Evaluation of PSEG Long Island Energy Efficiency Programs

Prepared for PSEG Long Island

By Demand Side Analytics, LLC
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PREFACE

GLOSSARY OF TERMS

Key Term	Definition
Delta MWh	The total change in annual electric energy consumption. Equal to $MWh_{ee} - MWh_{be}$. 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 2021 evaluation.
Ex-Ante Gross Savings	The energy and demand savings recorded by the implementation contractor in the program tracking database. Ex-ante gross savings are sometimes referred to as claimed savings.
Ex-Post Gross Savings	The energy and demand savings estimated by the evaluation team, using the best methods and data available at the time of the evaluation.
Ex-Post Net Savings	The savings realized by the program after independent evaluation determines ex-post gross savings and applies NTGRs and line losses. The evaluation team uses the ex-post net impacts in the cost-effectiveness calculation to reflect the current best industry practices.
Gross Impacts	The change in energy consumption or demand directly due to the participants' program-related actions, regardless of why they participated. These impacts include coincidence factors (CFs) for demand, waste-heat factors, and installation rates. Gross impacts presented in this report do not include line losses and, therefore, represent the energy and demand savings as would be measured at the customers' meters.
kW 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.
MWh Beneficial Electrification (MWh_{be})	The increase in weather-normalized annual electric energy consumption attributable to beneficial electrification measures.

Key Term	Definition
MWh Energy Efficiency (MWh_{ee})	The reduction in weather-normalized annual electric energy consumption attributable to energy efficiency programs or measures.
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.
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

Key Term	Definition
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 for 2020. Equal to the sum of $MMBtu_{be}$ and $MMBtu_{ee}$. This metric represents the change in site-level fuel consumption attributable to the measure or program. This metric does not consider the amount of MMBtu required to generate a kWh of electricity – only the embedded energy in the delivered energy.
Utility Cost Test (UCT)	A test that measures the net costs of an energy efficiency program as a resource option, based on the costs that the program administrator incurs (including incentive costs) and excluding any net costs incurred by the participant. To allow for direct comparison with PSEG Long Island's assessment of all supply-side options and consistent with previous evaluation reports, we continue to show the UCT as a secondary method of determining cost-effectiveness.
Verified Ex-Ante Gross Savings	A key question is if the ex-ante gross energy impacts claimed by the implementation contractors were calculated consistently using the calculations and assumptions approved by PSEG Long Island and LIPA and used to develop annual savings goals. To verify claimed savings, the evaluation team independently calculates the saving using the calculations and assumptions pre-approved by PSEG Long Island. These savings estimates are used to determine if PSEG Long Island achieves its annual scorecard goals.

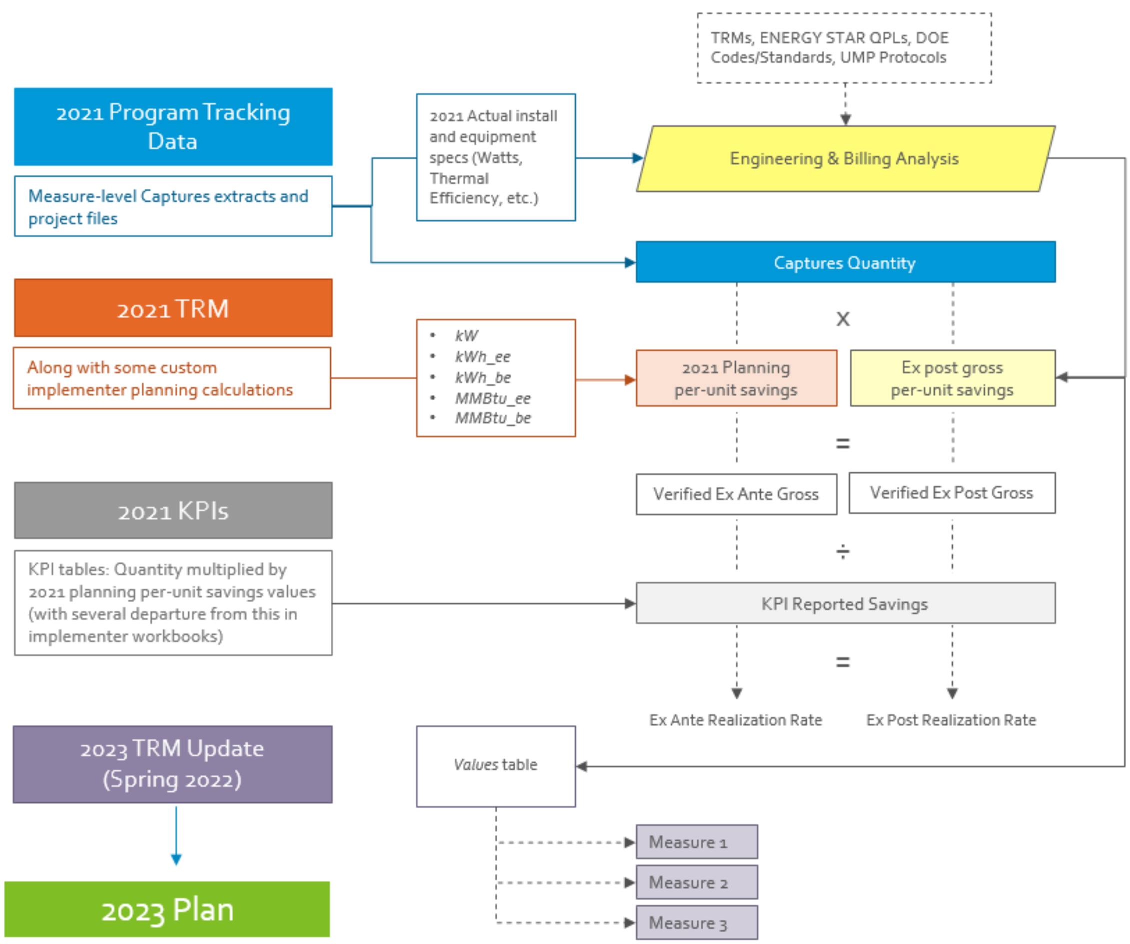
ANNUAL EVALUATION TASKS AND CYCLE TIMELINE

Figure 1 outlines annual energy efficiency and beneficial electrification programming timeline for planning, verified ex-ante, and verified ex-post as well as 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 using the calculations and assumptions approved by PSEG Long Island and the Long Island Power Authority (LIPA). 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, 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.

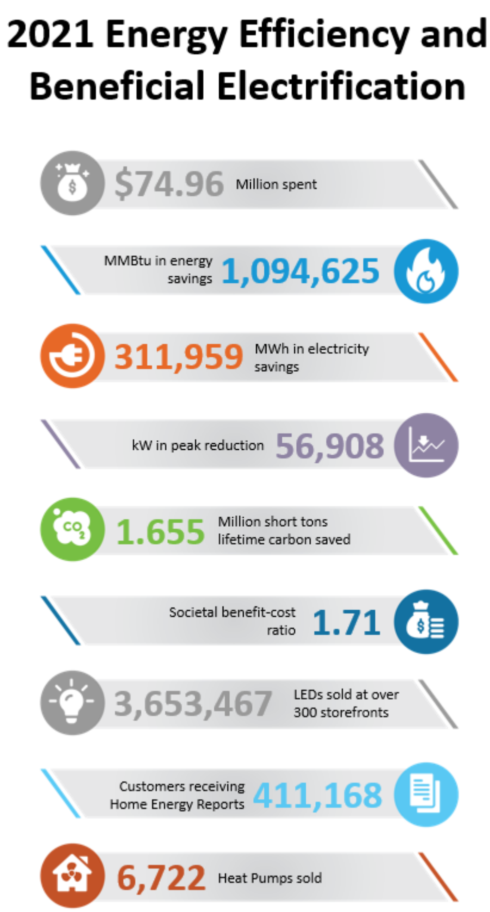
It is important to note that the feedback loop is a nearly two-year cycle. PSEG Long Island has already established 2022 goals and planning assumptions, therefore findings and recommendations from the 2021 ex-post evaluation will not be reflected in the 2022 program claimed savings methodology. The findings and recommendations of this 2021 impact evaluation will be reflected in 2023 planning assumptions, goal setting, and ex-ante savings values. Additionally, major drivers in differences between ex-post and claimed ex-ante savings discovered in the 2020 evaluation were expected to persist in the 2021 evaluation results.

Figure 1: Annual Evaluation Data Flow



1 INTRODUCTION

PSEG Long Island's Energy Efficiency programs offer a wide array of incentives, rebates, and programs to PSEG Long Island residential and commercial customers to assist them in reducing their energy usage and thereby lowering their energy bills. The Energy Efficiency and Beneficial Electrification Portfolio is administered by PSEG Long Island and its subcontractor, TRC, on behalf of the Long Island Power Authority (LIPA). The sole exception is the residential behavioral program, Home Energy Management (HEM), which is administered by Uplight. This report presents the 2021 Energy Efficiency and Beneficial Electrification Portfolio program evaluation ex-post gross results and covers the period from January 1, 2021 to December 31, 2021.



The Demand Side Analytics evaluation team produced two volumes that together compose the entire Annual Evaluation Report. This document, the 2021 Program Guidance Document (Volume II), provides detailed program-by-program impact analysis results. The 2021 Annual Evaluation Report (Volume I) provides an overview of the portfolio-level evaluation findings.

In 2021, PSEG Long Island spent $74.96 million implementing the Energy Efficiency and Beneficial Electrification Portfolio. The investment led to 1,094,625 of total MMBtu savings and avoided 1.655 million short tons of CO2 emissions – the equivalent of removing over 321,000 combustion engine cars for a year.[1] PSEG Long Island's efforts led to $209 million in net societal benefits, with a societal benefit cost ratio of 1.71. Overall, the 2021 activities reduced the Long Island's electricity use by 1.56% and peak demand by 0.85%.

As part of its overall goal of reducing GHG emissions by 40% by 2030, New York set new statewide energy efficiency targets in the New Efficiency New York (NENY) Order in 2018. The 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:

[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

- **Included beneficial electrification measures in its offerings.** PSEG Long Island expanded energy efficiency programs to include rebates and incentives for customers to install measures that supply beneficial electrification to the grid, such as heat pumps, and allow customers to save on their fossil fuel-based costs. Adopting fuel-neutral savings targets allows PSEG Long Island to aggregate efficiency achievements across electricity, natural gas, and delivered fuels such as oil and propane, which in turn shifts investment towards more non-lighting opportunities.
- **Changed its primary performance metric from electric energy (kWh) and peak demand (kW) to MMBtu.** The switch allows PSEG Long Island to pursue beneficial electrification measures like heat pumps that increase electric consumption but lower overall energy consumption and emissions. The MMBtu performance metric is "MMBtu at the site" meaning saved or increased kWh is converted to MMBtu using a static factor of 3.412 MMBtu per MWh - the thermal efficiency of the electric power generation fleet does not affect the calculations. 2021 was the second program year in the switch from electric energy to MMBtu. The transition was overall quite successful, and most of the variation between ex-ante and ex-post evaluated savings are attributable to this fundamental shift in resource accounting and two-year lag between planning and evaluation.

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 2 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 2021 were conducted in 2020 and set the goals, rules, and algorithms for calculating energy savings. 2020 was the first program year PSEG Long Island used MMBtu as its primary performance metric. The 2020 energy efficiency and beneficial electrification measures were not evaluated until the spring of 2021, meaning 2021 programs were already being implemented before performance metrics were available for the first year of MMBtu impact programming. Considering this lag, we expected major drivers in differences between claimed savings and ex-post impacts that were discussed in the 2020 evaluation to persist into 2021. Additionally, the findings and recommendations of this 2021 impact evaluation will be reflected in 2023, not 2022, planning assumptions, goal setting, and ex-ante savings values since PSEG Long Island has already established 2022 goals and planning assumptions.

Figure 2: 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 2020**: Planning for 2021 using draft 2021 TRM assumptions.	• **2021**: Portfolio Programs implemented	• **January 2022**: Verified Ex-Ante Savings Calculated using assumptions from 2020	• **Spring 2022**: Ex-Post evaluation of 2021 portfolio using most up-to-date methods (including PSEG-LI TRMs 2020-2022, NYS TRMs v8 and v9)	• **Spring 2022**: 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

Throughout the 2021 program year, the COVID-19 pandemic continued to affect all aspects of life. While onsite work resumed for many workplaces in the summer of 2020, various waves of COVID-19 variants created extra barriers and difficulties in implementing measures through 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 2021, PSEG Long Island administered six programs, described in Table 1.

Table 1: Energy Efficiency and Beneficial Electrification Program Descriptions

Program	Description
Commercial Efficiency Program	The program assists non-residential customers in saving energy by offering customers rebates and incentives to install energy conservation measures as well as beneficial electrification measures. In addition, Technical Assistance rebates are available under the CEP to offset the cost of engineering and design services for qualifying projects.
Energy Efficient Products	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

Program	Description
	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. 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 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.

1.1 PORTFOLIO ENERGY SAVINGS AND PERFORMANCE

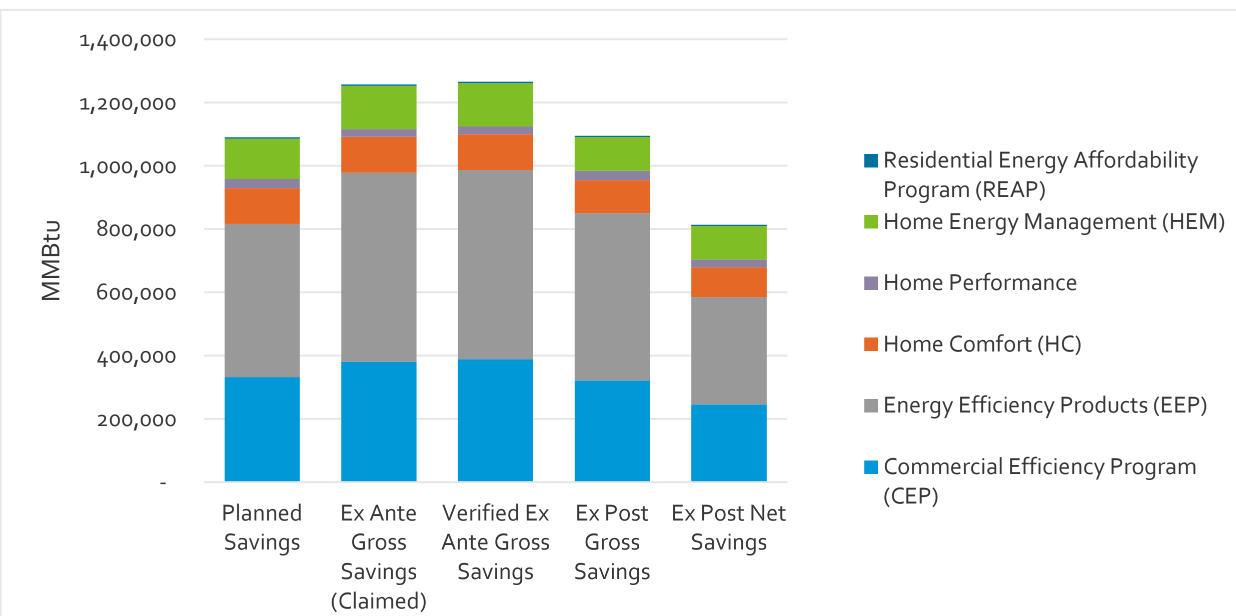
Table 2 below compares planned, claimed, verified, and ex-post gross and net savings under the primary performance metric, MMBtu. A few observations stand out. The claimed and verified ex-ante values exceeded planning targets for all programs except Home Performance. Implementation contractor performance 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 2: Summary of 2021 Energy Program Performance

Sector	Program	Planned Savings (Goals)	Ex-Ante Gross Savings (Claimed)	Verified Ex-Ante Gross Savings	Ex-Post Gross Savings (Evaluated)	Ex-Post Net Savings
		MMBtu	MMBtu	MMBtu	MMBtu	MMBtu
Commercial	Commercial Efficiency Program (CEP)	332,125	380,534	388,871	321,096	245,042
Residential	Energy Efficiency Products (EEP)	484,059	597,662	597,646	529,226	339,821
	Home Comfort (HC)	113,425	113,615	113,544	104,455	95,001
	Home Performance	28,760	24,307	24,307	29,435	23,449
	Home Energy Management (HEM)	127,374	136,606	136,606	106,447	106,447
	Residential Energy Affordability Program (REAP)	4,532	4,648	4,650	3,966	3,966
Subtotal Commercial:		332,125	380,534	388,871	321,096	245,042
Subtotal Residential:		758,150	876,838	876,753	773,529	568,684
Total Portfolio:		**1,090,275**	**1,257,372**	**1,265,623**	**1,094,625**	**813,726**

Figure 3 and Figure 4 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 electricity consumption and peak demand (MW) metrics.

Figure 3: Portfolio MMBtu Savings



The ex-post results are driven by a handful of measures in the three most prominent programs, Energy Efficient Product (EEP), Commercial Efficiency Program (CEP), and Home Energy Management (HEM). Most of these drivers were identified in the 2020 program year evaluation. With the inherent lag in the evaluation and planning cycle, these differences were expected to persist in the 2021 evaluation. Adjustments to address these major drivers were incorporated into the 2022 program year plan.

Figure 4 visualizes how evaluated savings compare to claimed savings (the Realization Rate), how evaluated savings compare to planned savings, and how claimed savings compare to planned savings. The size of the circle in the plots is scaled based on the goals for the program. At the portfolio level, the ex-post gross savings over planned savings was 100%. This indicates that, in aggregate, the energy efficiency and beneficial electrification programs met PSEG Long Island's goals for 2021. Please note, for Home Comfort the ratio for both the Ex-Post Gross/Goals and Ex-Post Gross/Ex-Ante Gross was 92%, so they overlap perfectly in the chart below.

Figure 4: Portfolio Performance Metrics

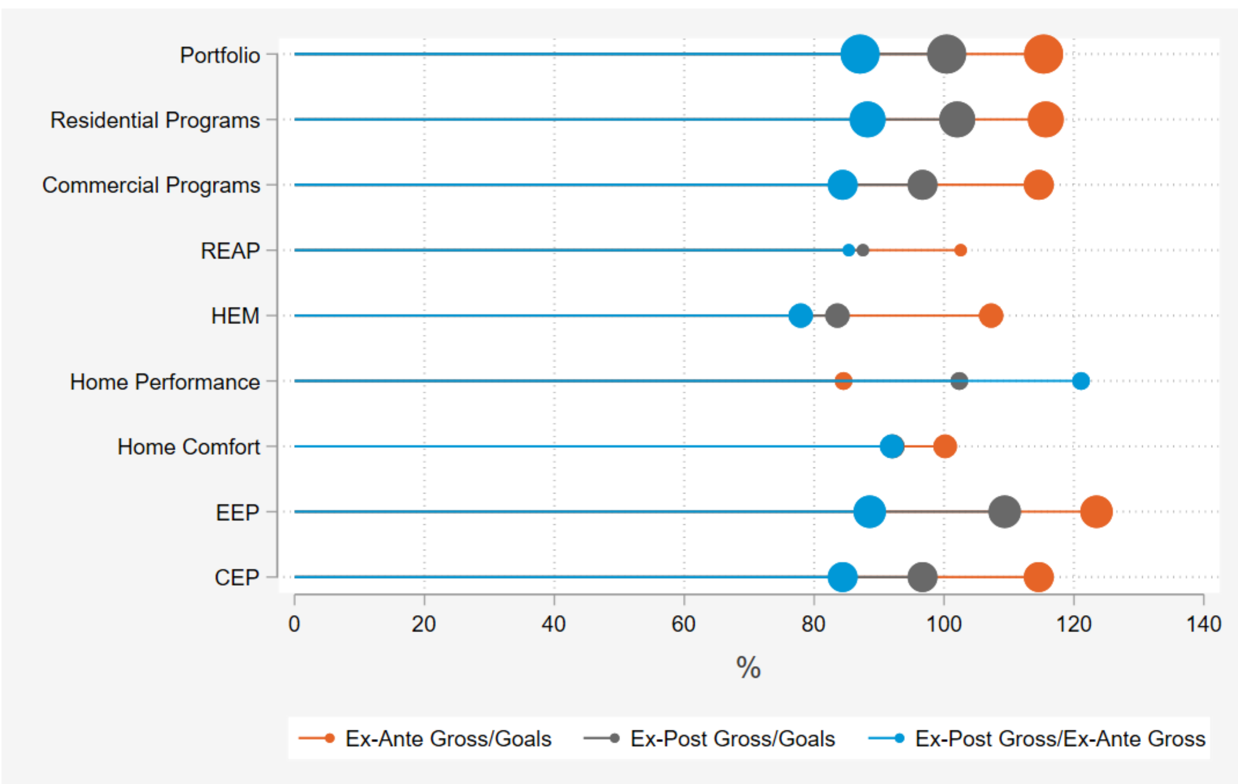


Table 3 summarizes the primary reasons as to why portfolio ex-post gross (evaluated) savings departed from the planned and claimed savings. As Table 3 shows, the biggest drivers of the gap between claimed and ex-post gross savings are the results for EEP, CEP, and HEM. For EEP, the main driver for differences between claimed and ex-post evaluated results are heat pump pool heaters, a carryover issue identified as part of the 2020 evaluation. For CEP, the gap between claimed and ex-post gross (evaluated) saving is the application of waste heat factors, a carryover issue arising due to the shift from electricity (MWh) and peak demand (kW) metrics to at-site MMBtu. For HEM, the actual average savings per household were lower than planned driving down evaluated savings.

These three items led to a 179,116 MMBtu decrease between ex-ante gross and ex-post gross savings. The portfolio level difference between ex-ante gross and ex-post gross was 162,747 MMBtu, meaning that absent these three items the rest of the portfolio had a realization rate greater than 100%. As noted earlier, the change in the primary performance metric from electric energy (kWh) and peak demand (kW) to MMBtu required significant modifications to PSEG Long Island's planning, tracking, and reporting infrastructure. These issues were also primary drivers of portfolio realization rate in the 2020 evaluation. With the lag in the cycle of planning and evaluation, these differences persisted in 2021 but have been updated for 2022. The 2021 evaluation didn't uncover any new large drivers of variance between ex-post gross and ex-ante gross.

