

To: Dan Zaweski, Jossi Fritz-Mauer, Ronan Murphy, Gabrielle Scibelli; PSEG Long Island

From: Adam Greenwade and Jesse Smith, Demand Side Analytics

Re: 2023 TRM Update to Nonroad Vehicle (Golf Cart and Forklift) Electrification Assumptions

UPDATE TO GOLF CARTS AND FORKLIFTS

The TRM methodology used for *CEP Standard > Nonroad Vehicle Electrification*, comprising electric golf carts and forklifts, originated with the prior EM&V contractor for PSEG Long Island and was in place prior to the 2021-2024 evaluation period. Based on a review of CAPTURES projects, it appears that TRC is correctly applying the 2022 TRM methodology to 2022 projects. During summer 2022 as part of a continuous TRM improvement process, PSEG LI requested a review of the methodology and savings assumptions given conspicuously low $/ MMBtu savings from golf carts. In response, DSA reviewed the golf cart and forklift TRM entries and made some suggested changes to the methodology and parameters for 2023.

To clarify the 2022 evaluation approach:

- **Verified ex ante savings for 2022 will use the 2022 TRM algorithm and therefore we expect that VEA will be identical to what TRC claims.**
- For verified ex post savings, the evaluation team will likely use the 2023 TRM method shown here, putting downward pressure on the ex post realization rate for golf carts and forklifts.

GOLF CARTS

A synopsis of the changes to the golf carts TRM entry is shown in **Table 1.** Default per-project MMBtu savings decrease from 93 MMBtu to 10 MMBtu.

Table 1: Golf Cart Update Summary

	Metric (annual)	Prior to Update	Updated
Miles traveled	miles	21,971[1]	3,306
Baseline	gallons of gasoline	799	120
	MMBtu	96	14
Efficient	kWh	913	1,302
	MMBtu	3	4
Savings	MMBtu	93	10

[1] Derived from 799 gallons of gasoline * 27.5 mpg

The most impactful update to the golf carts entry is a reduction in estimated baseline annual gasoline consumption from 799 gallons (96 MMBtu equivalent) to 120 gallons (15 MMBtu). The prior method of using 1,080 hours of gasoline-powered run time alongside a gallons-per-horsepower-hour assumption suggests about 22k miles traveled annually per cart, while we think about 3,300 is more accurate. This parameter update is one outcome of a broader methodology update that changes the algorithm to a miles-traveled-per-year basis and miles-per-gallon (baseline) or miles-per-kWh (efficient). This makes baseline and efficient use cases more consistent, relies on parameters observable from golf cart specs and project-specific CAPTURES data, bases efficient kWh on actual incentivized golf cart projects from 2019-2022, and can be refined going forward should better assumptions about mileage or battery specs become available.

Figure 1: Golf Cart TRM Savings Algorithm Before and After Update

Before:

Gross Savings Algorithms		
Location	**Metric**	**Algorithm**
Customer Meter	kW	kW = ΔkWh / HOU
	kWh_{ee}	kWh_{ee} = 0
	kWh_{be}	kWh_{be} = ((V * Ah) / 1000 * HOU
	ΔkWh	ΔkWh = kWh_{ee} - kWh_{be}
	$MMBtu_{ee}$	MMBtuee = kWhee * kWh_to_MMBtu
	$MMBtu_{be}$	MMBtube = HP * LF * Hours * BSFC * mmbtu_per_gal_gasoline - kWhbe * kWh_to_MMBtu
	$MMBtu_{total}$	$MMBtu_{total}$ = $MMBtu_{ee}$ + $MMBtu_{be}$

After (changes highlighted):

Gross Savings Algorithms		
Location	**Metric**	**Algorithm**
Customer Meter	kW	kW = ΔkWh / $HOU_{charger}$
	kWh_{ee}	kWh_{ee} = 0
	kWh_{be}	kWh_{be} = (Miles / MPkWh)
	ΔkWh	ΔkWh = kWh_{ee} - kWh_{be}
	$MMBtu_{ee}$	MMBtuee = kWhee * kWh_to_MMBtu
	$MMBtu_{be}$	$MMBtu_{be}$ = (Miles/MPG) * mmbtu_per_gal_gasoline - (kWhbe * kWh_to_MMBtu)
	$MMBtu_{total}$	$MMBtu_{total}$ = $MMBtu_{ee}$ + $MMBtu_{be}$

FORKLIFTS

A synopsis of changes to the Forklifts TRM entry is shown in Table 2. Default per-project MMBtu savings decrease from 272 MMBtu to 159 MMBtu.

Table 2: Forklift Update Summary

	Metric (annual)	Prior to Update	Updated
Hours of use	hours	1,800[2]	2,000
Gals/hour	gallons of propane	1.7	1.0
Baseline	gallons of propane	3,008	2,000
	MMBtu	305	183
Efficient	kWh	9,485	6,913
	MMBtu	32	24
Savings	MMBtu	272	159

The forklift savings algorithm update retains the hours of use (HOU) parameter for baseline and efficient cases and nudges it upward based on the operating hours of participating CEP forklift customers in CAPTURES. The 1 gal/hour assumption is lower than the derived assumption of 1.7 in the prior algorithm, bringing baseline MMBtu down from 305 to 183. This is based on an industry standard and could be refined with actual customer input. Efficient case kWh usage is revised from the TVA TRM provided 9,485 kWh to an estimate of 6,913 kWh based on customer operating days, battery specs in CAPTURES cut sheets, and a typical 8 hrs. use/ 8 hrs. cool/ 8 hrs. charge schedule.

Figure 2: Forklift TRM Savings Algorithm Before and After Update

Before (same as Golf Cart before):

Gross Savings Algorithms		
Location	**Metric**	**Algorithm**
Customer Meter	kW	kW = ΔkWh / HOU
	kWh_{ee}	kWh_{ee} = 0
	kWh_{be}	kWh_{be} = ((V * Ah) / 1000 * HOU
	ΔkWh	ΔkWh = kWh_{ee} - kWh_{be}
	$MMBtu_{ee}$	MMBtuee = kWhee * kWh_to_MMBtu
	$MMBtu_{be}$	MMBtube = HP * LF * Hours * BSFC * mmbtu_per_gal_gasoline - kWhbe * kWh_to_MMBtu
	$MMBtu_{total}$	$MMBtu_{total}$ = $MMBtu_{ee}$ + $MMBtu_{be}$

After (changes highlighted):

Gross Savings Algorithms		
Location	**Metric**	**Algorithm**
Customer Meter	kW	kW = ΔkWh / $HOU_{charger}$
	kWh_{ee}	kWh_{ee} = 0
	kWh_{be}	kWh_{be} = kWh_{batt} * Charges per year * (1/$Eff_{charger}$)
	ΔkWh	ΔkWh = kWh_{ee} - kWh_{be}
	$MMBtu_{ee}$	MMBtuee = kWhee * kWh_to_MMBtu
	$MMBtu_{be}$	$MMBtu_{be}$ = HOU * gal_per_hr *mmbtu_per_gal_propane - (kWhbe * kWh_to_MMBtu)
	$MMBtu_{total}$	$MMBtu_{total}$ = $MMBtu_{ee}$ + $MMBtu_{be}$

[2] Derived from 3,008 gals / 1,800 hours