Table 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
EEP Heat Pump Pool Heaters	▪ Ex-post gross < ex-ante gross ▪ 91,613 MMBtu difference ▪ 38% Measure Realization Rate	▪ The 2021 evaluation found that the assumed heat delivery of electric baseline pool heaters was overstated in the ex-ante savings assumptions. This was a key finding from the 2020 evaluation. However, since 2021 planning assumptions were finalized before the 2020 evaluation was completed, the 2021 evaluation shows the same variance between ex-ante and ex-post as the 2020 evaluation. The realization rate volatility for heat pump pool heaters should lessen considerably in 2022 once planning assumptions are aligned with these findings. ▪ The actual efficiency of HPPH rebated in 2021 was higher than planning assumptions (COP = 5.98 versus 5.0). Using the actual efficiency values increases MMBtu savings.
CEP Comprehensive and Fast Track Lighting Calculations	▪ Ex-post gross < ex-ante gross ▪ 57,344 MMBtu difference ▪ 78% Realization Rate for two measures	▪ For most of 2021, heating system impacts from reduced waste heat were not considered in ex-ante MMBtu savings calculations. This was observed in the 2020 program evaluation and was expected to persist into the 2021 program year. ▪ In Q4-2021, PSEG Long Island incorporated waste heat factors into the commercial lighting

Portfolio Component	Difference Between Ex-Ante Gross and Ex-Post MMBtu Savings	Summary of Savings Difference
		savings algorithms. We expect the realization rate to increase in 2022 once this change is fully reflected in ex-ante savings claims.
Home Energy Management	▪ Ex-post gross < ex-ante gross ▪ 30,159 MMBtu difference ▪ 78% Realization Rate	▪ The 2021 realization rate for HEM was closer to 100% than 2020 but ex-post savings still fell short of ex-ante claims. ▪ The average savings per household for 2021 was 76 kWh, which is approximately 10% lower than the planned savings of 85 kWh per household, despite issuing more reports than planned. ▪ PSEG Long Island claims ex-ante savings based on the number of reports sent over the year and an assumed savings per report. We recommend that PSEG Long Island adjust their ex-ante calculation method to key off the number of households receiving reports. This change will make the ex-ante claimed savings less sensitive to the actual number of reports issued.

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.

[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.

In addition, all calculated benefits and cost benefit ratios reflect net impacts. Net impacts are the change in energy consumption or demand that results directly from program-related actions taken by customers (both program participants and non-participants) that would not have occurred absent the program. The difference between the gross and net impacts is the application of the net-to-gross ratio (NTGR). Net impacts presented in this report also include line losses and, therefore, represent the energy and demand savings as would be measured at the generator.

Critical drivers of portfolio SCT ratio and net benefit changes in 2021 compared to prior years include:

- **Increases to heat pump measures incremental costs**: analysis of actual project costs and baseline measure costs was leveraged to update incremental cost assumptions. The updated costs were applied to ducted and ductless heat pump measures under the Home Comfort and Home Performance programs. This put some downward pressure on the societal cost test results for each but does not change overall screening results.
- **Overall improvement in EEP measure levelized costs**: While the societal cost results improved noticeably for the EEP program it was not due to any single assumption, but rather a move away from less cost-effective measures and an overall improvement in the cost-effectiveness of remaining measures.

Table 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).

Table 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	$63,555	$51,982	1.22
Residential	Energy Efficient Products	$96,878	$28,264	3.43
	Home Comfort	$36,893	$22,264	1.66
	Residential Energy Affordability Partnership	$1,127	$1,517	0.74
	Home Performance	$7,928	$13,611	0.58
	Home Energy Management	$2,868	$2,691	1.07
Total Residential Portfolio:		$145,695	$68,326	2.13
Total Portfolio[1]:		**$209,250**	**$122,182**	**1.71**

[1] Portfolio costs include $1.87M of advertising that was not allocated to individual programs

Figure 5 shows SCT ratios for each program. Note that the size of markers are proportional to the planned MMBtu savings for each program. The SCT ratio was less than 1.0 for two programs in 2021: REAP and Home Performance, though the reasons for each and the change relative to prior years vary by program. Some key observations are:

- **CEP**: The SCT ratio for CEP is 1.22 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. Further, administrative costs are about a quarter of total costs at the portfolio level. Given that energy savings are relatively low compared to the incremental costs for CEP, spreading these costs proportionately to energy savings further reduces the cost effectiveness margin for CEP.
- **EEP:** The SCT ratio for EEP is 3.43 in 2021, an increase over the 2.85 ratio from in 2020. EEP was the most cost-effective program in the portfolio for 2021. However, it relies heavily on lighting and 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 1.66 in 2021 compared to 2.71 in 2020. The cost effectiveness decreased primarily due to the updates to incremental cost assumptions based on the evaluation team's research into actual project costs after subtraction of baseline measure costs, outlined in Appendix C.
- **REAP**: The SCT ratio for REAP is 0.74. Notably, cost-ineffectiveness is not unusual for income-qualified programs, which typically are not required to be cost-effective.
- **Home Performance**: The SCT for Home Performance is 0.58 in 2021 compared to 0.97 in 2020. The cost effectiveness for Home Performance is also affected by the evaluation team's 2021 research into the incremental cost of heat pumps.
- **HEM**: The SCT is 1.07 in 2021 compared to 1.23 in 2020. The cost effectiveness decreased relative to 2020 due to a relative increase in investment per participant and per MMBtu impact.

Figure 5: Societal Cost Test Ratios by Program

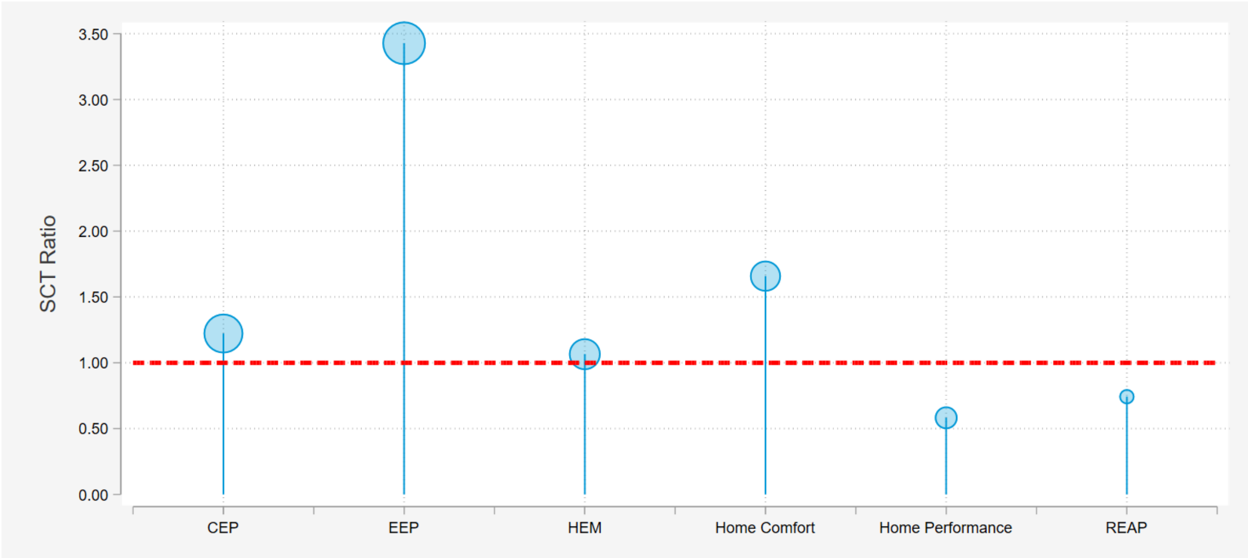
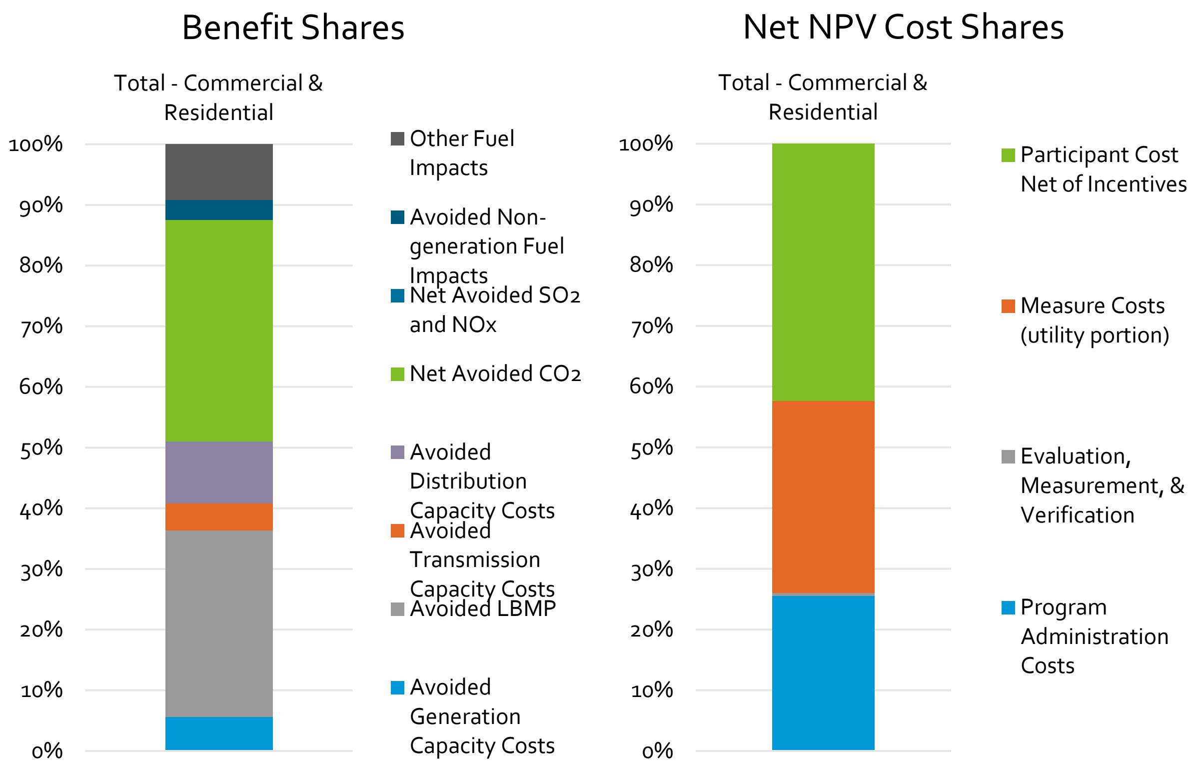


Figure 6 summarizes the benefit and cost categories analyzed and the share each contributed to the SCT. The primary two benefits for the SCT are avoided electric energy (LBMP) at 31% of benefits and avoided carbon emissions at 37% of benefits[3,4]. The combined benefits for capacity (generation, transmission, distribution) together comprise about 20% of societal benefits. From a societal perspective, the largest cost category is the measure costs borne by participants, followed by the measure costs borne by the utility in the form of customer rebates and contractor incentives. Together these two categories comprise the full incremental cost of efficiency measures over baseline measures. Program administration costs, including utility labor, advertising, and implementation vendor fees, comprise about 26% of societal costs.

[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

Figure 6: 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 5.

Table 5: 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.
HVAC		CEP's HVAC offerings have expanded over time and now include high-efficiency unitary and split-system air conditioners, air-source heat pumps, and geothermal heat pumps.
Custom		The Custom program sponsors projects that are not conducive to the prescriptive path, providing business customers support for complex, interactive, or unique efficiency measures.
Distributed Generation (DG)		Over the years, CEP has sponsored a variety of combined heat and power (CHP) projects that result in significant MMBtu savings. In PY2021, CEP sponsored two CHP projects that comprised 14% of the program's claimed MMBtu savings.
Standard Measures		The Standard category includes commercial measures that do not fall into the above categories and includes compressed air, variable frequency drives (VFDs), battery operated lawn equipment, non-road electric vehicles, and pool equipment.

PSEG Long Island instituted notable changes in 2020 that impacted 2021 savings and are expected to become even more prominent in future program years. These changes include:

- CEP's savings goals continue to reflect MMBtu savings. As a result, CEP will continue to provide new offerings to promote beneficial electrification and achieve the MMBtu savings goal.
- During the pandemic, the CEP developed a Small Business Stimulus called the Small Business First program. The Small Business First program was available to qualifying small business customers and provided enhanced rebates for lighting projects. PSEG Long Island offered the

Small Business First program from June to October 2020 and paid nearly $4 million in rebates for 925 projects. Even though the program ended in 2020, some projects were completed and claimed in 2021.

2.1.1 PROGRAM DESIGN AND IMPLEMENTATION

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

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

2.1.2 PROGRAM PARTICIPATION AND PERFORMANCE

PSEG Long Island's CEP exceeded its MMBtu goals in 2021, as shown in Table 6.

Table 6: 2021 CEP Verified Ex-Ante Gross Program Performance vs. Goals

Metric	MMBtu
Goal	332,125
Verified Ex-Ante Gross Savings	388,871
% of Goal	117%

Comprehensive Lighting projects accounted for the largest share of CEP ex-ante gross energy savings in 2021. As shown in Table 7, Comprehensive Lighting projects accounted for 61% of ex-ante gross MMBtu savings, outpacing Fast Track (7%) and Refrigerated Lighting (2%) measure groups within the lighting category.

Table 7. 2021 CEP Percent of Total Ex-Ante Gross Savings by Program Component

Category	Program Component	Ex-Ante Gross Savings		
		% MMBtu	% MWh	% kW
Lighting	Comprehensive Lighting	61%	65%	72%
	Fast Track Lighting	7%	7%	8%
	Refrigerated Case Lighting	2%	2%	1%
	Lighting Subtotal	**70%**	**74%**	**81%**
Distributed Generation	CHP	14%	15%	11%
Standard	Refrigeration	2%	2%	1%
	Motors & VFDs	1%	1%	0%
	Compressed Air	1%	1%	0%
	Other Commercial Equipment	0%	0%	0%
	Standard Subtotal	**19%**	**19%**	**12%**
Custom	Custom	10%	6%	5%
HVAC	HVAC	2%	2%	2%

The lighting category's share of CEP ex-ante gross savings has gradually decreased in recent years, from 94% of CEP kWh savings in 2016, to 77% of claimed kWh savings in 2019, and now 70% of MMBtu in 2021. The program sponsored two CHP projects in 2021 that accounted for 14% of the claimed MMBtu savings. These projects are carryover from the 2018 and 2019 program years when distributed generation projects were still eligible for CEP funding. PSEG Long Island has since stopped supporting new fossil fuel DG offerings, as they do not align with New York's and PSEG Long Island's electrification goals.

2.2 COMMERCIAL EFFICIENCY PROGRAM IMPACTS

2.2.1 OVERVIEW OF IMPACTS BY RESOURCE TYPE

Table 8, Table 9, and Table 10 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 84% of its ex-ante gross MMBtu energy savings claims, 94% of MWh savings claims, and 98% of kW savings claims. As evidenced by high Realization Rates for MWh and kW savings, CEP's electric savings claims were reasonable and generally aligned with the savings algorithms recommended in PSEG Long Island and New York State TRMs. The 84% Realization Rate for MMBtu savings is driven primarily by the evaluation team's inclusion of waste heat penalties for lighting, which reduce overall savings. Opportunities to refine MMBtu savings claims are further addressed in Table 12.

Table 8: 2021 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	1,649	233,474	185,568	79%
	Fast Track Lighting	608	24,863	15,425	62%
	Refrigerated Case Lighting	67	7,434	6,263	84%
	Lighting Subtotal	2,324	265,771	207,256	78%
Distributed Generation	CHP[1],[2]	2	54,881	53,772	98%
Standard	Refrigeration	95	8,099	8,370	103%
	Motors & VFDs	14	2,438	2,527	104%
	Compressed Air	47	3,785	6,143	162%
	Other Comm. Equipment	3	1,521	1,617	106%
	Standard Subtotal	159	15,843	18,656	118%
Custom	Custom	57	37,450	35,578	95%
HVAC	HVAC	59	6,588	5,834	89%
Total[3],[4]		**2,601**	**380,534**	**321,096**	**84%**

[1] The ex-post gross MMBtu savings shown for the Fuel Cell Project is savings "at source". For all other measures, the MMBtu savings are "at site."

[2] One CHP project that was closed in 2021 was installed and incentives paid for in PY2021, but is not operational yet. We applied evaluation realization rates from prior years' DG installations on Long Island for this project to calculate ex-post savings.

[3] One project adjustment of 0.51 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 9: 2021 CEP Ex-Post Gross MWh Impacts by Program Component

Category	Program Component	N	Ex-Ante Gross Savings (Claimed)[a] MWh	Ex-Post Gross Savings MWh	Realization Rate %
Lighting	Comprehensive Lighting	1,649	71,512	67,686	95%
	Fast Track Lighting	608	7,474	5,740	77%
	Refrigerated Case Lighting	67	2,179	1,836	84%
	Lighting Subtotal	2,324	81,165	75,262	93%
Distributed Generation	CHP[1]	2	16,085	15,718	98%
Standard	Refrigeration	95	2,374	2,471	104%
	Motors & VFDs	14	714	744	104%
	Compressed Air	47	1,109	1,800	162%
	Other Comm. Equipment	3	18	0	2%
	Standard Subtotal	159	4,215	5,015	119%
Custom	Custom	57	6,190	5,881	95%
HVAC	HVAC	59	1,664	1,380	83%
Total[2],[3]		**2,601**	**109,468**	**103,255**	**94%**

[1] One CHP project that was closed in 2021 was installed and incentives paid for in PY2021, but is not operational yet. We applied evaluation realization rates from prior years' DG installations on Long Island for this project to calculate ex-post savings

[2] One project adjustment of 148 kWh is included in ex-ante gross savings and overall realization rates, but not shown as a separate line item in this table

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

Table 10: 2021 CEP Ex-Post Gross kW Impacts by Program Component

Category	Program Component	N	Ex-Ante Gross Savings (Claimed) kW	Ex-Post Gross Savings kW	Realization Rate %
Lighting	Comprehensive Lighting	1,649	14,182	13,842	98%
	Fast Track Lighting	608	1,510	1,481	98%
	Refrigerated Case Lighting	67	226	439	194%
	Lighting Subtotal	2,324	15,917	15,763	99%
Distributed Generation	CHP[1]	2	2,168	1,876	87%
Standard	Refrigeration	95	111	157	141%
	Motors & VFDs	14	48	49	102%
	Compressed Air	47	96	352	367%
	Other Comm. Equipment	3	0.3	3	880%
	Standard Subtotal	159	255	561	220%
Custom	Custom	57	1,022	817	80%
HVAC	HVAC	59	361	388	108%
Total[2]		**2,601**	**19,723**	**19,405**	**98%**

[1] One CHP project that was closed in 2021 was installed and incentives paid for in PY2021, but is not operational yet. We applied evaluation realization rates from prior years' DG installations on Long Island for this project to calculate ex-post savings
[2] kW Ex-Ante Gross Savings (Claimed) in table might not match KPI scorecard values. Table values include all Energy Efficiency Savings as well as Beneficial Electrification, while KPI scorecard reports Energy Efficiency Savings only.

2.2.1.1 Combined Heat and Power Projects Impacts

2021 program activity included two CHP projects. Both projects were initiated in 2018 and carried over into 2021, during which the program wholly claimed its impacts. We received actual operational data from one of the two CHP projects to estimate ex-post electricity impacts. To estimate thermal impacts from this project, we utilized the ex-ante assumptions for heat rates (Btu/kWh) during both cooling and heating seasons based on the vendor's observation of faulty dump control valve and BTU meter at the facility. The second CHP project was closed in 2021 by PSEG Long Island utilizing savings estimated during the preapproval stage, and a site inspection by TRC confirmed the installation of the system on site. However, the system is not yet operational. To estimate ex-post impacts from this project, we therefore applied realization rates from PY2018, PY2019, and PY2020 DG installations on Long Island. The 2018, 2019, and 2020 program years involved installation of 7 DG units which ranged from 70 kW to 1,890 kW and were evaluated in prior years.

PSEG Long Island dropped fossil fuel distributed generation from CEP in 2020 because of state policy. PSEG Long Island and LIPA negotiated how to handle DG projects that were approved prior to change under the new fuel-neutral accounting framework and decided to simply convert the electricity generated on-site at 3.412 MMBtu per MWh. The evaluation team's ex-post impacts estimate an "MMBtu at source" metric that takes into account the total impact of the project on Long Island by considering the additional natural gas consumed on-site to power the CHP, line losses, and the thermal efficiency of the grid. Table 11 summarizes the "at site" and "at source[5]" impacts and interim calculations for the participating facility. Our alternative calculation approach returns MMBtu savings 25% lower than the methodology established by PSEG Long Island and LIPA.

Table 11: 2021 CEP CHP Projects Summary

Reporting Basis	Parameter of Interest	Value	Units
Ex-Ante Gross Savings	Annual Energy Savings	16,085	MWh
	Peak Demand Reduction	2,168	kW
	Total MMBtu Savings (MWh generation * 3.412)	54,881	MMBtu
Ex-Post Gross Impacts	Electricity Generation at Site (Reduction in Grid Supplied Power)	15,718	MWh
	Gross MMBtu Associated with Reduction in Grid-Supplied Electricity (MWh generation * 3.412)	53,629	MMBtu
	Summer Peak Generation at Site (Reduction in Participant's Peak Load)	1,876	kW
	Natural gas offset by Useful Heat from CHP	59,325	MMBtu
	Annual natural Gas consumption by CHP	162,947	MMBtu
	Additional Annual Natural Gas Consumption at Site	103,622	MMBtu
	Total Fuel Impact at Site (MMBtu of electricity generated – MMBtu of additional gas input)	-49,993	MMBtu
	Assumed Heat Rate of Marginal Generating Unit	9,413	Btu/kWh
	Fuel Required for Grid-Supplied Electricity Offset	157,394	MMBtu
	Overall Energy Impact at Source	53,772	MMBtu
	MMBtu Realization Rate (53,772 / 54,881)	98%	Ratio

2.2.2 Key Drivers for Differences in Impacts

As the lighting program components comprised the majority of CEP savings in 2021, their performance greatly influenced the overall realization rates. Table 12 summarizes the major differences that contributed to the MMBtu realization rates, along with the evaluation team's recommendations to improve savings claims moving forward. In most cases, our recommendations apply to the 2023 program year. Planning for the 2022 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 2023 PSEG Long Island TRM.

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

Table 12: Key Contributors to CEP MMBtu RR and Proposed Solutions

Component	Summary of Savings Difference	Recommendation
Comprehensive Lighting	▪ Heating system impacts from reduced waste heat were not considered in ex-ante MMBtu savings calculations prior to Q4 2021. ▪ Operating hours by building type differed from values in the 2020 PSEG-LI TRM for a few building types analyzed.	▪ None. Corrective action has been implemented by TRC beginning Q4 2021. ▪ Align savings assumptions with PSEG-LI TRM.
Fast Track Lighting	▪ Claimed energy savings included both demand and energy waste heat factors. This issue was fixed in 2021 Commercial Master Internal Workbook 1.1 version and later ▪ Heating system impacts from reduced waste heat were not considered in ex-ante MMBtu savings calculations prior to Q4 2021, which comprised over 50% of overall fast track lighting projects in 2021. ▪ Actual kW saved per fixture differed from 2021 ex-ante assumptions for a few combinations of existing and installed fixture types.	▪ None. Corrective action has been implemented by TRC beginning Q4 2021. ▪ Consider updating kW savings per fixture per PY2021 evaluation results.
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.
CHP	▪ The ex-post calculations utilized actual performance data for one out of two CHP projects, which showed much lower electricity generation than ex-ante estimates. The evaluation also uncovered faulty dump control valve and Btu flow meters at the facility. Therefore, we used the ex-ante heat rate assumptions, in	▪ We recommend a phased incentive approach for DG projects so that a portion of the total incentive reflects actual system operation. The program should consider deferring a portion of the total project incentive 9-12 months after the system is commissioned to ensure that seasonal fluctuations, downtime, or other

Component	Summary of Savings Difference	Recommendation
	Btu/kWh, to estimate ex-post MMBtu impacts. ▪ The ex-ante and ex-post MMBtu calculations were fundamentally different. Ex-ante claimed savings convert kWh production to MMBtu at site while the ex-post evaluation considers increased fuel consumption, line losses, and the heat rate of the grid to estimate MMBtu impacts at source.	unexpected occurrences are appropriately considered in the final incentive payment. ▪ While the CEP no longer sponsors new DG measures, we recommend applying an "at source" calculation approach to any remaining DG projects claimed in 2022. ▪ MMBtu-at-source calculations require an assumption about the heat rate of the downstate New York electric grid. We recommend a value in the 9,000-9,500 range to account for the mix of combined cycle and combustion turbines on the margin.
Custom Measures	▪ The evaluation timeline did not allow for a full impact evaluation of 2021 custom measures. Consequently, RRs of 95% for MMBTU and kWh savings and 80% for kW savings were used per a 2012 evaluation of custom projects cited in the 2021 PSEG-LI TRM.	▪ PSEG Long Island should consider a refresh of the 2012 custom evaluation in future years.
HVAC	▪ We aligned the cooling equivalent full load hours for packaged air conditioning units with cooling EFLH values stipulated in PSEG Long Island TRM by building type. ▪ HVAC projects can have a long timeline. This leads to carryover across program years. TRC's application workbooks have aligned with the PSEG Long Island TRM since 2020, so this issue should be resolved in 2022.	▪ Ensure that ex-ante EFLH values align with PSEG Long Island TRM recommendations by building type.
Compressed Air	▪ Evaluated kW and kWh savings factors per installed horsepower were higher than ex-ante assumptions, resulting in realization rates over 100%.	▪ Align savings assumptions with PSEG-LI TRM.

2.3 CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this evaluation, our key findings and recommendations for the Commercial Efficiency Program are presented in Table 13. In most cases, our recommendations apply to the 2023 program year. Planning for the 2022 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 2023 PSEG Long Island TRM.

Table 13: 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 now accounts for 70% of ex-ante gross MMBtu savings and 67% of ex-post gross MMBtu savings.	▪ PSEG Long Island should continue to expand program offerings to make up for lighting's continually decreasing share of program savings. Such offerings include non-lighting segments like refrigeration and HVAC, as well as lighting controls, for which the market is rapidly evolving.
▪ For some CEP components, such as refrigeration and compressed air, program savings algorithms and input assumptions continue to reference the 2010 LIPA Technical Manual.	▪ CEP program implementers should reference the PSEG Long Island TRM whenever possible, as it represents the most accurate source of assumptions and includes Long Island-specific research where available.
▪ For select measures such as lighting and compressed air, critical project-level details are excluded from Captures tracking data. As a result, we could not conduct measure-level engineering analysis of the population of projects but rather relied on desk reviews among a sample of comprehensive lighting and refrigeration measures.	▪ CEP administrators should start collecting and tracking relevant measure- and project-specific data in Captures, most notably for the following: ▪ Existing fixture quantity (Comprehensive Lighting program component) ▪ Evaporator Fan Horsepower (Refrigeration Program)
▪ 70% of custom MMBtu comes from one project. The 2021 claimed savings for that project is 50% of its total expected contribution with the full balance to be claimed in 2022.	▪ Our initial review of this project raised some concerns. We think it's prudent for the evaluation team to work with TRC on the M&V approach for this project before PSEG Long Island claims and pays for the second half of the project.

3 ENERGY EFFICIENCY PRODUCTS PROGRAM

3.1 ENERGY EFFICIENCY PRODUCTS PROGRAM DESCRIPTION

The following sections detail the program design, implementation strategies, and PY2021 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 2021 include LED lighting, heat pump pool heaters (HPPH), pool pumps, ENERGY STAR appliances, appliance recycling, battery operated lawn equipment, and heat pump water heaters (HPWH).

Notable changes for PY2021 include a 45% increase in total MMBtu savings over PY2020, and larger contributions from Smart Thermostats as incented units increased five-fold.

Starting in 2020 the EEP program introduced several measures aimed at beneficial electrification, namely heat pump pool heaters and battery-operated lawn maintenance equipment. Beneficial electrification measures increase electricity consumption (negative kWh savings) but reduce total energy consumption (MMBtu) and emissions. Some beneficial electrification measures, like heat pump water heaters, have a composite baseline of electric and fossil fuel units. This leads to both electricity savings and increases in electricity consumption. While heat pump pool heaters kept pace, electric lawn equipment measures grew at a slower rate than the EEP program overall from 2020-2021, rebating about 200 more lawn mowers, weed trimmers and leaf blowers in 2021 than in 2020. These measures are characterized specifically in Table 25 to illustrate the more complex fuel accounting.

In July 2021, a new DOE standard took effect, requiring virtually all pool pumps to be variable speed. This introduces a new baseline assumption and lowers per-unit savings by about 90 percent. As a result of this new baseline, pool pumps were removed from the 2022 EEP portfolio. More detail on this issue is provided in Section 3.2.2.2: Pool Pumps.

3.1.2 PROGRAM PARTICIPATION AND PERFORMANCE

The EEP program achieved 123% of 2021 program MMBtu goals, saving 597,646 MMBtu on a verified ex-ante basis. Ninety-six percent of EEP verified ex-ante savings are attributable to four measure categories: LED lighting (69%), pool heaters (38%), pool pumps (8%), and thermostats (8%). No other measure category contributes more than 2% of overall EEP ex-ante savings. Table 14 shows 2021 EEP program performance compared to goals.

Table 14: EEP Verified Ex-Ante Gross Program Performance vs. Goals

Metric	MMBtu
Goal	484,059
Verified Ex-Ante Gross Savings	597,646
% of Goal	123%

In 2021, the EEP program incentivized nearly 4 million energy efficient products to PSEG Long Island residential customers. PSEG Long Island rebated about 7,000 major appliances (washers, dryers, refrigerators, freezers, and dishwashers) through EEP in 2021 and incentivized 1,867 heat pump pool heaters and 3,519 pool pumps.

The biggest contributor to EEP program savings is LED Lighting (69% of ex-post MMBtu). In 2021, EEP Lighting measures provided point-of-sale discounts on more than 3.6 million LED lamps and fixtures at Long Island retailers.

Pool heater and pool pump quantities and overall savings grew at about the same pace as the overall EEP program relative to 2020, and pool measures again contributed about 20% of EEP program-wide ex-post savings. Pool Pump rebate quantity grew 35% from 2,626 in 2020 to 3,519 in 2021 (128% of the planned quantity of 2,750). The heat pump pool heater rebate quantity increased about 15% from 1,636 pool heaters in 2020 to 1,867 in 2021 (more than 12 times the planned quantity of 150).

Table 15 summarizes participation for each program measure compared to the planning goal.

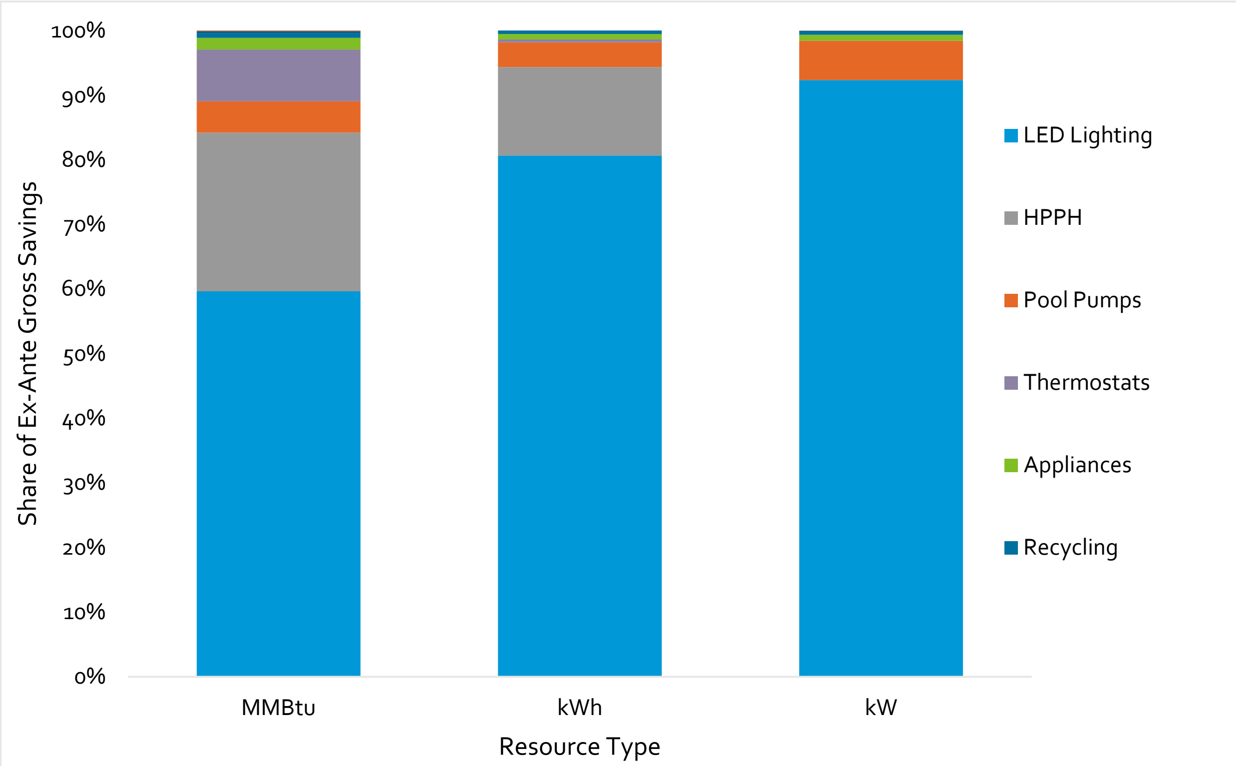
Table 15. 2021 EEP Program Participation vs. Goals, by Measure

Measure	Number of Units	Planned Units (Goal)	Percentage of Goal Achieved
EEP ES Room Air Purifier (<200 CADR)	1,177	1,060	111%
EEP ES Room Air Purifier (>200 CADR)	504	940	54%
EEP Advanced Power Strip Tier 1	1,569	15,000	10%
EEP Advanced Power Strip Tier 2	159	1,000	16%
EEP Clothes Dryer - Electric Resistance	2,305	2,500	92%
EEP Clothes Dryer - Most Efficient	53	350	15%
EEP ME Clothes Washer	2,219	3,500	63%
EEP ES Dehumidifier	3,656	7,500	49%
EEP Heat Pump Water Heater - Small	124	214	58%
EEP Heat Pump Water Heater - Large	54	107	50%
Tankless Water Heater	10	300	3%
EEP Pool Pump Variable Speed	3,519	2,750	128%
Heat Pump Pool Heater	1,867	150	1245%
EEP Refrigerator Recycle- Pre 2001	834	800	104%
EEP Refrigerator Recycle- Post 2001 & Pre 2010	1,710	2,000	86%
EEP RAC Recycle	14	-	-
EEP Dehumidifier Recycle	126	150	84%
LED Standard	1,691,372	1,200,000	141%

Measure	Number of Units	Planned Units (Goal)	Percentage of Goal Achieved
Connected Lighting Bulbs	-	6,400	0%
LED Specialty	1,946,843	2,400,000	81%
EEP Redeemed Recycling Voucher	73	-	-
Connected Thermostat	3,576	3,750	95%
Learning Thermostat	4,036	3,750	108%
EEP Most Efficient Dishwasher	32	-	-
EEP Most Efficient Bathroom Exhaust Fans	1	-	-
EEP ES Freezer	43	-	-
EEP Electric Lawn Mower <4aH	14	50	28%
EEP Electric Lawn Mower 4-5aH	353	200	177%
EEP Electric Lawn Mower >5aH	832	250	333%
EEP Electric Weed Trimmer	1,382	500	276%
EEP Electric Leaf Blower	1,422	500	284%
EEP ES Storm Window	93	5,000	2%
ES Linear Fixture	15,252	2,000	763%
In-storage LEDs	298,760	298,760	100%
Total	**3,983,984**	**3,959,481**	**101%**

Figure 7 shows the distribution of ex-ante gross energy and demand savings across the EEP program. Lighting measures (LED Standard/Specialty, Connected Lighting, Linear LEDs, and In-storage LEDs) account for most of the ex-ante gross savings across all resources. Heat pump pool heaters, pool pumps, and Wi-Fi connected thermostats are other top measures; along with LED lighting, these account for 98% of ex-ante gross MMBtu savings. Savings distribution by measure category did not change much from 2020. For a comparison of MMBtu savings between 2020 and 2021, see Figure 11.

Figure 7: 2021 EEP Program Ex-Ante Gross Savings by Resource and Measure Category



3.1.2.1 Lighting Detail

Table 16 shows examples of the LED lighting types supported during 2021. Table 17 shows the most common product sold by each lighting type. Table 18 shows the distribution of incented LED lights by retailer and style. The "Other" row in Table 18 aggregates several small retail partners with limited 2021 program volume. Over 60% of LED sales came through Home Depot or Costco. Lowe's sold 8% of the LEDs. About 2,000 LEDs, or 0.14%, were sold through the PSEG online store. It should be noted that N&S Electric, REVCO, and Schwing Lighting are electrical distributors that represented about 8% of all EEP lighting sales and a much higher share of EEP fixtures. Table 20 shows the distribution of sales by purchase program. Ninety-nine percent of 2021 bulb rebates took place through lighting buydowns.

Table 16: 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.

Table 17: Most Common Product by Bulb Type

Product	Bulb Type	Description
	**A-Lamp**	Feit Electric Led 60W Replacement Soft White, 6 Count
	**Candelabra**	EcoSmart 60W Equivalent Soft White Clear Dimmable LED Light Bulbs B11 Candelabra Base (3 Pack)
	**Fixture**	HALO LT460WH6930 90CRI, 3000K, Integrated LED Recessed Retrofit Baffle Trim LED Module, 4", White
	**Globe**	Satco S21738 – 120V – 4.5W – G25 LED – Medium Base – Dimmable – White – 350 Lumens – 2700K Warm White – 83 CRI – 2 Packs
	**Reflector**	EcoSmart 65-Watt Equivalent BR30 Dimmable LED Light Bulb, Bright White
	**Linear Fixture**	3 ft. 1-Light 30-Watt Integrated LED White Utility Shop Light with Power Cord

Table 18: Distribution of Standard and Specialty LED Bulbs by Retailer and Bulb Type

Retailer	General Service	Reflectors	Globes	Candelabra	Total
ACE Hardware	96,236	35,297	26,981	23,541	182,055
BJ'S'	75,500	21,586	---	9,964	107,050
Costco	389,610	98,792	5,492	85,266	579,160
Home Depot	719,630	305,030	83,991	170,221	1,278,872
Lowe's	150,097	59,950	12,536	48,070	270,653
N&S ELECTRIC	581	4,710	38	8	5,337
Other	101,436	27,681	7,882	14,310	151,309
PSEG Online Marketplace	2,034	---	---	---	2,034
REVCO	11,816	37,644	---	5,468	54,928
SCHWING	16,612	9,955	---	1,915	28,482
TARGET	59,187	7,233	3,781	5,964	76,165
Walmart	86,010	11,104	1,664	9,140	107,918
Total	**1,708,749**	**618,982**	**142,365**	**373,867**	**2,843,963**

Table 19: Distribution of LED Fixtures by Retail and Bulb Type

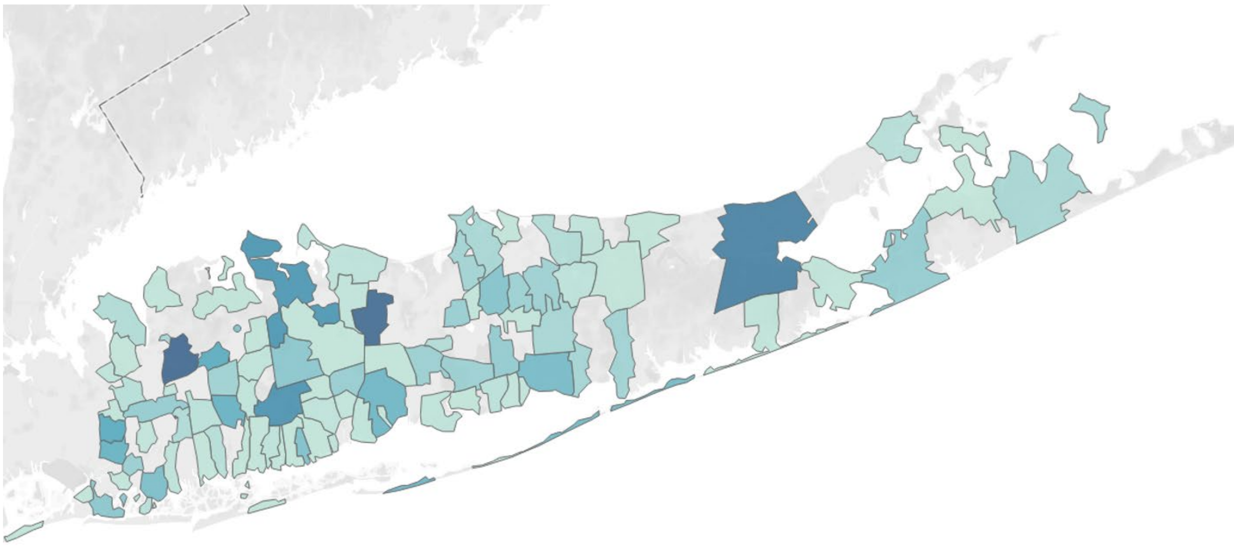
Retailer	Integrated Fixtures	Linear Fixtures	Total
ACE Hardware	30,220	582	30,802
BJ'S	---	1,100	1,100
Costco	57,806	---	57,806
Home Depot	282,844	9,885	292,729
Lowe's	30,908	3,685	34,593
N&S ELECTRIC	89,274	---	89,274
Other	120,955	---	120,955
REVCO	67,147	---	67,147
SCHWING	115,098	---	115,098
Total	**794,252**	**15,252**	**809,504**

Table 20: Purchase Program Breakdown

Retailer	Percentage of Total LED Products
Bulk Lighting: Retail Promotions/Trade Show	1.4%
Catalog: PSEG Online Marketplace	0.1%
Lighting Buydowns: Retail Sales	98.6%

Figure 8 shows how the incented bulbs were dispersed geographically using retailer zip codes. Each polygon represents a different zip code. The shade of the polygons represents the share of 2021 LED bulbs incented in that zip code (where a darker shade means more). Note the figure is not normalized to the population.

Figure 8: Geographic Distribution of Incented LED Bulbs



3.1.2.2 Pool Research during 2021 Ex-Post and 2023 TRM Update

As part of the 2021 evaluation, DSA conducted research to refine pool assumptions critical for calculating annual heating energy load—namely pool volume and surface area—using observations of actual Long Island pools. The average volume of pools in the EEP program is 24,598 gallons. This average was calculated using midpoints of the volume range selected by the customer as reported in the Captures tracking data.

The average surface area of pools in the EEP program is 596 square feet. Addresses for a sample of 150 EEP participants with a pool were located using either Google Earth, Google Maps satellite or the Zoom Earth web application and categorized based on shape according to the TRM (elliptical, kidney, oval or rectangular). Pool surface area was estimated by overlaying a measurement with the satellite image (see upper right corner of Figure 9) and using the applicable TRM formula for the shape, as shown in Table 21.

Figure 9: Example of Pool Satellite Imagery and Measurement

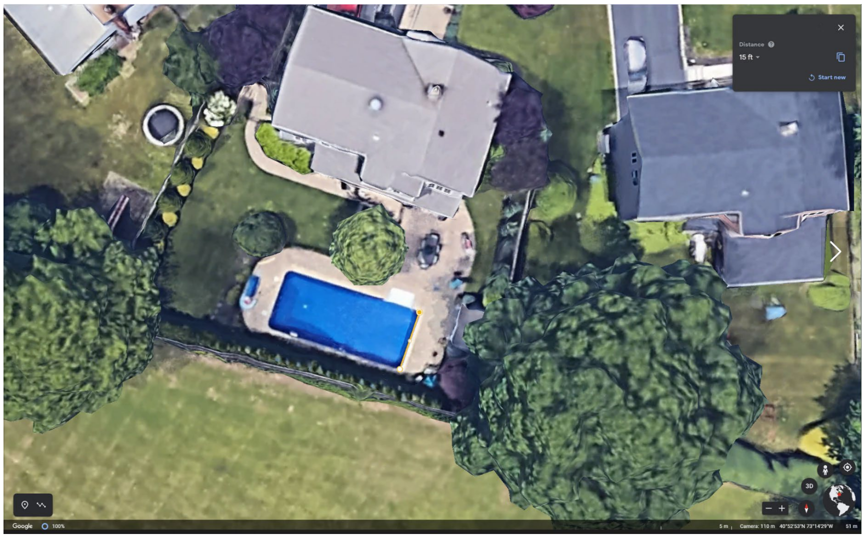


Table 21: Pool Surface Area Formulas

Pool Shape	Elliptical	Kidney Shaped	Oval	Rectangular
Measurements Needed	Short radius Long radius	Length Longest width at one end Longest width at the other end	Radius of a round end Length of straight sides Width between the straight sides	Length Width
Surface Area Formula	SA = 3.14 * short radius * long radius	SA = 0.45 * length * (width1 + width2)	SA = 3.14 * radius^2 + (length of straight sides * width)	SA = l * w

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 22 shows ex-ante and ex-post gross MMBtu impacts and realization rates by measure category. Table 23 and Table 24 show the equivalent impacts for MWh and kW.

Table 22: 2021 EEP MMBtu Impacts by Measure Category

Measure Category	Ex-Ante Gross Savings (Claimed) MMBtu	Ex-Post Gross Savings MMBtu	Realization Rate %
Lighting	356,605	365,456	102%
Heat Pump Pool Heaters	146,581	54,968	38%
Pool Pumps	29,040	44,474	153%
Thermostats	47,967	42,719	89%
Appliances	10,706	8,459	79%
Recycling	4,165	9,893	238%
Water Heaters	1,403	2,048	146%
Lawn Equipment	786	797	101%
Other (APS, Storm Windows, Exhaust Fan)	409	410	100%
Total	**597,662**	**529,226**	**89%**

Table 23: 2021 EEP MWh Impacts by Measure Category

Measure Category	Ex-Ante Gross Savings (Claimed[1]) MWh	Ex-Post Gross Savings MWh	Realization Rate %
Lighting	178,523	162,138	91%
Heat Pump Pool Heaters	30,293	2,379	8%
Pool Pumps	8,511	13,035	153%
Thermostats	982	1,528	156%
Appliances	1,858	1,659	89%
Recycling	1,221	2,900	238%
Water Heaters	(114)	(98)	86%
Lawn Equipment	(54)	(53)	98%
Other (APS, Storm Windows, Exhaust Fan)	120	120	100%
Total	**221,340**	**183,607**	**83%**

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

Table 24: 2021 EEP kW Impacts by Measure Category

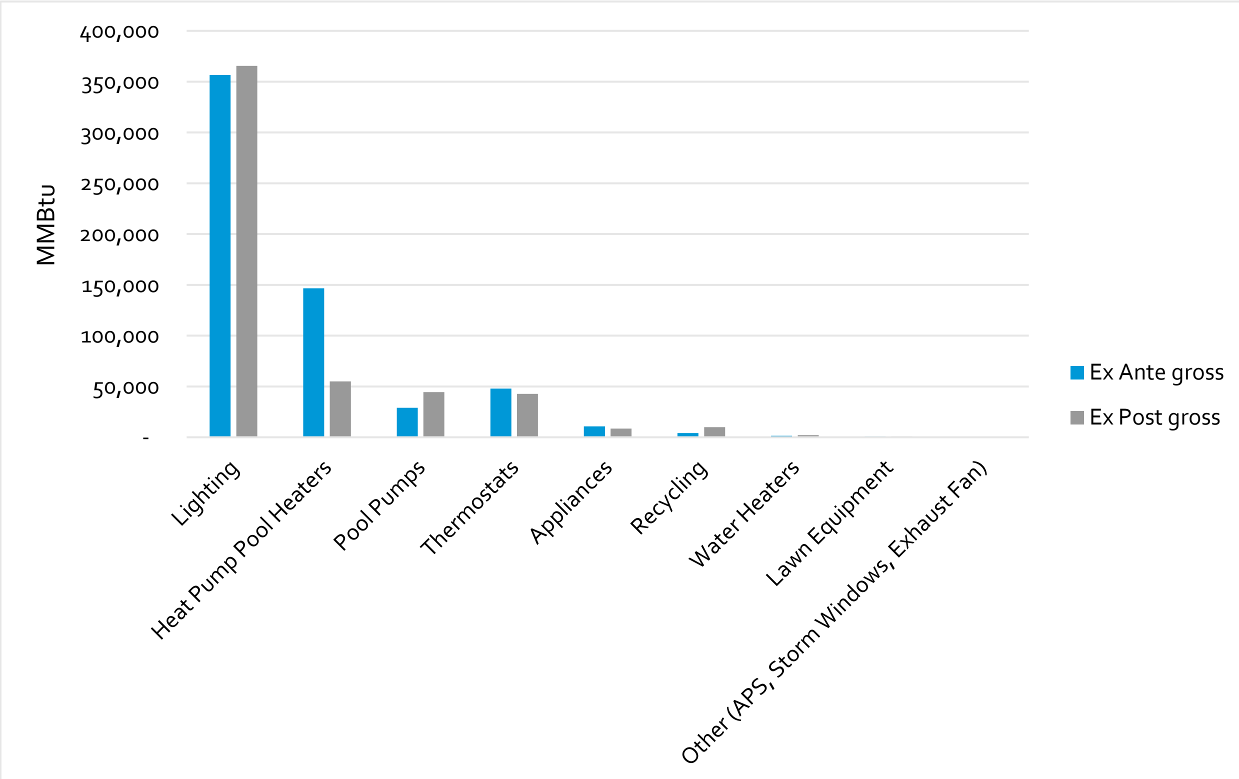
Measure Category	Ex-Ante Gross Savings (Claimed[1]) kW	Ex-Post Gross Savings kW	Realization Rate %
Lighting	31,965	23,564	74%
Heat Pump Pool Heaters	-	-	
Pool Pumps	2,103	3,228	154%
Thermostats	-	-	
Appliances	315	333	106%
Recycling	181	438	242%
Water Heaters	31	(9)	-28%
Lawn Equipment	-	-	
Other (APS, Storm Windows, Exhaust Fan)	13	13	100%
Total	**34,608**	**27,568**	**80%**

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

3.2.1.1 Ex-Post Findings

The overall EEP program MMBtu realization rate, calculated as the ratio of ex-post gross savings to ex-ante gross savings, is 89%. The heat pump pool heater measure accounts for 85% of the program level difference between the claimed and ex-post gross MMBtu (the MMBtu variance). Pool pumps contribute the second-most (24%) to overall MMBtu variance. The EEP program achieved 109% of the 2021 MMBtu goal on an ex-post gross basis. Figure 10 compares ex-ante gross and ex-post gross MMBtu savings by measure category.

Figure 10 EEP Ex-Ante Gross and Ex-Post Gross MMBtu Savings by Measure Category

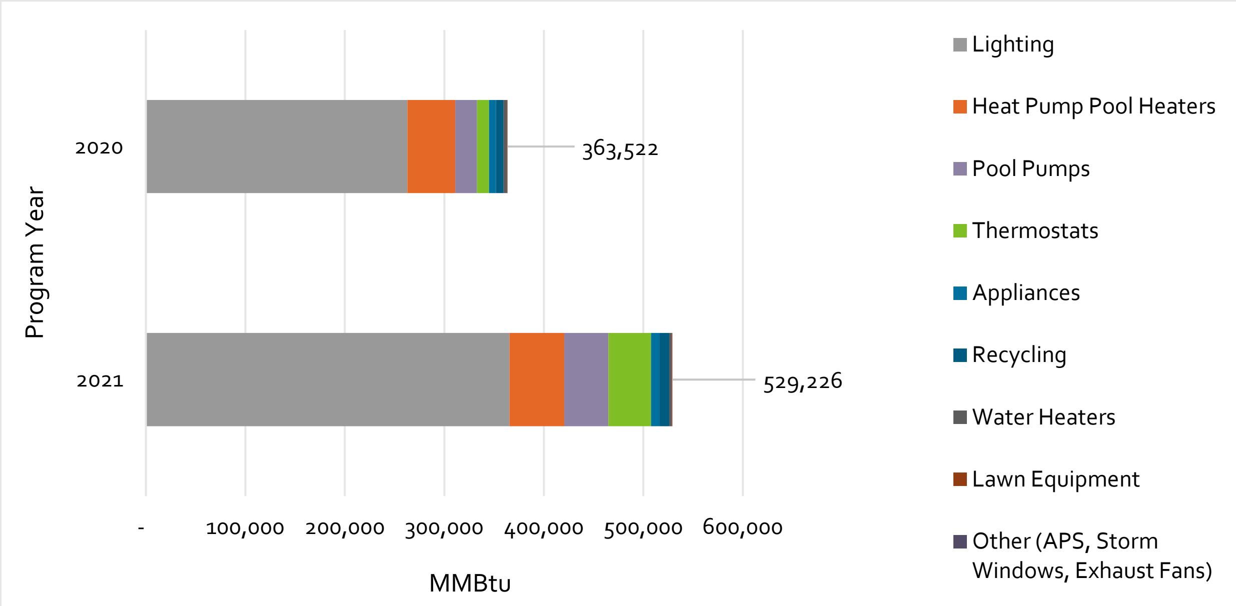


Overall, 20 out of 34 EEP measures have MMBtu realization rates of greater than 100%, and 14 measures have realization rates of less than 100%. Just like in 2020, the highest realization rate is for Room AC Recycling (2,407%). The lowest realization rate is for Tankless Water Heaters (25%). The biggest positive ex-post gross MMBtu variance is in LED Standard, which exceeds ex-ante values by 17,081 MMBtu (RR = 114%), and Refrigerator Recycling, which exceeds ex-ante estimates with a combined RR of 239% and ex-post gross savings that exceed ex-ante gross by 5,673 MMBtu.

3.2.1.2 Comparison to 2020

EEP MMBtu savings increased by 45% from 2020 to 2021. The biggest increases are in the obvious measure categories—that is, Lighting, Pool Heaters, and Pool Pumps—as the number of incented units grew across each of these categories. Thermostat MMBtu savings tripled between 2020 and 2021 as the number of rebated WiFi and Learning thermostats grew from 1,500 to more than 7,600. Figure 11 shows how EEP MMBtu savings changed from 2020 to 2021.

Figure 11: EEP MMBtu Impacts by Measure Category, 2020 and 2021 (ex-post gross)



3.2.1.3 Beneficial Electrification Impacts

Table 25 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 25: 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 – Elec. Resistance	0.07	0.07	0.21	22	202	(181)
EEP-310 EEP Clothes Dryer – Most Efficient	0.35	0.35	0.51	102	50	51
EEP-600 EEP Heat Pump Water Heater – Small	1.07	1.07	12.40	313	696	(384)
EEP-610 EEP Heat Pump Water Heater – Large	0.52	0.52	8.26	153	690	(536)
EEP-650 Tankless Water Heater	0.08	0.08	6.46	24	1,960	(1,936)
EEP-655 Tankless Water Heater	0.08	0.08	6.46	(204)	1,960	(2,164)
EEP-720 Heat Pump Pool Heater	7.79	7.79	29.44	2,283	1,008	1,274
EEP-1900 EEP Electric Lawn Mower <4aH	-	-	0.40	-	26	(26)
EEP-1905 EEP Electric Lawn Mower 4-5aH	-	-	0.40	-	26	(26)
EEP-1910 EEP Electric Lawn Mower >5aH	-	-	0.40	-	26	(26)
EEP-1920 EEP Electric Weed Trimmer	-	-	0.12	-	5	(5)
EEP-1930 EEP Electric Leaf Blower	-	-	0.11	-	11	(11)

3.2.2 Key Drivers for Differences in Impacts

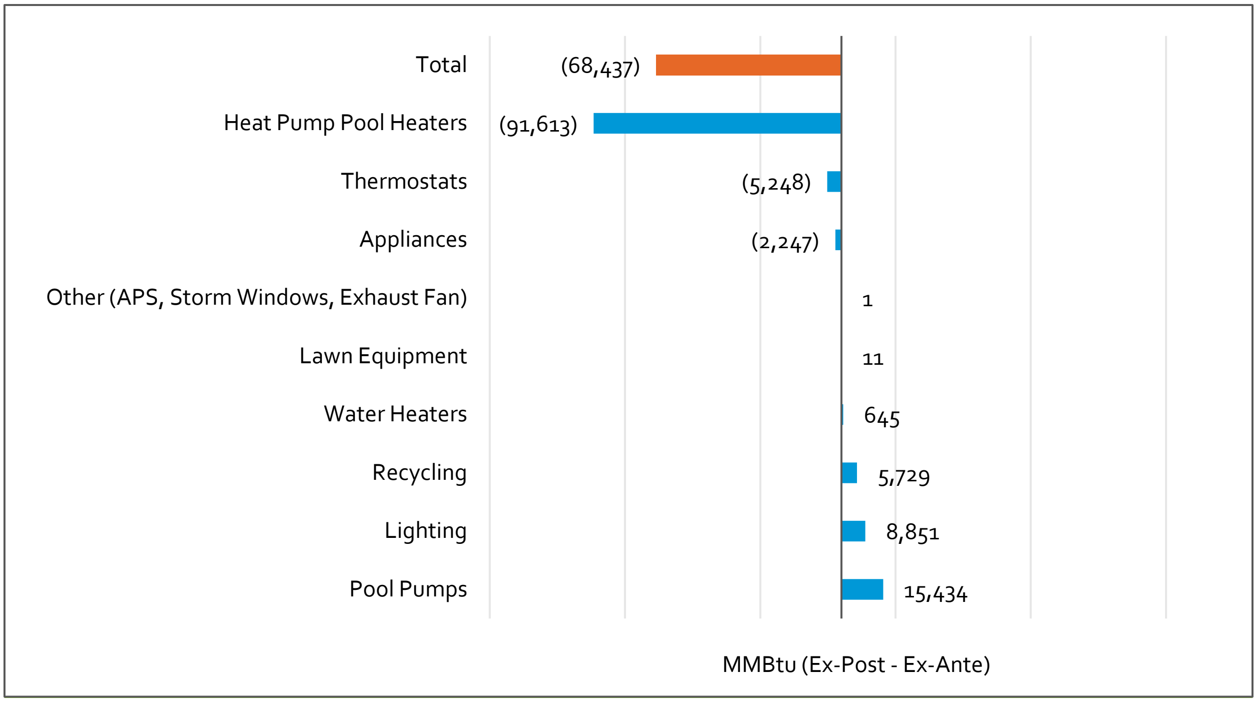
This section describes key drivers of the overall gross realization rates, with an emphasis on MMBtu savings. Figure 12 shows the variance between ex-post and ex-ante MMBtu impacts by measure category. Most variance between ex-ante gross and ex-post gross savings is due to one or more of the following evaluation activities:

- **Use of 2021 equipment characteristics to inform and refine per-unit savings assumptions.** For example, by cross-referencing model numbers from the 1,681 Air Purifiers rebated in PY2021, we were able to use actual manufacturer specifications for size and efficiency. For this measure, the actual program-supported units were, on average, more efficient than the 2021 planning assumptions used to claim ex-ante gross savings.
- **Refinement to other algorithm inputs, such as a baseline efficiency standard or coincidence factor (CF), based on an improved source or revised assumption.** For instance, we updated the central AC factor (FCAC) for the Smart Thermostat measure to reflect a higher propensity of smart thermostat purchasers to have central AC. In that case, the FCAC assumptions was also updated in the PSEG LI TRM.
- **Improvement of the calculation method/algorithm itself as compared to planning assumptions, often enabled by install data.** For example, the 2021 Refrigerator Recycling tracking data contains model specifications like volume, age, and configuration for all recycled units. This enabled the evaluation team to replace deemed savings values with unit-specific annual consumption estimates derived using the Uniform Methods Project regression model for Refrigerator Recycling.[6]

The sub-sections below summarize the key drivers in order of measure contribution to the overall EEP MMBtu realization rates. The measure categories detailed in this section (Heat Pump Pool Heaters, Pool Pumps, Lighting, and Thermostats) account for nearly all of the overall EEP MMBtu variance. Measures *not* covered in detail (Power Strips, Storm Windows, and Lawn Equipment) are summarized in Table 34 at the end of this section.

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

Figure 12: MMBtu Variance by Measure Category (Ex-Post Gross Minus Ex-Ante Gross)



3.2.2.1 Heat Pump Pool Heaters

Heat Pump Pool Heaters accounted for 10% of EEP ex-post gross MMBtu savings in 2021. Planning, ex-ante, and ex-post per-unit savings, and therefore the realization rates, look the same as they did in PY2020. HPPH realization rates are 38% for MMBtu and 8% for MWh (PY2020 was 37% and 8% respectively). Demand (kW) savings are assumed to be zero because we assume limited pool heating is required on the system peak day.

The key contributor to realization rate variance is a superseded planning assumption heating load. Heat pump pool heater measures have been added to both the PSEG LI and New York State TRMs since this measure was first characterized for PSEG LI planning in 2019. Heating capacity calculations used for ex-post savings estimates and the PSEG LI TRM are anchored in the heating load assumption of the gas pool heater measure in the NYS TRM. We also made minor refinements to the algorithm this year to explicitly acknowledge solar heating, and pool size assumptions were updated based on a sample of Long Island pools. Table 26 shows key contributing factors to HPPH realization rate variance along with related recommendations.

It's important to highlight that, in most cases, our recommendations apply to the 2023 program year. Planning for the 2022 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 2023 PSEG Long Island TRM.

Table 26 Key Contributors to RR Variance and Recommendations: Heat Pump Pool Heaters

Component	Summary of Contributing Factors	Recommendations
Heat Pump Pool Heaters	▪ **2021 Planning Assumptions Rely on Inconsistent Heating Loads between Baseline and Efficient Case:** 2021 planning assumptions were based on faulty logic that suggested the electric baseline pool heaters were delivering ten times more heat to the pool than the HPPH. We standardized the algorithm assumptions about heat load starting with the PY2020 Evaluation, which lowered baseline electric use significantly. ▪ **HPPH COP and Baseline Energy Use:** The actual average coefficient of performance (COP) of all HPPH units incentivized according to AHRI model lookups in 2021 was 5.98, higher than the planning assumption of 5.0, which was developed before significant install data was available. The planning value was adjusted to 5.98 for 2022.	▪ **Revise planning assumptions** to match the PSEG LI TRM. Standardized pool assumptions have improved since 2020. ▪ **Work with the Joint IOUs to refine the HPPH measure in the NYS TRM**. Version 9.0 of the NYS TRM includes a detailed measure characterization for HPPH. Typically, we seek to align Long Island methods and assumptions with the rest of New York State. However, we identified concerns with the heating load algorithms and elected not to align the 2021 ex-post calculations or 2023 PSEG Long Island TRM until the NYS TRM approach is updated to account for pool heating performed by sunlight.

Table 27 shows how per-unit HPPH resource impact assumptions have varied across sources since 2020. We expect less ex-ante-to-ex-post variance in this measure going forward assuming that 2022 planning calculations adopted HPPH per-unit savings estimates introduced with the finalization of the 2022 PSEG LI TRM in late 2021.

Table 27: HPPH Assumptions and Resource Savings by Source

Resource	2021 Planning	2021TRM	2021 Evaluation
kW	0	0	0
kWh_{ee}	17,392	2,117	2,283
kWh_{be}	1,167	1,167	1,009
ΔkWh	16,225	953	1,274
$MMBtu_{ee}$	19	7	8
$MMBtu_{be}$	19	19	22
$MMBtu_{total}$	79	26	29

3.2.2.2 Pool Pumps

Pool pumps accounted for about 8% of EEP ex-post gross MMBtu in 2021. Pool Pump realization rates are 153% for MMBtu, 153% for MWh, and 154% for kW. The DOE introduced new pool pump standards in July 2021 requiring virtually all pool pumps to be variable speed, however the 2021 evaluation used the prior baseline assumption for the entire year, as is accepted practice for mid-year standard changes.

Table 28: Key Contributors to RR Variance and Recommendations: Pool Pumps

Component	Summary of Contributing Factors	Recommendations
Pool Pumps	▪ **2021 Install data revealed higher installed weighted energy factors (WEF) than assumed in planning:** This has an upward impact on savings. ▪ **Install data informed several other assumptions** including higher efficient daily hours of use (upward impact on savings), lower baseline flow rate (downward impact on savings), and lower installed flow rate (downward). ▪ **Pool pump measures EEP-710 and EEP-711** have similar realization rates across the board, but 711, the larger of the two, accounted for 99% of the rebated units in 2021.	▪ **None:** As a result of the new DOE standard introduced in July 2021, pool pumps were removed from the EEP portfolio starting in 2022.

Starting with PY2022, pool pump measures will use the updated DOE standard and variable speed baseline assumption. Table 29 shows approximate changes to per-unit savings estimates that would result from increasing the baseline weighted energy factor (WEF) to reflect the new ENERGY STAR 3.0 standard. Because this baseline update would reduce per-unit savings for pool pumps about 95% from 2021 values, from 3,312 to 166 kWh per pump, PSEG Long Island removed this measure from the 2022 EEP portfolio.

Table 29: Anticipated Changes to Pool Pump Savings with DOE Standard Effective July 2021

Resource	2021 Evaluation Weighted Average	2022 TRM Weighted Average
kW	0.82	0.03
kWh_{ee}	3,312	166
kWh_{be}	-	-
ΔkWh	3,312	166
$MMBtu_{ee}$	11.3	0.57
$MMBtu_{be}$	-	-
$MMBtu_{total}$	11.3	0.57

3.2.2.3 Lighting

As shown in Table 30, the gross realization rates (ratio of Ex-Post Gross to Claimed savings) for lighting measures combined are 102% for MMBtu savings, 91% for kWh savings, and 74% for kW.

Table 30: EEP Lighting Realization Rates by Measure

Measure	N	MMBtu RR	kWh RR	kW RR
EEP-1200 LED Standard	1,691,372	114%	97%	80%
EEP-1250 LED Specialty	1,946,843	96%	82%	68%
EEP-2200 ES Linear Fixture	15,252	341%	297%	77%
LED-S In-storage LEDs	298,760	96%	146%	83%
Total (Weighted Average)	**3,952,227**	**102%**	**91%**	**74%**

Table 31 lists the key drivers of differences between ex-ante gross and ex-post gross impacts for EEP lighting measures along with our recommendations for better aligning ex-ante and ex-post savings going forward.

It's imperative to highlight that 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. Therefore, when assessing the recommendations below the practicality of implementing them for half a program year should be considered.

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

Table 31: Key Contributors to Lighting RR Variance and Recommendations

Component	Summary of Contributing Factors	Recommendations
Standard and Specialty LEDs	▪ **Wattage:** Actual 2021 install wattages varied slightly from planning assumptions. LED Standards exceeded ex-ante MMBtu while LED Specialty under-achieved relative to ex-ante MMBtu. For integrated fixtures, the evaluation team assumed a 50:50 blend of halogen and incandescent efficacy (lumen/W) to estimate baseline wattage using fixture lumens. ▪ **Hours of Use:** Revised from planning assumptions (NYS TRM v7) for both interior (formerly 3.2 hrs, now 2.7) and exterior (4.5/5.7) ▪ **Coincidence Factor:** The 23% CF used for planning was based on "LED-only" metering results from 2016 when LEDs were still relatively expensive and mostly installed in high-use sockets. Updated to 16% to align with the NYS TRM. ▪ **Waste Heat Factors** were updated as part of the 2020 evaluation and development of the 2022 PSEG LI TRM and were carried through to the 2021 evaluation.	▪ **Split out integrated fixtures from the Specialty Lamp category.** Integrated fixtures are more expensive, which carries implications for SCT costs. They have a separate ENERGY STAR Qualified Product List (QPL) and there is more nuance required to calculate integrated fixture baselines. ▪ **Record the ENERGY STAR Unique ID for each supported LED product.** This enables definitive lookups of all product characteristics and ensures that the products receiving program support are ENERGY STAR certified. ▪ **Align the 2022 in-storage savings claim with actual program counts from 2020 and 2021.** We recommend multiplying the final verified counts from 2020 and 2021 by the per-unit savings assumptions in the 2022 PSEG Long Island TRM to arrive at the ex-ante MMBtu, MWh, and MW savings for in-storage lighting in 2022.
In-storage LEDs[8]	▪ In-storage planning/reporting was not based on actual counts from 2019-2020, instead was a carryover from the prior planning year.	

3.2.2.4 Thermostats

Smart Thermostats provided 8% of EEP ex-post gross MMBtu savings in 2021. Realization rates are 89% for MMBtu and 156% for kWh. Zero kW are claimed. Table 32 shows key contributors to Thermostat variance.

[8] DSA applied the second-year and third-year carryover in-service rates of 5% and 3%, respectively, to 2020 and 2019 LEDs supported via EEP. The delayed savings claim accounts for 298,760 LEDs or about 8% of total bulbs verified for 2021.

Table 32: Key Contributors to RR Variance and Recommendations: Thermostats

Component	Summary of Contributing Factors	Recommendations
Smart Thermostats	▪ We calculated savings for both types of thermostats using the 2022 PSEG Long Island TRM savings algorithm of the Learning Thermostat and the ENERGY STAR product specifications for Connected Thermostats. ▪ The central cooling factor (FCAC) was revised to 90% to reflect higher propensity of customers who purchase smart thermostats to have central AC. This led to an increase in kWh_{ee} and $MMBtu_{ee}$ per-unit savings estimates.	▪ **Standardize the Wi-Fi thermostat savings algorithms.** Rather than using deemed per-unit savings for Connected Thermostats and a savings-factor-based algorithm for Learning Thermostats, combine these measures and apply different savings factor(s) to each. This methodology was applied to 2022 planning in accordance with the 2022 PSEG LI TRM.

3.2.2.5 Other EEP Measures

Table 33 presents a summary for other EEP program components where ex-post gross savings differed materially from ex-ante gross savings. Tankless/instantaneous water heaters were added in 2021.

Table 33 Key Contributors to RR Variance and Recommendations: Other EEP Measures

Component	Summary of Contributing Factors	Recommendations
Recycling	Combined realization rates for recycling measures (refrigerators, room air conditioners, and dehumidifiers) are 238% for MMBtu, 238% for kWh, and 242% for kW.	
	Recycling realization rates are driven by the removal of the replacement equipment energy consumption from the energy usage differential. Ex-Post savings are based on the removed unit only, in accordance with the industry standard practice, the NYS TRM, and the Uniform Methods Project protocol.	▪ **Consolidate refrigerator recycling into a single measure**. The program tracking database includes a rich set of characteristics that can be used to calculate annual energy consumption using the regression model from the DOE's Uniform Methods Project protocol. [9]
Appliances	Combined Appliance RRs are 79% for MMBtu, 89% for kWh, and 106% for kW. In 2021 Air Purifiers overtook Clothes Washers as the largest contributor to Appliance savings.	

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

Component	Summary of Contributing Factors	Recommendations
	Air purifiers: ENERGY STAR spec has been updated and CADR tiers resized since 2021 planning; units are more efficient than planned on a cfm/W basis. **Clothes Dryers:** actual 2021 installs had lower average CEF than planning assumptions, and other minor updates have been made since 2021 planning. **Clothes Washers:** Updates to assumptions since 2021 planning including switching to using the NYS TRM for deemed fossil fuel savings (MA value was used prior to 2022 PSEG LI TRM). **Dehumidifiers:** Parameter updates for 2021 installs vary from planning assumptions using PY2018 data.	▪ **Revise planning assumptions 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, only rebate units that comply with current ENERGY STAR standards.
Water Heaters	Combined Water Heater realization rates across Heat Pump and Instantaneous measures are 146% for MMBtu, 86% for kWh, and -28% for kW. Install data was used to derive uniform energy factors (UEFs) for baseline and efficient cases based on model numbers and ENERGY STAR standards for tank capacity.	

Component	Summary of Contributing Factors	Recommendations
	For instantaneous water heaters, planning used several assumptions from NYS v7, including efficient-case Uniform Energy Factor (UEF), ambient temperature, and baseline storage water heater capacities. For the larger EEP-655 version of the measure, kWh_{ee} savings are deemed to be negative based on the baseline UEF for an 80 gallon, electric storage water heater with medium draw pattern according to the NYS TRM, and 15% of the baseline units are assumed to be electric. **The use of a Uniform Energy Factor (UEF) for a code minimum baseline fossil fuel water heater** instead of the baseline UEF of an electric water heater use for planning (which is much higher) explains higher ex-post beneficial electrification MMBtu savings. The participating household is assumed to purchase a new water heater because their old heater has reached the end of its useful life. An 85/15 fossil fuel/electric split is assumed in baseline water heating fuel based on the 2018 PSEG Long Island Baseline study. For the 85% of participants assumed to have a fossil fuel baseline, the baseline thermal efficiency is that of a code-minimum fossil fuel unit.	▪ **Revise planning assumptions** to align with the PSEG LI TRM.

Table 34 shows the realization rates for EEP program components not detailed above, comprising the *Lawn Equipment* and *Other* categories in the preceding tables.

Table 34 Realization Rates for Remaining Program Components

Measure	N	MMBtu RR	kWh RR	kW RR
Power Strip	1,728	100%	100%	100%
ES Storm Windows	93	100%	100%	100%
Lawn Mower	1,199	96%	131%	-
Weed Trimmer	1,382	100%	100%	-
Leaf Blower	1,422	100%	100%	-

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 heat pumps (DMHP), and ground source heat pumps (GSHP). The Home Comfort program has evolved each year to align more closely with New York State's aggressive greenhouse gas reduction goals, found in the Climate Leadership Community Protection Act (Climate Act). In 2020, to align with NYSERDA's plans to promote the installation of more air-source heat pumps, the Home Comfort program offered higher rebates for air-source heat pumps.

4.1 HOME COMFORT PROGRAM DESIGN AND PARTICIPATION

The following sections detail the program design, implementation strategies, and PY2021's participation and performance for the Home Comfort program.

4.1.1 PROGRAM DESIGN AND IMPLEMENTATION

The Home Comfort program offers customer rebates and contractor incentives for heating and cooling system upgrades. Program participation is primarily driven through partnerships with installation contractors, also called Home Comfort Participating Contractors.

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[10] in 2021 required a Quality Installation Verification installation.

4.1.2 PROGRAM PARTICIPATION AND PERFORMANCE

Based on verified ex-ante estimates, the Home Comfort program reached 100% of its energy savings goal in 2021. Table 35 presents 2021 Home Comfort programs verified ex-ante gross MMBtu savings compared to goal.

Table 35: Home Comfort Program Verified Ex-Ante Gross MMBtu Savings versus Goals

Metric	MMBtu
Goal	113,425
Verified Ex-Ante Gross Savings	113,544
% of Goal	100%

[10] 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.

The installation of ductless mini split and ducted ASHPs through the Home Comfort program continued to increase in 2021, consistent with PSEG Long Island MMBtu-based savings goals and New York State Clean Heat initiatives. The split CAC measures were completely phased out at the end of 2019 with no carryover projects into 2021, and the program started incentivizing heat pump water heater (HPWH) installations in 2021.

Table 36: Comparison of Home Comfort Program Measures Installed – 2019 to 2021

Measure	2019	2020	2021	Percent Difference 2020 to 2021
Split CAC	2,315	1,304	0	-100%
Smart Thermostats	162	227	68	-70%
ASHP	385	822	985	+20%
DMHP	2,045	2,837	2,917	+3%
GSHP	142	132	146	+11%
HPWH	0	0	11	+100%
Total	**5,049**	**5,322**	**4,127**	**-22%**

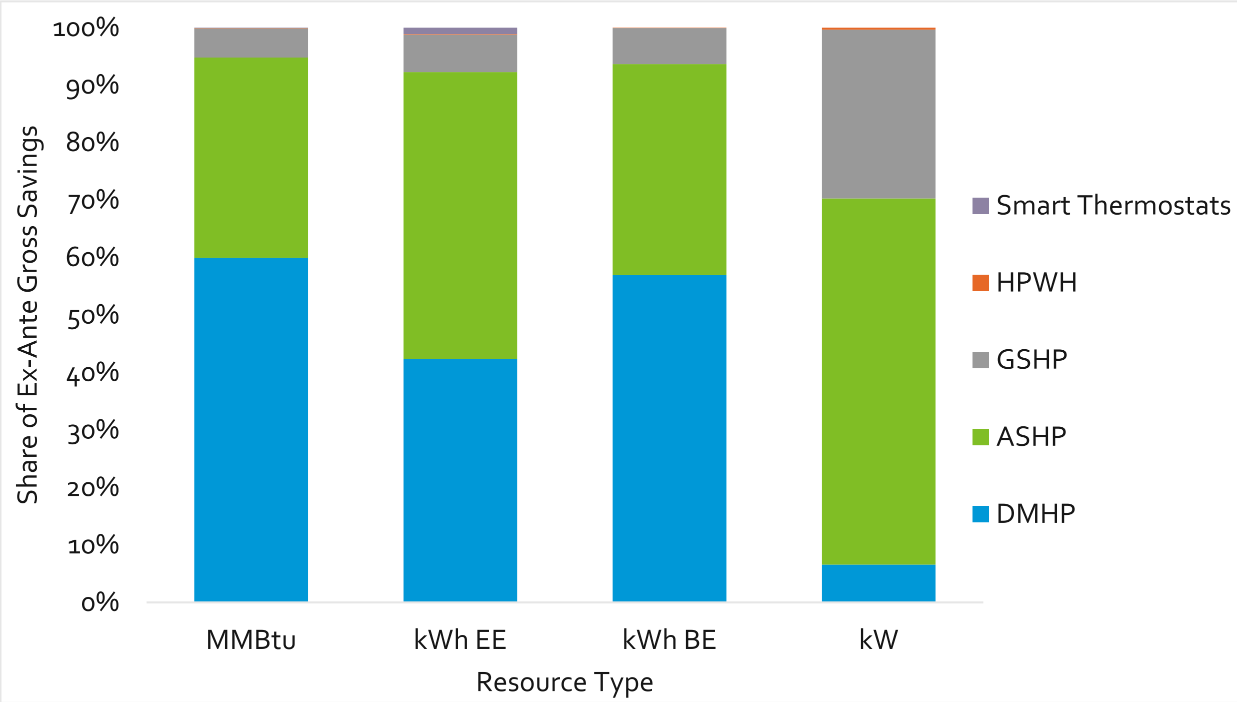
Figure 13 shows the distribution of ex-ante gross energy and demand savings across the Home Comfort program. Ducted and ductless mini split heat pumps accounted for a combined 95% of the ex-ante gross MMBtu savings in 2021. These installations also resulted in beneficial electrification impacts for which a baseline heating load supplied by a fossil fuel source was displaced by the incented heat pump. When planning for the 2021 program year, program implementers identified the cooling and heating baseline scenarios for heat pump installations shown in Table 37. 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 37: Cooling and Heating Baseline Scenarios for Heat Pump Installations

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

Beneficial electrification measures increase electricity consumption, resulting in negative kWh impacts, but reduce total energy consumption (MMBtu) and emissions from the displacement of fossil fuels. Scenarios 1 and 2 above result in beneficial electrification impacts, shown as kWh BE in Figure 13. The electric savings resulting from the installation of efficient heating and cooling equipment is shown as kWh EE.

Figure 13: 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 38 shows ex-post gross MMBtu impacts by measure category. Table 39 and Table 40 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 92% of its ex-ante gross MMBtu energy savings claims, 126% of MWh impacts claims, and 53% of kW savings claims. Note that the overall gross MWh impacts are negative for the Home Comfort program due to significant increase in site-level electric consumption from beneficial electrification measures (e.g., heat pumps). We expand on the impacts of beneficial electrification for Home Comfort measures in Section 4.2.1.1.

Table 38: 2021 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 splits and Ducted ASHPs	3,902	107,889	96,274	89%
GSHP	146	5,752	8,149	142%
Smart Thermostats	68	85	90	106%

Heat Pump Water Heaters (HPWH)	11	71	124	175%
Totals[1]	**4,127**	**113,615**	**104,455**	**92%**

Note: Totals may not sum due to rounding.

[1] Two project adjustments of -182 MMBtu are 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 39: 2021 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 splits and Ducted ASHPs	3,902	-6,880	-7,868	114%
GSHP	146	262	-453	-173%
Smart Thermostats	68	24.9	26.5	106%
HPWH	11	-5.33	-4.68	88%
Totals[1]	**4,127**	**-6,651**	**-8,352**	**126%**

Note: Totals may not sum due to rounding.

[1] Two project adjustments of -53.3 MWh are 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 40: 2021 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 splits and Ducted ASHPs	3,902	373	138	37%
GSHP	146	156	142	91%
Smart Thermostats	68	0	0	N/A
HPWH	11	2	-1	-27%
Totals	**4,127**	**531**	**279**	**53%**

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 heat pump water heater measures due to the displacement of preexisting fossil fuel heating with electricity.

4.2.1.1 Beneficial Electrification Impacts

Table 41 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 41: 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 splits and Ducted ASHPs	1,548	9,416	-7,868	5,316	90,958	96,274
GSHP	144	597	-453	485	7,664	8,149
HPWH	3	8	-5	10	114	124
Total	**1,695**	**10,020**	**-8,325**	**5,811**	**98,736**	**104,547**

We estimate that 2021 program-supported heat pump and water heater measures added 10,020 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 1,695 MWh of energy savings. The overall electric consumption therefore increased by 8,325 MWh. However, accounting for the consumption of displaced fossil fuels in the $MMBtu_{be}$ column, Home Comfort heat pumps led to 104,547 MMBtu savings.

4.2.2 Key Drivers for Differences in Impacts

We conducted a measure-level savings approach to calculate the total PY2021 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, there was an increased emphasis on electrification of fossil fuel systems in 2021, for the purpose of meeting decarbonization goals. There was an overall increase of electric equipment load on the grid due to the displacement of fossil fuel heating loads by heat pumps.

Below we describe the reasons for differences between gross ex-ante savings and ex-post savings for each measure. In most cases, our recommendations apply to the 2023 program year. Planning for the 2022 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 2023 PSEG Long Island TRM.

Table 42: Key Contributors to Home Comfort Realization Rates and Recommended Adjustments

Component	Summary of Contributing Factors	Recommendation
Ductless Mini splits and Ducted ASHPs	▪ Full load heating and cooling hours in planning differed from 2021 PSEG-LI TRM recommendations, specifically for ductless mini split heat pumps. The 2021 PSEG-LI TRM	▪ Align the full load heating and cooling hours with PSEG-LI TRM for ductless mini split units.

Component	Summary of Contributing Factors	Recommendation
	recommendations align with values provided for residential units in NYS TRM.	
Geothermal Heat Pumps	▪ Evaluation and Planning baseline equipment assumptions were inconsistent for 2020 carryover installations: For these units, we standardized baseline equipment assumptions based on the latest PSEG-LI TRM to be CAC and oil-fired furnace for cooling and heating respectively, resulting in beneficial electrification impacts. TRC's calculation did not include beneficial electrification impacts for 43% of these units.	▪ Align baseline scenarios with 2022/2023 PSEG-LI TRM.
Smart Thermostats	▪ TRC applied deemed savings values for Wi-Fi-enabled thermostats using the 2021 PSEG-LI TRM. However, we applied energy savings factors per 2022/2023 PSEG-LI TRMs, resulting in a realization rate over 100%.	▪ Align savings estimation methods with PSEG-LI TRM.

5 RESIDENTIAL ENERGY AFFORDABILITY PARTNERSHIP PROGRAM

5.1 PROGRAM DESCRIPTION

The Residential Energy Affordability Partnership (REAP) program assists low-income households with energy efficiency improvements. The program helps low-income customers save energy, improves overall residential energy efficiency on Long Island, and lowers PSEG Long Island's financial risk associated with bill collection by lowering utility bills. To be eligible to participate in the REAP program, household income must correspond with the United States Department of Housing and Urban Development low-income guidelines. In April 2019, the income eligibility guidelines changed from 70% of the median income to 80% of area median income, allowing more customers to qualify.

5.1.1 PROGRAM DESIGN AND IMPLEMENTATION

The REAP program includes a free home energy audit and free installation of energy-saving measures. Program measures included LED light bulbs (general service, globes, reflectors, candelabras, and night lights), domestic hot water (DHW) measures, thermostatic valves, exterior lighting, Tier II smart power strips, room air conditioners (RACs), dehumidifiers, refrigerators, 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.

5.1.2 PROGRAM PARTICIPATION AND PERFORMANCE

Based on verified ex-ante estimates, the REAP program reached 102.6% of its energy savings goal in 2021. Table 43 presents verified ex-ante gross MMBtu savings compared to goals for the 2021 REAP program.

Table 43. 2021 REAP Program Verified Ex-ante Gross Program Performance against Goals

Metric	MMBtu
Goal	4,532
Verified Ex-ante Gross Savings	4,650
% of Goal	102.6%

Table 44 shows the distribution of savings by program component. Lighting continues to account for the largest share of gross REAP program savings, accounting for 40% of ex-ante gross MMBtu savings, 57.9% of ex-ante gross MWh savings, and 63.6% of ex-ante gross kW savings in 2021.

Table 44. 2021 REAP Program Component Percent of Total Ex-Ante Gross Savings

Program Component	Ex-Ante Utility Gross Savings		
	MMBtu (%)	MWh (%)	kW (%)
REAP Lighting	40.0%	57.9%	63.6%
Energy Star Refrigerators	1.4%	3.0%	2.1%
Power Strips	17.5%	14.7%	8.5%
Aerators	2.2%	0.2%	0.0%
DHW Pipe Insulation	1.9%	0.2%	0.0%
DHW Temperature Turndown	0.1%	0.0%	0.0%
Energy Star Dehumidifier	2.6%	2.2%	2.3%
Low Flow Showerhead	7.2%	0.6%	0.0%
Room Air Conditioners	2.7%	2.2%	10.8%
Thermostatic Valve	2.2%	0.2%	0.0%
Room Air Purifier	22.3%	18.8%	12.6%
Total	**100%**	**100%**	**100%**

The REAP program treated 1,548 unique participants in 2021 compared to 1,175 customers in 2020 for an increase of 32%. Nearly all REAP participants received LED lighting and a Tier 2 Power Strips.

Table 45. Percent of REAP Program Participants Receiving each Measure Category

Category	Percent Receiving
Power Strips	96.6%
Night Lights	94.6%
Lighting	91.6%
Room AC	31.1%
Air Purifiers	19.1%
Dehumidifiers	13.2%
Refrigerators	11.5%
DHW - Aerators	11.0%
DHW - Low Flow Showerheads	8.2%
DHW - Thermostatic Shower Valve	8.0%
DHW - Pipe Insulation	5.3%
DHW - Temp Turndown	3.0%

5.2 REAP PROGRAM IMPACTS

5.2.1 Overview of Impacts by Resource

As in previous years, we used both engineering and consumption analysis to estimate savings for the REAP program in 2021. 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[11]. Table 46 below shows that the program achieved ex-post gross MMBtu savings of 4,089 MMBtu, ex-post gross MWh savings of 1,366 MWh, and ex-post gross kW savings of 211 kW. Since the consumption analysis is performed at the program level, the results of the engineering to consumption analysis calculation is at the REAP program levels.

Table 46. 2021 REAP Program Impacts

Resource	N	Ex-Ante Gross Savings	Ex-Post Gross Savings	Realization Rate
MMBtu	25,601	4,647	4,089	88%
MWh	25,601	1,618	1,366	84%
kW	25,601	298	211	71%

5.2.2 Analysis Approach and Detailed Results

The Evaluation Team used both engineering and consumption analysis to estimate savings for the REAP program in 2021. 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 MWh savings on the results of the consumption analysis. We used the engineering analysis to calculate MMBtu to MWh and kW to MWh ratios at the program level and utilize these ratios to estimate ex-post gross MMBtu and kW impacts. In addition, because the engineering analysis provides savings at the measure level, we gain insights into the relative savings contributions of the measures offered by the REAP program. Finally, these measure-level savings allow us to make recommendations to the implementation team for adjusting ex-ante planning assumptions going forward.

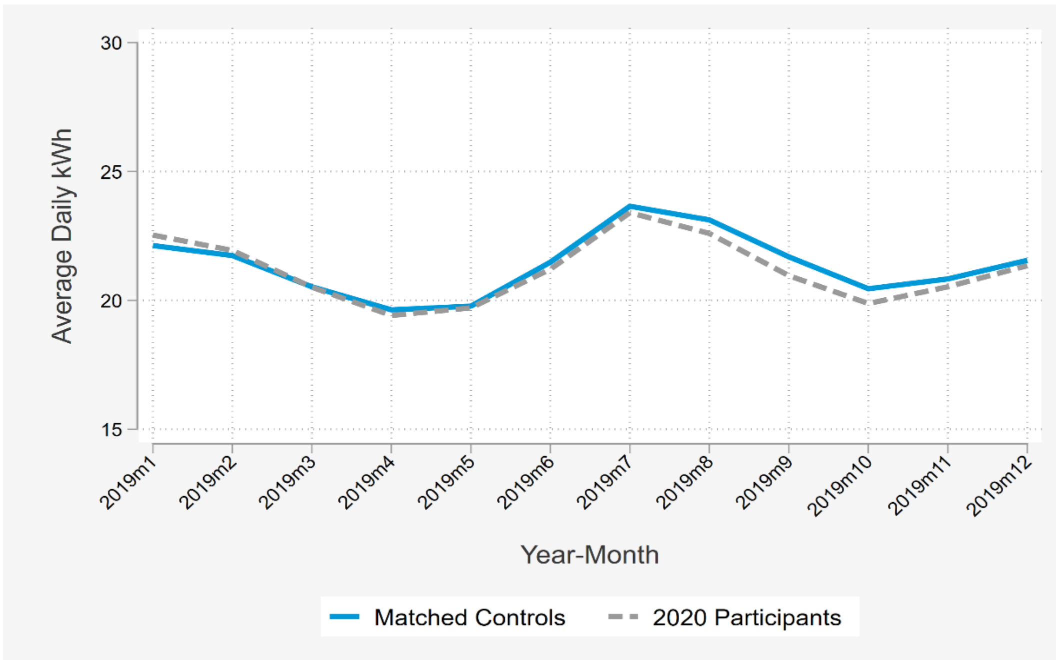
5.2.2.1 Consumption Analysis – Approach

Because the consumption analysis requires post-installation electricity usage data for approximately one year after treatment, our analysis uses 2020 participants as the treatment group. We used the pre-participation period of the 2020 participants as a basis for comparison, which is consistent with prior evaluations. The energy use of the comparison group prior to their program participation acts as the counterfactual or point of comparison for the treatment group (2020 participants) in their post-installation period. In this framework, each treatment group home is matched with exactly one

[11] To calculate ex-post gross MWh savings due to energy efficiency (EE MWh savings), we applied the consumption analysis realization rate (84.4%) to the ex-ante gross EE savings. 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 MWh savings.

comparison group home based on weather-normalized annual consumption (prior to the energy upgrades) and the weather sensitivity of their consumption. Figure 14 compares average daily consumption between treatment group homes and their matched comparison homes. Usage between the two groups shows good alignment. Another benefit to using 2020 participants as a comparison group is that this accounts for the self-selection of program participation.

Figure 14: 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 2021) 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 2020, the status the participant group in aggregate gradually shifts as projects are completed.

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

5.2.2.2 Consumption Analysis – Results

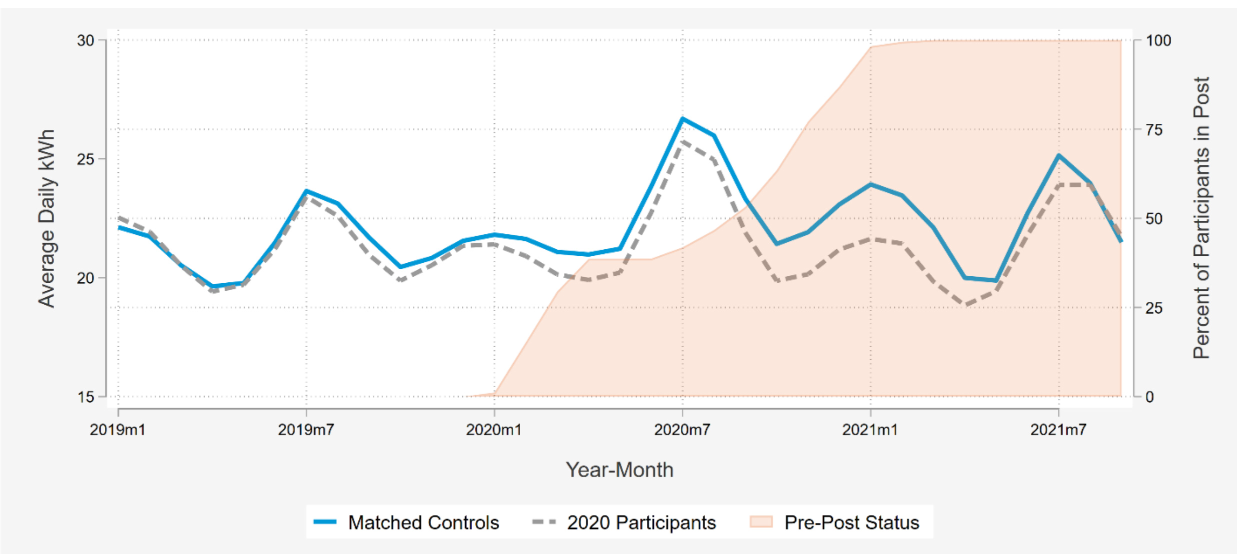
In Table 47, we use the results of the REAP consumption model to estimate average savings for 2020 participants and compare the estimated impact to the ex-ante gross kWh savings claimed by the implementer. Across the 966 Long Island homes included in the regression model, the average annualized savings was 713 kWh.[12] This equals 84.4% of the average ex-ante gross kWh savings claim for the same homes. We applied this 84.4% realization rate to the ex-ante gross kWh savings claim of 2021 participants to estimate ex-post gross kWh savings for REAP.

Table 47: REAP Consumption Analysis Results (n=966)

Parameter	Estimate	Lower Bound of 95% CI	Upper Bound of 95% CI
Daily Treatment Effect (kWh Saved)	1.954	1.682	2.227
Daily Treatment Effect (% Savings)	9.1%	7.8%	10.4%
Annual Savings	713.3	613.8	812.9
Ex-Ante Gross kWh	845.2		
Realization Rate	84.4%	72.6%	96.2%

Figure 15 visualizes consumption analysis results. As more participants move into the post period, the average daily electric usage for the treatment group begins to depart from the matched control group. This is the effect of interest.

Figure 15: REAP Consumption Analysis Results Visualized



5.2.2.3 Engineering Analysis

The evaluation team used program tracking data and engineering analysis to estimate gross kWh and kW savings achieved by each measure installed through the 2021 REAP program. As described above,

[12] There were more than 966 REAP participants in 2020. However, only participants with at least one year of pre-participation data and one year of post-participation data were included in the modeling.

the results of the engineering impacts analysis provide us with (1) the kW to MWh ratio needed to develop demand savings from the energy consumption analysis, (2) an MMBtu to MWh 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 48, Table 49, and Table 50 show the ex-post gross MMBtu, MWh, and kW savings as determined by the engineering analysis for each measure category. The sum of measure-level energy savings in the engineering analysis is slightly lower than the total gross ex-post energy savings determined through the consumption analysis (see the MWh row of Table 46). The electric energy realization from the engineering analysis (90.4%) is within the 95% confidence interval of the consumption analysis results, which stretches from 72.6% to 96.2%.

Table 48. 2021 REAP Program Measure-Specific MMBtu Gross Impacts: Engineering Analysis

Category	N	Ex-Ante Gross Savings (Claimed) MMBtu	Engineering Analysis Ex-Post Gross Savings MMBtu	Engineering Analysis Realization Rate
REAP Lighting	21,783	1,857	1,598	86.1%
Energy Star Refrigerators	178	67	65	97.6%
Power Strips	1,494	811	810	99.8%
Aerators	314	102	102	99.8%
DHW Pipe Insulation	279	87	87	99.8%
DHW Temperature Turndown	12	4	3	89.6%
Energy Star Dehumidifier	203	121	121	99.8%
Low Flow Showerhead	158	334	333	99.9%
Room Air Conditioners	726	124	124	99.8%
Thermostatic Valve	159	102	102	99.8%
Room Air Purifier	295	1,037	1,035	99.8%
Total	**25,601**	**4,648**	**4,382**	**94.3%**

Table 49. 2021 REAP Program Measure-Specific MWh Gross Impacts: Engineering Analysis

Category	N	Ex-Ante Gross Savings (Claimed)[1] MWh	Engineering Analysis Ex-Post Gross Savings MWh	Engineering Analysis Realization Rate
REAP Lighting	21,783	937	784	83.6%
Energy Star Refrigerators	178	48	48	99.9%
Power Strips	1,494	238	237	99.9%

Category	N	Ex-Ante Gross Savings (Claimed)[1] MWh	Engineering Analysis Ex-Post Gross Savings MWh	Engineering Analysis Realization Rate
Aerators	314	3	3	99.9%
DHW Pipe Insulation	279	3	3	99.9%
DHW Temperature Turndown	12	0	0	89.6%
Energy Star Dehumidifier	203	36	36	99.9%
Low Flow Showerhead	158	10	10	100.2%
Room Air Conditioners	726	36	36	99.9%
Thermostatic Valve	159	3	3	99.9%
Room Air Purifier	295	304	303	99.9%
Total	**25,601**	**1,618**	**1,464**	**90.4%**

Table 50. 2021 REAP Program Measure-Specific kW Gross Impacts: Engineering Analysis

Category	N	Ex-Ante Gross Savings (Claimed) kW	Engineering Analysis Ex-Post Gross Savings kW	Engineering Analysis Realization Rate
REAP Lighting	21,783	189.5	124.9	65.9%
Energy Star Refrigerators	178	6.2	6.0	96.8%
Power Strips	1,494	25.5	23.6	92.7%
Aerators	314	0.0	0.0	-
DHW Pipe Insulation	279	0.06	0.05	92.9%
DHW Temperature Turndown	12	0.012	0.010	83.2%
Energy Star Dehumidifier	203	6.9	6.4	92.6%
Low Flow Showerhead	158	0.0	0.0	-
Room Air Conditioners	726	32.3	30.0	92.6%
Thermostatic Valve	159	0.0	0.0	-
Room Air Purifier	295	37.6	34.8	92.7%
Total	**25,601**	**298**	**226**	**75.8%**

5.2.3 Key Drivers for Differences in Impacts

5.2.3.1 Reasons for Differences in Engineering Impacts

For MMBtu and MWh savings, the sum of the measure-level savings estimates from our engineering analysis was less than ex-ante gross savings for MMBtu, MWh, and kW (see Table 48, Table 49, and Table 50). Reasons for discrepancies between the ex-ante assumptions and measure-level engineering results are shown in Table 51. In most cases, our recommendations apply to the 2023 program year. Planning for the 2022 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 2023 PSEG Long Island TRM.

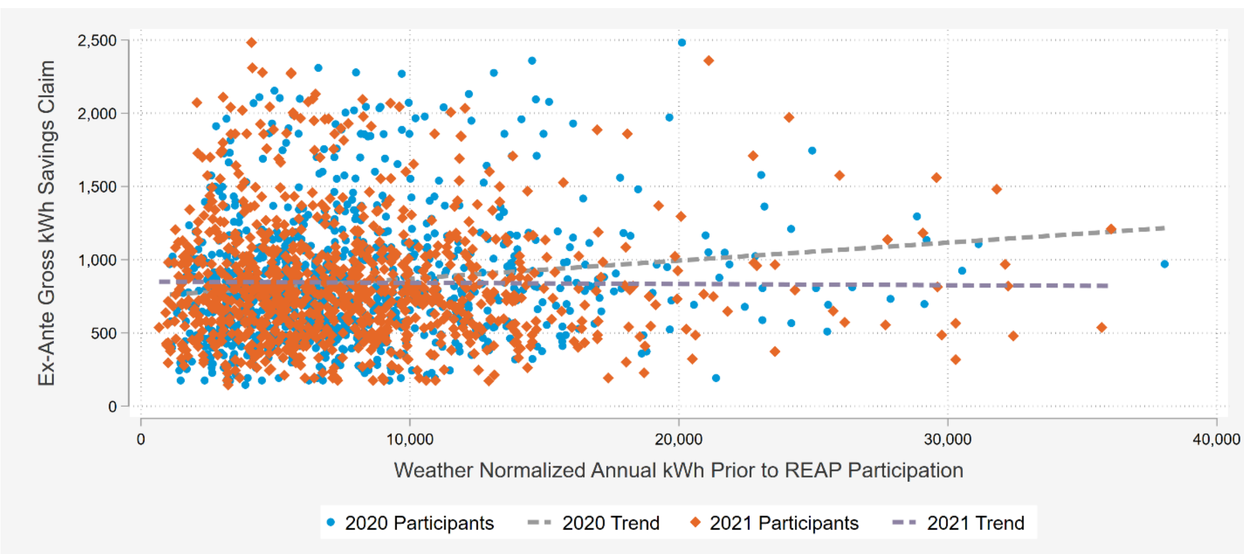
Table 51: Realization Rate Drivers

Component	Summary of Contributing Factors	Recommendations
Lighting	▪ MMBtu, MWh, and kW realization rates were all less than 100%. The assumptions that were used for the ex-ante savings in 2021 program tracking database were based on a stipulated mix of lamp types and baseline wattages. A different mix of lamps was actually installed. ▪ The kW realization rate of 65.9% was driven by the coincidence factor. For the ex-post evaluation, we used a coincidence factor of 16% based on version 9.0 of the NYS TRM. The ex-ante savings calculation used 23% which was in the 2021 plan and based on "LED-only" metering results from 2016 when LEDs were still relatively expensive and mostly installed in high-use sockets. ▪ Ex-post evaluation assumed an updated 2.7 daily hours of use for interior lamps (excluding nightlights) versus 3.2 hours in the ex-ante savings calculation. This resulted in average kWh and MMBTU realization rates of 79.7%. ▪ Our engineering analysis assumed 5.7 daily hours of use for exterior lamps versus 4.5 hours in the ex-ante savings calculation. This resulted in average kWh and MMBTU realization rates of 141.9%. ▪ MMBtu and MWh realization rates averaged 86.1% and 83.6% respectively. ▪ HVAC interactive effect assumptions were updated based on modeling completed by the evaluation team during the 2020 evaluation.	▪ Develop baseline wattages by lamp type to eliminate lamp type mix effects on realization rate. For the ex-post evaluation, we utilize federal minimum efficiency values, by lamp type, for baseline wattages. ▪ Implement the updated lighting coincidence factor in 2023 planning to align with assumptions in the engineering analyses. ▪ Align HVAC interactive effect assumptions with the PSEG-LI TRM.

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

The 2021 consumption analysis resulted in slightly lower overall ex-post gross savings than ex-ante gross savings, as shown by the 84% 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 73% to 96%. 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 16 compares the ex-ante gross kWh savings claim (y-axis) to the weather-normalized annual kWh consumption (x-axis) for each participant in 2020 and 2021. 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 therefore high for some homes and low for others. The upper left portion of Figure 16 is likely pulling the REAP realization rate below 100%. It is unlikely any set of EE measures will save 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 16: Comparison of Ex-Ante Gross kWh Savings and Pre-Retrofit Annualized Consumption



End-of-life replacement measures like the Room Air Purifiers may actually add consumption to a household. The engineering estimates for the Room Air Purifier measure assume an ENERGY STAR unit 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.

5.3 CONCLUSIONS AND RECOMMENDATIONS

Our key findings and recommendations based on this evaluation are shown in Table 52. In most cases, our recommendations apply to the 2023 program year. Planning for the 2022 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 2023 PSEG Long Island TRM.

Table 52: REAP Findings and Recommendations

Finding	Recommendation
▪ REAP savings continue to be dominated by lighting measures. In 2021, lighting accounted for over half of the REAP kWh and kW savings and approximately 40% of REAP MMBtu savings.	▪ Continue monitoring the lighting market. As market transformation continues, LEDs will represent a greater share of residential sockets. This may change may limit the number of lamps per household the program can convert.
▪ For the second consecutive year, our consumption analysis results were reasonably well-aligned with ex-ante savings claims. Lighting measures were the primary driver of realization rates less than 100%.	▪ We recommend aligning the hours of use and HVAC interactive effect values used to claim ex-ante savings with the PSEG-LI TRM.
▪ The low realization rate for demand (71%) was largely driven by a low realization rate for lighting, which itself was driven by the coincidence factor assumption. The value used for ex-ante savings (23%) is based on "LED-only" metering results from a 2016 study when LEDs were still relatively expensive and mostly installed in high-use sockets.	▪ We recommend aligning the 2023 CF assumption with the 16% assumption in the NYS and PSEG Long Island TRMs.
▪ For several measures, the key driver of the realization rate was the same: In our engineering analysis, we used actual values from the program tracking database rather than TRM assumptions.	▪ When actual values are known (for example, baseline and post water temperatures for the Temperature Turndown measure), use them rather than TRM assumptions.

6 HOME PERFORMANCE PROGRAM

PSEG Long Island's Home Performance programs are separated into two distinct tracks: Home Performance Direct Install (HPDI) and Home Performance with ENERGY STAR (HPwES). The primary objective of the Home Performance suite of programs is to make high efficiency choices part of the decision-making process for PSEG Long Island customers when upgrading their home. The goal of the Home Performance programs is to reduce the carbon footprint of customers who utilize electric, oil, or propane as a primary heat source.

6.1 HOME PERFORMANCE PROGRAM DESIGN AND PARTICIPATION

6.1.1 PROGRAM DESIGN AND IMPLEMENTATION

The Home Performance portfolio offers customer rebates and contractor incentives for heating and cooling system upgrades, weatherization, and building shell upgrades like insulation, air sealing, and duct sealing. Certain minimum efficiency requirements must be met to receive 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. Once the free direct install measures are completed (LEDs, duct sealing, low flow DHW devices, smart strips), the customer receives their free HEA and is eligible for HPwES rebates.

6.1.2 PROGRAM PARTICIPATION AND PERFORMANCE

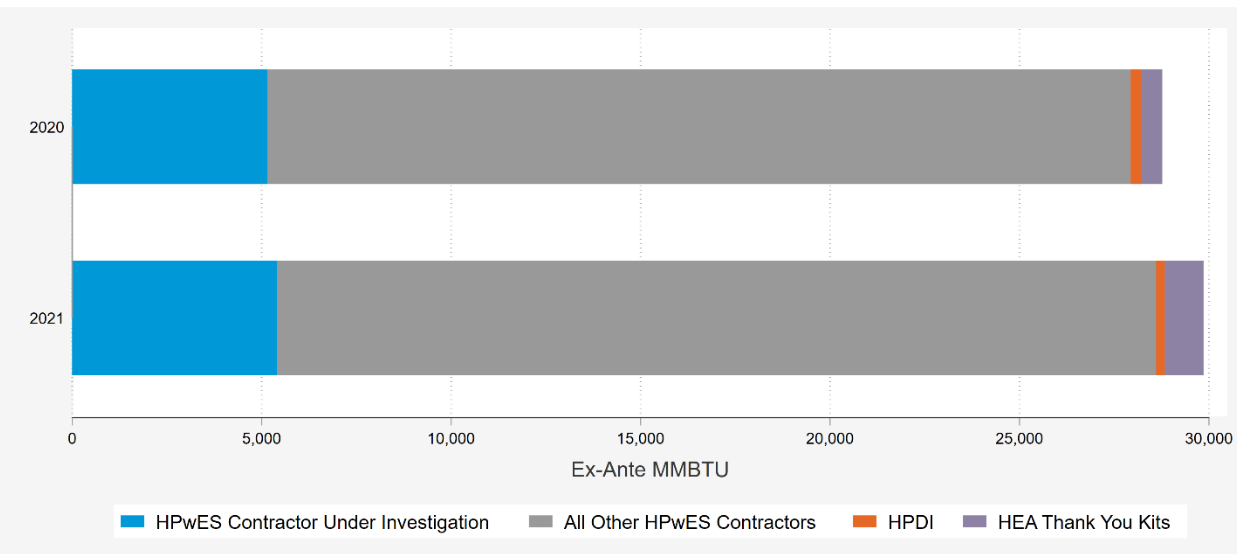
Based on verified ex-ante estimates, the Home Performance program reached 84.5% of its energy savings goal in 2021. Table 53 presents 2021 Home Performance programs verified ex-ante gross MMBtu savings compared to goal.

Table 53: Home Performance Programs Verified Ex-Ante Gross MMBtu Savings versus Goals

Metric	MMBtu
Goal	28,760
Verified Ex-Ante Gross Savings	24,307
% of Goal	84.5%

The Home Performance program was the only program to fall short of goals in 2021. Due to an ongoing investigation of 2020 and 2021 reporting practices by one of the more active HPwES contractors, PSEG Long Island removed 4,999 MMBtu of savings from the HPwES track in its year-end reporting. The evaluation team mirrored PSEG Long Island's handling of these projects in the VEA analysis. Absent the removal of this contractor's savings claims, the Home Performance program would have claimed 102% of goal for 2021. Figure 17 shows the claimed MMBtu savings by Home Performance program component. The contractor whose projects are under investigation accounted for approximately 18% of total program MMBtu savings in both 2020 and 2021.

Figure 17: Ex-Ante MMBtu Savings by Program Component and Year



In 2021, the HPDI program completed projects with 84 customers, while the HPwES program treated 1,310 customers. A total of 24 customers participated in both programs. The HEA program delivered thank you kits to 3,403 customers. Of the HEA recipients, 1,132 customers also participated in the HPDI or HPwES programs. Overall, 3,887 unique customers were treated by the Home Performance programs in 2021.[13]

6.2 HOME PERFORMANCE PROGRAMS IMPACTS

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

[13] These numbers include 113 HPwES customers who installed beneficial electrification measures.

6.2.1 Overview of Impacts by Resource Type

For the ex-post evaluation, we used both engineering and consumption analysis to estimate savings for the Home Performance programs in 2021.[14] The combined consumption and engineering analyses found that the programs generated approximately 29,285 MMBtu in ex-post gross energy savings in 2021, or approximately 120% of the ex-ante gross MMBtu savings. Table 54 shows ex-ante gross impacts, ex-post gross impacts, and the realization rate by resource (MMBtu, MWh, and kW) category.

Table 54: 2021 Home Performance Program Ex-Post Impacts

Resource	N	Ex-Ante Gross Savings	Ex-Post Gross Savings	Realization Rate
MMBtu	8,334	24,307	29,435	121%
MWh	8,334	886	885	100%
kW	8,334	485	754	155%

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

Recall that PSEG Long Island reduced its 2021 ex-ante savings claim by 4,999 MMBtu due to an investigation of contractor performance in the HPwES program component. If PSEG Long Island had claimed the full MMBtu savings stored in the Captures tracking system without adjustment (29,306 MMBtu) the realization rate of the Home Performance program would have been almost exactly 100%.

6.2.2 Analysis Approach and Detailed Results

Our ex-post gross savings estimates are anchored in the analysis of billed kWh and supplemented by engineering calculations to estimate total MMBtu conservation and peak demand savings. We use the engineering analysis to calculate MMBtu to MWh and kW to MWh ratios at the program level and utilize these ratios to estimate ex-post gross MMBtu and kW impacts. In addition, because the engineering analysis provides savings at the measure level, we gain insights into the relative savings contributions of the measures offered by the programs. Finally, these measure-level savings allow us to make recommendations to the implementation team for adjusting ex-ante planning assumptions going forward.

6.2.2.1 Consumption Analysis – Approach

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

[14] To calculate ex-post gross MWh savings due to energy efficiency (EE MWh savings), we applied the consumption analysis realization rate (88.9%) 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.

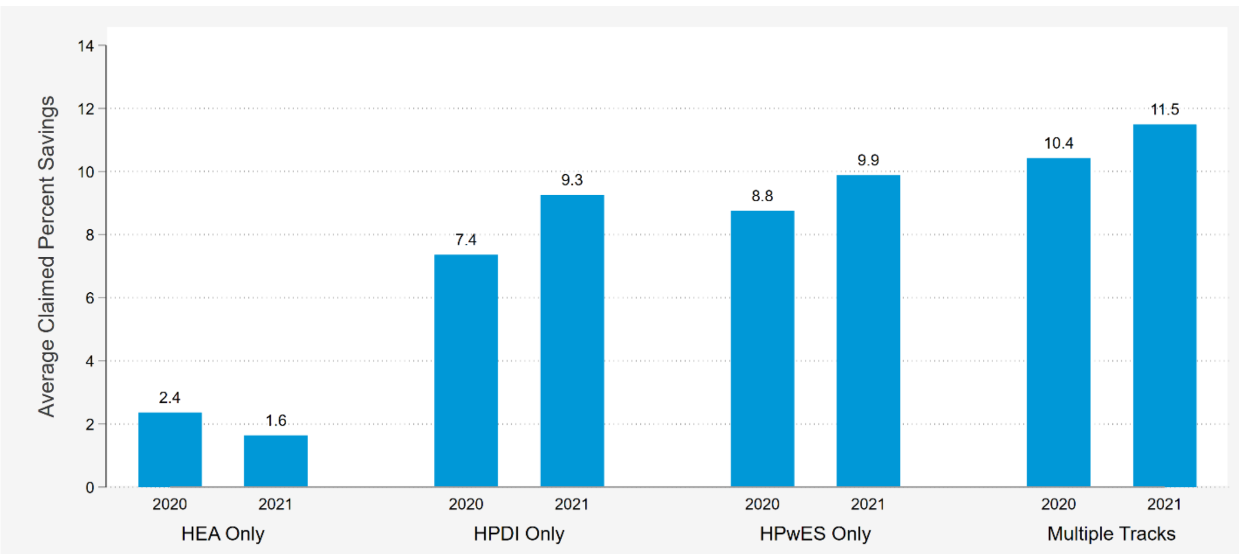
- **The measures are retrofit rather than replace-on-burnout**. This means that the equipment installed and condition of the home prior to program participation are the appropriate baseline to use in the savings calculation.

- **We have a large pool of homes to analyze**. With over 2,000 participating households per year in 2020 and 2021, 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.

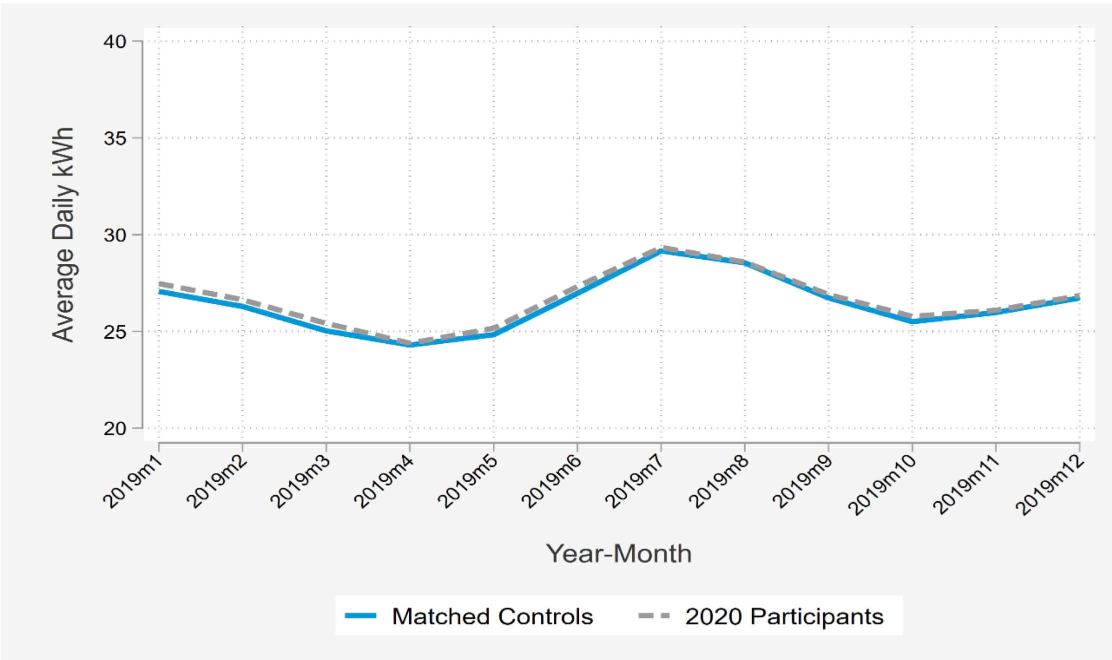
- **Savings are reasonably large on a percent basis**. On average, the ex-ante gross claimed kWh savings represented 4.7% of pre-retrofit annual billed electricity usage. As shown in Figure 18, ex-ante kWh savings as a percentage of weather-normalized pre-retrofit electric consumption varies by program component. Households that only participate in HEA show the smallest expected percent savings. HEA Only participants accounted for approximately two-thirds of all Home Performance participation in 2020 and 2021. This pulls down the average savings per household compared to the HPDI and HPwES components, which claim more kWh per participant, on average.

Figure 18: 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 2020 participants as the treatment group and construct a matched comparison group from the 2021 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 19 compares the average monthly billing analysis of the 'treatment group' and matched control group during 2019, which is the year prior to the treated homes' participation. Although the matches are quite good, we employ a difference-in-differences regression model that nets out pre-period differences from the impact estimates.

Figure 19: 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 2021) 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 2020, the status the participant group in aggregate gradually shifts.

The consumption analysis model is a linear fixed effects panel regression model. A fixed effects model absorbs time-invariant household characteristics via inclusion of separate intercept terms for each account in the treatment and comparison group. Additional details regarding the consumption analysis model, including the model specification and model parameter definitions, is presented in Appendix G. 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 2020 and 2021 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 2020 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 2020 performance and realization rates are applicable to 2021 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 2020 participants to 2021. This assumption is particularly important given the ongoing investigation of one of the most active HPwES contractors and PSEG Long Island's decision to remove 4,999 MBTU and 264 MWh from the ex-ante savings claim for 2021. As shown in Figure 17, this contractor accounted for a very similar share of savings across program years. Survey and site visit efforts completed by the evaluation team as part of the investigation revealed no discernable pattern in job quality between 2020 and 2021.

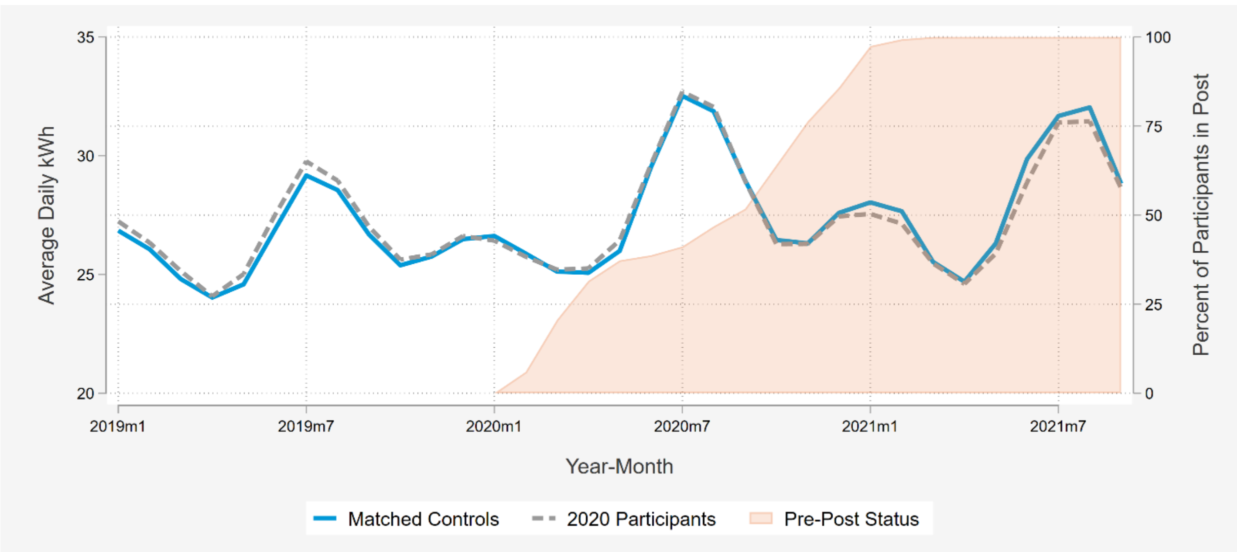
6.2.2.2 Consumption Analysis – Results

In Table 55, we use the results of the combined Home Performance programs model to estimate average savings for 2020 participants and compare the estimated impact to the ex-ante gross kWh savings claimed by the implementer. Across the 2,087 Long Island homes included in the regression model, the average annualized savings was 388 kWh. This equals 88.9% of the average ex-ante gross kWh savings claimed for the same homes. We applied the 88.9% realization rate to the ex-ante gross kWh savings claim of 2021 participants (without adjustment for the ongoing investigation) 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 20 visualizes the consumption analysis results. As more participants move into the post period, the average daily electric usage for the treatment group begins to depart from the matched control group. This is the effect of interest. The savings are largest during the winter and summer months, which is expected given the focus on HVAC and envelope improvement measures.

Table 55: Home Performance Consumption Analysis Results (n=2,085)

Parameter	Estimate	Lower Bound of 95% CI	Upper Bound of 95% CI
Daily Treatment Effect (kWh Saved)	0.946	0.702	1.189
Daily Treatment Effect (% Savings)	3.47%	2.58%	4.36%
Annual Savings	345.2	256.4	434.1
Ex-Ante Gross kWh		388.4	
Realization Rate	88.9%	66.0%	111.8%

Figure 20: 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 this ratio to the energy savings estimates derived from the consumption analysis to generate ex-post demand savings.

6.2.2.3 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 2021 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 56, Table 57, and Table 58 show the engineering analysis gross savings for each HPDI measure category in MMBtu, MWh, and kW, respectively.

Table 56: 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	912	137.2	101.4	74%
Domestic Hot Water	105	38.7	38.7	100%
Duct Sealing	41	13.4	8.0	60%
Advanced Power Strips	83	45.0	45.0	100%
HPDI Subtotal	**1,141**	**234.3**	**193.1**	**82%**

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

Table 57: 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	912	40.2	34.6	86%
Domestic Hot Water	105	11.3	11.3	100%
Duct Sealing	41	3.9	2.3	60%
Advanced Power Strips	83	13.2	13.2	100%
HPDI Subtotal	**1,141**	**68.7**	**61.5**	**90%**

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

Table 58: 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	912	6.24	4.62	74%
Domestic Hot Water	105	0.23	0.23	100%
Duct Sealing	41	3.67	2.75	75%
Advanced Power Strips	83	1.33	1.31	99%
HPDI Subtotal	**1,141**	**11.47**	**8.91**	**78%**

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

6.2.2.4 Reasons for Differences in Engineering Impacts: HPDI

The engineering analysis found variance between ex-post and ex-ante measure-level gross savings among the HPDI measure categories. Key reasons for differences are summarized in Table 59 below. In most cases, our recommendations apply to the 2023 program year. Planning for the 2022 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 2023 PSEG Long Island TRM.

Table 59: Key Contributors to HPDI Engineering Analysis MMBtu RR and Proposed Solutions

Component	Summary of Savings Difference	Proposed Solution
Lighting	▪ MMBtu, MWh, and kW realization rates were all less than 100%. The assumptions that were used for the ex-ante savings in the 2021 program tracking database were based on a stipulated mix of lamp types and baseline wattages. A different mix of lamps was actually installed. ▪ The kW realization rate of 74.1 % was driven by the coincidence factor. We used a coincidence factor of 16% based on version 9.0 of the NYS TRM. The ex-ante savings calculation used 23% which was based on "LED-only" metering results from 2016 when LEDs were still relatively expensive and mostly installed in high-use sockets. ▪ We assumed 2.7 daily hours of use for interior lamps (excluding nightlights) versus 3.2 hours in the ex-ante savings calculation. We also assumed 5.7 daily hours of use for exterior lamps versus 4.5 hours in the ex-ante savings calculation. ▪ Ex-ante MMBTU savings were calculated without taking interactive factors into account. This resulted in greater claimed savings than if the interactive factors had been used. ▪ HVAC interactive effect assumptions were updated based on modeling completed by the evaluation team during 2020 evaluation. ▪ The differences in wattages and operating assumptions, combined with the impact of interactive factors resulted in MMBTU, kWh and kW realization rates of 43.6%, 74.9%, and 74.1% and respectively.	▪ Align lighting operating assumptions, HVAC interactive effects, and baseline wattage values with the PSEG Long Island TRM.
Duct Sealing	▪ TRC used a delta CFM value of 111.9 and we used a delta CFM value of 67 per the Captures data. The difference in these assumptions is driving the Realization Rate of 60%. ▪ The duct flash testing was halted as part of COVID-19 protocols, so the captures data used	▪ The duct flash testing was halted as part of COVID-19 protocols, and have not yet resumed. If TRC does not plan to restart duct flash testing to record the actual

Component	Summary of Savings Difference	Proposed Solution
	to generate the 67 delta CFM value were not actually measured at participant homes.	CFM, then a different method for calculating this assumption should be used. ▪ Home Performance with Energy Star currently uses an algorithm for Duct Sealing that is not based in CFM values.

6.2.2.5 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 60, Table 61, and Table 62 compare gross engineering analysis savings to ex-ante gross savings by HPwES measure category for MMBtu, kWh, and kW savings, respectively.

Table 60: 2021 HPwES Engineering Analysis Gross MMBtu Impacts

Category	N[1]	Ex-Ante Gross Savings[2] (MMBtu)	Engineering Analysis Gross Savings (MMBtu)	Engineering Analysis Realization Rate (MMBtu)
Duct Sealing	1,050	3,587	3,789	106%
Air Sealing	1,273	4,842	4,842	100%
Envelope (Attic, wall, basement, and garage insulation)	1,698	11,272	9,656	86%
Heat Pumps	186	8,238	7,677	93%
HVAC (Non heat pumps - thermostats)	67	4	4	100%
DHW	18	116	116	100%
Investigation Adjustment[4]	-504	-4,999	N/A	N/A
Measure-Level Total	3,788	23,060	26,084	113%

[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.
[4] PSEG Long Island reduced its 2021 ex-ante savings claim by 4,999 MMBtu due to an investigation of contractor performance in the HPwES program component. This adjustment was not applied in the ex-post evaluation.

Table 61: 2021 HPwES Engineering Analysis Gross MWh Impacts

Category	N[1]	Ex-Ante Gross Savings[2] (MWh)	Engineering Analysis Gross Savings (MWh)[3]	Engineering Analysis Realization Rate (MWh)
Duct Sealing	1,050	380	371	98%
Air Sealing	1,273	199	199	100%
Envelope	1,698	414	120	29%
Heat Pumps	186	-431	-520	121%
HVAC (Non heat pumps - thermostats)	67	1	1	100%
DHW	18	-9	-9	100%
Investigation Adjustment[4]	-504	-264	N/A	N/A
Measure-Level Total	3,788	290	162	56%

[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] PSEG Long Island reduced its 2021 ex-ante savings claim by 264 MWh due to an investigation of contractor performance in the HPwES program component. This adjustment was not applied in the ex-post evaluation.

Table 62: 2021 HPwES Engineering Analysis Gross kW Impacts

Category	N[1]	Ex-Ante Gross Savings[2] (kW)	Engineering Analysis Gross Savings (kW)	Engineering Analysis Realization Rate (kW)
Duct Sealing	1,050	430	457	106%
Air Sealing	1,273	59	59	100%
Envelope	1,698	98	58	59%
Heat Pumps	186	57	24	43%
HVAC (Non heat pumps - thermostats)	67	0	0	100%
DHW	18	3	3	100%
Investigation Adjustment[3]	-504	-266	N/A	N/A
Measure-Level Total	3,788	381	601	158%

[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] PSEG Long Island reduced its 2021 ex-ante savings claim by 266 kW due to an investigation of contractor performance in the HPwES program component. This adjustment was not applied in the ex-post evaluation.

6.2.2.6 Reasons for Differences in Engineering Impacts: HPwES

Table 63 identifies the key contributors to the overall engineering analysis gross MMBtu realization rate of 148%. In most cases, our recommendations apply to the 2023 program year. Planning for the 2022 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 2023 PSEG Long Island TRM.

Table 63: Key Contributors to HPwES Engineering Analysis and Proposed Rectification Steps

Component	Summary of Savings Difference	Proposed Solution
HPwES General Recommendation	▪ Key data on each home's HVAC system type and efficiency are not available via a Captures bulk query. This information is only available by downloading individual measure workbooks. This makes a line-by-line analysis unfeasible for HPwES measures. The ex-post analysis is conducted using a sample of projects.	▪ We recommend adding heating and cooling system types and efficiencies to the Captures fields available via a bulk query, to allow for a complete line-by-line ex-post analysis in the future.
Insulation Measures	▪ Insulation measures are the largest source of variance among HPwES projects. The program used deemed savings/kSF values for existing and proposed insulation R-values in NYS TRM v8, while we used the updated insulation algorithms in NYS TRM v9. The deemed values are not traceable in the TRM, so we were unable to recreate the ex-ante savings/kSF values to pinpoint the driving factors. ▪ The source of pre-existing R-values in Captures is unclear and some tracked values are not physically possible, such as R-values of 0. Thus, evaluators used the NYS TRM V9 baseline assumptions for all insulation measures except for basement ceiling insulation, where we used the IL TRM assumption for floors. The NYS TRM recommends making baseline R-value assumptions based on home vintage, which is not tracked in Captures. We identified home vintage based on address for each site in the sample, which would not be feasible for a line-by-line analysis.	▪ Consistent with the 2023 PSEG-LI TRM, for 2023 planning we recommend updating insulation savings calculations to use the methodology set forth in NYS TRM V9. ▪ We recommend adding home vintage as a tracked field in Captures.

Component	Summary of Savings Difference	Proposed Solution
Duct Sealing	▪ We both used duct leakage assumptions per the Building Performance Institute. These assumptions are based on R-value and leakage estimates. TRC assumed the efficient case to be the average of tightly sealed R-4 and R-8 ducts, while we applied the value closest to the installed case. Because many efficient cases are R-11, the evaluated efficient-case duct leakage is increased when we used the R-8 value as an approximation, rather than the average of R-4 and R-8, increasing overall savings. ▪ We found at least one case where the length of sealed ducting was greater than the total length of ducting in the home per Captures data. We manually adjusted these cases as to not impact the overall realization rate.	▪ We recommend updating the duct leakage assumptions to reflect the installed case as closely as possible, using the actual installed R-value. ▪ Because EFLH assumptions depend on home type, HVAC system type, and vintage, these parameters should be tracked in Captures.
Air Sealing	▪ Air sealing measures have a realization rate of 100% when calculated using the pre/post leakage rates available in Captures data. We used these values in the ex-post analysis, however, we understand that the program is not conducting blower door tests and noted that the ΔCFM values as calculated by these pre/post fields appear to be set assumptions. The NYS TRM recommends assuming ΔCFM = 0.5 * (sealed area, square feet) in the absence of blower door tests. When calculated using the NYS TRM ΔCFM assumption, the air sealing MMBtu realization rate would increase to 120%.	▪ When blower door tests are not available, we recommend that TRC use the NYS TRM ΔCFM assumption specific to sealed area, rather than set values. Otherwise, the reason for pre/post CFM assumptions should be made clear in algorithm descriptions.

6.2.2.7 Engineering Analysis: HEA Thank You Kits

For each HEA completed by PSEG Long Island in 2021, the program mailed a Thank You Kit to the customer; each kit contained four 9-Watt LED bulbs. Table 64, Table 65, and Table 66 compare ex-post savings (via engineering analysis) with ex-ante gross MMBtu, MWh, and kW savings, respectively, for the Thank You Kits measure.

Table 64: 2021 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	3,405	1,013	1,232	122%

Table 65: 2021 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	3,405	528	546	103%

Table 66: 2021 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	3,405	92	79	86%

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. We determined baseline wattages using the actual mix of installed lamp types tracked in program year 2021 tracking data. Differing baseline wattage assumptions result in a gross engineering analysis MMBtu realization rate of 122%.

6.2.2.8 Engineering to Billing Calibration Calculations

The 2021 consumption analysis resulted in lower ex-post gross kWh savings compared to ex-ante gross kWh savings, as shown by the 88.9% realization rate. However, if we compare the ex-post gross savings to the ex-ante gross savings claimed by PSEG Long Island in its 2021 KPI Scorecard after deducting 264 MWh of savings from the contractor under investigation, the electric energy realization rate for 2021 is 100%. 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 66% to 112%. The wide margin of error is expected given the average savings per household. As shown in Figure 18, 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. When we run the billing analysis separately by program component, HEA and HPDI participants show a realization rate greater than 100% and HPwES participants show a realization rate of less than 100%.

Ex-ante calculation issues for a limited number of cases are another likely source of differences. For example, one HPwES project claimed 61,000 kWh/year in heating savings because the ex-ante calculations assumed an HSPF of 0.8 instead of 8.0. The household in question had a weather-normalized annual consumption of approximately 17,000 kWh/year prior to HPwES participation so the consumption analysis necessarily estimates fewer kWh savings.

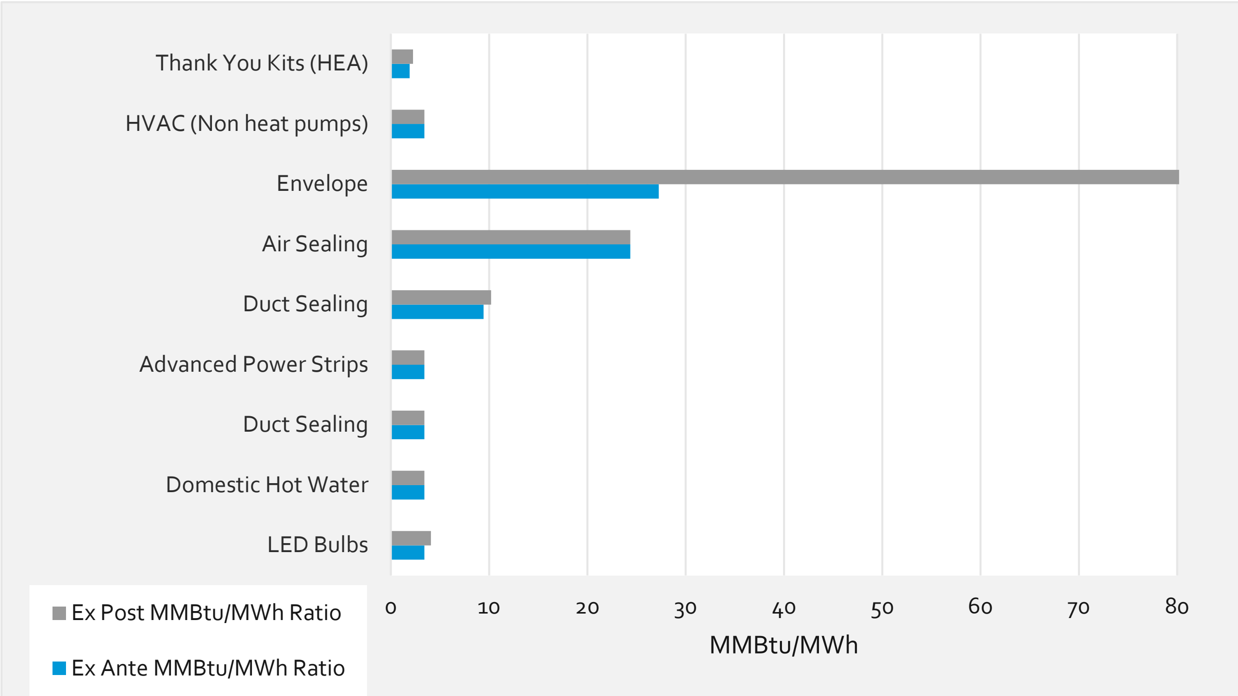
The MMBtu and peak demand savings for Home Performance are estimated via a calibration of the electric consumption analysis and engineering calculations. For both MMBtu and kW, the ex-post gross savings was larger than the ex-ante gross savings. This result is a function of the MMBtu/kWh and kW/kWh ratios 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 21 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 21: Ex-Ante Gross and Ex-Post Gross MMBtu/MWh Ratios



The billing analysis realization rate for the Home Performance program is 89%. 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 67 shows the steps for MMBtu savings. The aggregate ratio of kW to MWh from our engineering calculations was 0.51.

Table 67: 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	1,414 MWh
MMBtu/MWh Ratio	$\frac{\text{Engineering MMBtu Ex Post}}{\text{Engineering MWh Ex Post}}$	15.2 MMBtu/MWh
Calibrated MMBtu Impacts	Billing Analysis MWh Ex-Post Impacts * MMBtu/MWh Ratio	21,493 MMBtu
Add Beneficial Electrification Impacts	Calibrated MMBtu Impacts + HPwES Heat Pumps and HPWH	29,285 MMBtu

6.2.2.9 Beneficial Electrification Impacts

In 2021, the HPwES program completed 204[15] 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 68. The energy savings of the displaced fuel after electrification, and positive and negative impacts associated with energy efficiency measures, are expressed in MMBtu. Any ancillary savings indirectly associated with electrification measures have not been evaluated. Additionally, any fuel savings associated with non-electric measures, which are primarily NYSERDA-incented measures, have not been evaluated.

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

Table 68: 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 kWh Total (EE - BE)	Ex-Post Gross $MMBtu_{ee}$	Ex-Post Gross $MMBtu_{be}$	Ex-Post Gross MMBtu Total (EE + BE)
Heat Pumps	196,182	716,670	-520,488	669	7,008	7,677

Note that this table excludes EE and BE impacts for 18 HPWH measures. HPWH projects were assigned a 100% realization rate due to their small savings percentage (116 MMBtu).

6.3 CONCLUSIONS AND RECOMMENDATIONS

Our key findings and recommendations based on this evaluation are shown in Table 69. In most cases, our recommendations apply to the 2023 program year. Planning for the 2022 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 2023 PSEG Long Island TRM.

Table 69: Home Performance Findings and Recommendations

Finding	Recommendation
▪ HPwES program administrators used an unknown assumption for air sealing pre and post CFM values. Blower door tests were not permitted at the time under New York State COVID-19 protocols, and the NYS TRM at the time did not provide assumption guidelines.	▪ In the absence of blower door testing, moving forward, savings algorithms should use the site-specific area to assume change in CFM, provided in the current NYS TRM. If the program does not follow this assumption, the source of the alternative pre and post CFM values should be clearly identified.
▪ TRC utilizes deemed savings assumptions to claim ex-ante savings for insulation measures since the NYS TRM did not provide algorithms for these measures at the time.	▪ For 2023 planning, update insulation methodology to follow the algorithms provided in NYS TRM v9.
▪ We identified several instances of relevant measure-level parameters that were unavailable in the Captures tracking database, including HVAC type, HVAC efficiency, fuel type, home type, and home vintage.	▪ Contractors and program administrators should continue efforts to consistently collect and track these relevant measure-level parameters for transparency and evaluability.
▪ We found that that lighting hours of use assumptions are not consistent with HOU values in the PSEG Long Island TRM.	▪ Ensure that lighting hours of use and wattage assumptions match the PSEG Long Island TRM.

7 HOME ENERGY MANAGEMENT PROGRAM

PSEG Long Island's Home Energy Management (HEM) program currently delivers paper and electronic home energy reports (HERs) to over 411,000 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 2021 (PY2021) energy savings from PSEG Long Island's Home Energy Management Program. While behavioral programs typically deliver small percentage changes in energy use, they typically yield large aggregate savings because they reach a large volume of customers and do not require rebates or installations. The primary challenge is the need to accurately detect small changes in energy consumption while systematically eliminating plausible alternative explanations for those changes, including random chance.

The evaluation had three main research questions:

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

7.1 PROGRAM OVERVIEW

The Home Energy Management program offers a set of intervention strategies to influence customers' energy use behaviors. The primary strategy is a HER engagement campaign leveraging a randomized control trial (RCT) design. In addition to HERs, treatment customers can participate in "opt-in" interventions, such as High Usage Alerts, Home Energy Assessment Tools, Online Marketplace, and HEM Controls Pilot. The specific objectives of the program are to:

- Increase awareness of and participation in energy efficiency programs,
- Increase peak hour energy savings,
- Reduce energy usage,
- Consider renewable energy/energy storage and demand response programs, and
- Increase 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 initiation of this energy savings program occurred in September 2017 when 341,570 customers began receiving HERs. This first wave of customers is referred to as Cohort 1 for the remainder of the report. In August 2018, the program began to send HERs to an additional 159,348 customers. This second wave of customers is referred to as Cohort 2 for the remainder of the report.

The program's initial goal, set in 2017, was to achieve over 30,000 MWh of behavior-based energy savings per year over a two-year period. The new goal set for 2021 was to achieve 37,331 MWh in energy savings across both cohorts. Due to attrition, the treatment and control groups for both cohorts are smaller now compared to when the cohorts were first launched. Additional details on attrition and current treatment numbers are provided below. From 2022 onward, PSEG Long Island anticipates sending HERs to treatment customers in both Cohorts 1 and 2 and is considering launching an additional third cohort. The energy savings estimates do not include home energy reports sent to over 9,000 homes as part of distribution deferral project because those reports were not funded by energy efficiency.

7.2 2021 PROGRAM ENROLLMENT AND REPORT COUNTS

Table 70 presents HEM program participation in Cohorts 1 and 2. Cohort 1 contained 278,930 treatment customers and Cohort 2 contained 132,238 customers, which represents an attrition rate of 2% from PY2020. 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, which are approximately 94% of the evaluation, and apply the results to the full population.

Table 70: 2021 HEM Program Participation Summary[16]

Cohort	Number of Treatment Customers	Number of Control Customers	Number of Customers per Cohort
Cohort 1	278,930	34,005	312,935
Cohort 2	132,238	29,003	161,242
Total	**411,168**	**63,009**	**474,177**

Each treatment group household is sent a total of five reports over the course of the year. Some customers who are excluded from the analysis (due to the customer moving out) still received reports from PSEG Long Island in 2021. Based on the program tracking data, the verified count of paper reports sent was 2,359,442 with each participant receiving multiple reports throughout the year. The verified number of paper reports sent each month and the total for 2021 are presented in Table 71.

Table 71: HEM Program Paper HERs Sent by Month in 2021

Month	Verified Report Count
January	214,353
February	117,282
March	277,515
April	131,067
May	342,657
June	161,210
July	241,096
August	184,946
September	229,797
October	166,194
November	293,325
December	-
Total	**2,359,442**

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 22 shows the distribution of annual

[16] Counts represent the average number of customers with active billing data in 2021. Savings were calculated for each month separately based on the number of customers with active billing data that month.

consumption by cohort for the treatment and control groups prior to each HER cohort launch. Treatment and control groups are comparable, and the average customer size is relatively similar between cohorts.

Figure 22: Pre-Treatment Annual Electric Consumption by Cohort

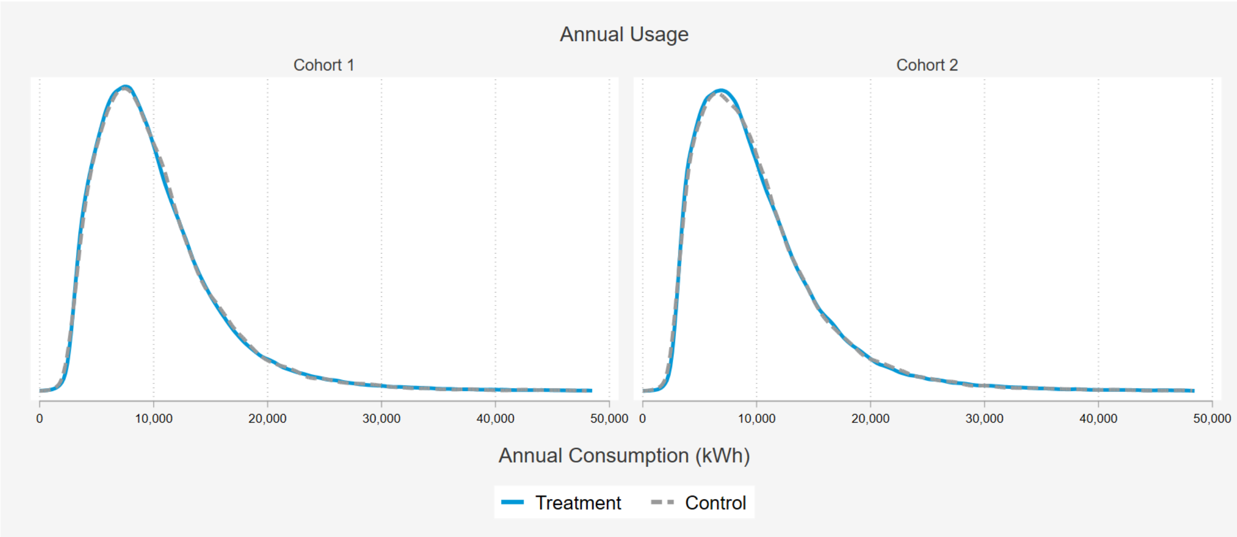


Table 72 shows the average annual usage between treatment and control groups by cohort. There are minor differences between the two groups for each cohort. On average, the annual usage is 0.09% different between the groups, and neither wave shows a statistically significant difference between the two groups. The minor pre-existing difference is netted out in the statistical analysis.

Table 72: 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	32,060	262,989	10,304.4	10,278.0	-26.4	-0.26%	(-99.0,46.2)
Cohort 2	8/27/2018	27,159	123,985	10,185.8	10,160.7	-25.1	-0.25%	(-116.1,65.8)
Total		**59,219**	**386,974**	**10,250.0**	**10,240.4**	**-9.6**	**-0.09%**	**(-96.8,77.6)**

[1] The estimating sample is limited to participants and control with a full year of pre-intervention data and are roughly 94% of the total participants

7.4 ELECTRIC EX-POST SAVINGS SUMMARY

Table 73 depicts the ex-post savings results for HEM in MMBtu and MWh. A total of 411,168 customers participated in the program in PY2021, on average saving 79 kWh per participant annually for total annual savings of 32,557 MWh, or 111,083 MMBtu before accounting for any dual enrollment in other programs, referred to here as uplift. Once we account for uplift, the average participant saved 76 kWh annually for total annual savings of 31,198 MWh and 106,447 MMBtu.

The HEM realization rate is the ratio between claimed ex-post savings and 2020 claimed ex-ante savings. In 2021, the realization rate for electric savings was 77.9%. The ex-post savings were 83.6% of the HEM goal for 2021. There are two major factors driving this realization rate. The first factor is the method for calculating savings for claimed ex-ante savings. Claimed ex-ante savings are calculated based on savings per report and are scaled up based on the number of reports sent out over the course of the year. However, energy savings are not linearly related to the number of reports sent, but to the number of participants. We can see in the table below that scaling based on the number of reports leads to far higher estimated participation compared to the goal or participation in the previous year. This leads to a lower realization rate for participation. The second reason is slightly lower per-customer annual savings than planned, with only 76 kWh saved annually compared to the planned annual savings of 85 kWh. However, these savings goals are far more aligned compared to the savings goals in PY2020. While slightly short of PSEG LI's goal for 2021, these savings are consistent with the savings observed in the 2020 evaluation of HEM.

Table 73: 2021 HEM Program Ex-Post Gross Impacts

Metric	Participation	kWh per participant	Energy Savings	
			MMBtu	MWh
Goal	440,000	85	127,374	37,331
Claimed Ex-Ante	471,910	85	136,606	40,037
Verified Ex-Ante	471,910	85	136,606	40,037
Unadjusted Ex-Post	411,168	79	111,083	32,557
Uplift Adjustment[1]	411,168	3	4,636	1,359
Adjusted Ex-Post After Accounting for Uplift	411,168	76	106,447	31,198
Realization Rate of Ex-Post to Claimed Ex-Ante	87.1%	89.4%	77.9%	77.9%
Ex-Post as Percent of Goal	93.4%	89.4%	83.6%	83.6%

Table 74 summarizes the demand savings in kW for the HEM program for 2021. The HEM population was able to reduce demand by 8.69 MW between 4 and 5 PM during summer 2021. 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 2021 and scaled for the full population of participants. Detailed methodology in Appendix A-F provides additional details on the peak demand savings calculations.

Table 74: HEM Peak Demand Reduction

Wave	MW Impact
Cohort 1	6.07
Cohort 2	2.62
Total	**8.69**

7.5 ELECTRIC EX-POST SAVINGS DETAIL

Table 75 depicts the unadjusted ex-post savings from the analysis. On average, participants saved approximately 79 kWh ± 13 kWh annually (95% confidence), or approximately 0.8% of their annual consumption. On an aggregate basis, HEM reduced electricity use by 111,083 MMBtu.

Table 75: 2021 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	278,930	0.73%	75.29	58.58	89.01	71,770
Cohort 2	132,238	0.86%	87.35	67.44	105.48	39,331
Total	**411,168**	**0.77%**	**79.15**	**66.02**	**89.68**	**111,083**

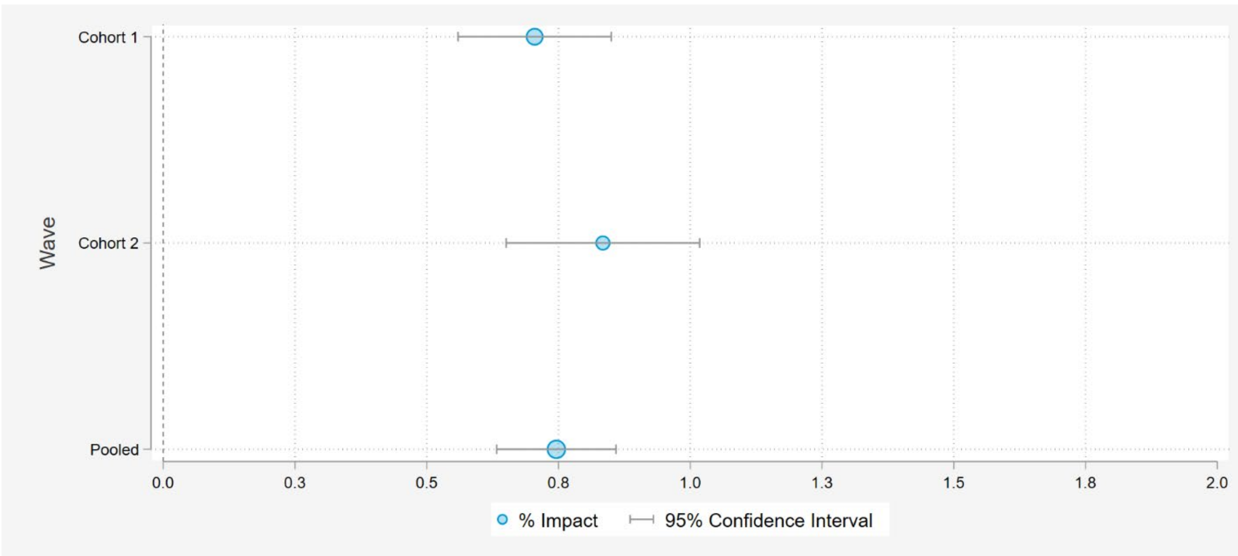
Table 76 depicts the percent savings for each cohort by month. We see that the highest percent savings generally occur in the winter, with Cohort 1 seeing savings over 1.2% in December.

Table 76: 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	0.89%	1.01%	0.93%
February	0.80%	0.98%	0.86%
March	0.71%	1.23%	0.88%
April	0.64%	0.93%	0.73%
May	0.60%	0.44%	0.55%
June	0.48%	0.63%	0.53%
July	0.66%	0.60%	0.64%
August	0.63%	0.86%	0.70%
September	0.37%	0.65%	0.46%
October	0.84%	0.99%	0.89%
November	1.16%	1.12%	1.15%
December	1.21%	0.97%	1.13%
Annual	**0.73%**	**0.86%**	**0.77%**

Figure 23 shows the percent impacts by cohort and the percent impact for all cohorts pooled. The size of the marker indicates the relative participant population size for each wave. The savings for individual cohorts are statistically significant, and there are 0.8% annual savings for the pooled analysis. The magnitude of savings is also similar between the two cohorts.

Figure 23: Electric Percent Impacts by Wave

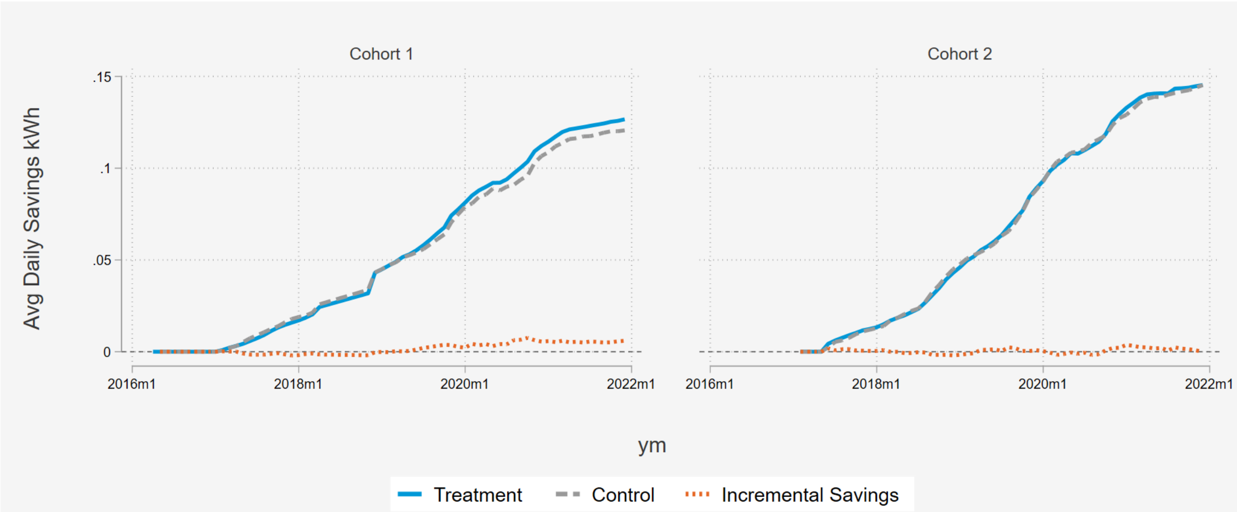


The evaluation team tested the robustness of the impacts by implementing two other common methods for estimating behavioral impacts: a panel difference-in-difference model and a manual difference-in-difference calculation. The panel difference-in-difference model uses data from both the pre and post periods. The manual difference-in-difference approach examines differences in raw averages. Monthly savings estimates were similar across the three methods. Figure 24 provides a comparison of the average daily savings estimates each method yields. Figure 24 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 24: Unadjusted Savings by Month by Model Specification

In order to avoid double counting savings, we also conducted a dual participation analysis to see if there was significantly higher participation in other energy efficiency programs in the treatment group compared to the control group. Customers engage in energy efficiency through either rebate programs (downstream) or through in-store discounts (upstream). Figure 25 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 increased enrollment in other 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. For more detail on how dual participation analysis was calculated, please see Detailed Methodology.

Figure 25: Downstream Dual Participation Analysis Output



7.6 COMPARISON TO PY2020

Table 77 compares per-customer savings from PY2020 and PY2021. In PY2021, the per-customer and percent savings were slightly lower for Cohort 1, although relatively similar to the previous year. Cohort 2 saw substantially higher per customer savings and percent savings. This aligns with the expectation that customers savings increase over the first few years of HEM program participation.

Table 77: Unadjusted Ex-Post Savings by Cohort and Evaluation Year

Cohort	2020 Energy Impact Per account		2021 Energy Impact Per account	
	kWh Impact	% Impact	kWh Impact	% Impact
Cohort 1	87.03	0.82%	75.29	0.73%
Cohort 2	46.23	0.44%	87.35	0.86%

7.7 CONCLUSIONS AND RECOMMENDATIONS

PSEG Long Island's HEM program remains a significant component of PSEG LI's portfolio, currently reaching over 410,000 electric accounts. While home energy reports deliver small percentage changes in energy use, they typically yield large aggregate savings because they reach a large number of customers and do not require rebates or installations. In PSEG LI, the program yielded 31.9 GWh (or 106,447 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 78. Additionally, we'd stress the importance of analyzing the impacts of this program using an RCT. While the approach requires withholding a subset of customers to serve as controls and provide a baseline, the approach is necessary because the signal (the percent savings) is small and would be extremely difficult to detect without a control group.

Table 78: HEM Findings and Recommendations

Finding	Recommendation
▪ The 2021 realization rate for HEM was closer to 100% than 2020 but ex-post savings still fell short of ex-ante claims	▪ PSEG Long Island claims ex-ante savings based on the number of reports sent over the year and an assumed savings per report. We recommend that PSEG Long Island adjust their ex-ante calculation method to key off the number of households receiving reports. This change will make the ex-ante claimed savings less sensitive to the actual number of reports issued.
▪ HEM's percent savings (0.8%) 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 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 2021 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 2022.
▪ One of the goals of HEM is to expand enrollment in renewable energy and/or energy storage programs.	▪ We recommend comparing treatment and control group solar and battery storage adoption over time to see if HEM has any influence on overall adoption of these technologies.

APPENDIX A DETAILED METHODOLOGY

A. CEP METHODOLOGY

	Evaluation Methodology: Commercial Efficiency Program
Key Considerations	• Availability of project-specific inputs in Capture queries vs. supporting workbooks for Comprehensive Lighting • Perspective on total MMBtu savings for Distributed Generation • Waste Heat Factors for Commercial Lighting
General Approach (Ex-post gross)	Engineering calculations rooted in PSEG-LI TRM algorithms and informed by install tracking (Captures) database
Sampling Method(s)	• Census of all measure installs for measures where Captures data includes all parameters • Stratified random sample of projects where the parameters and calculations are housed in supporting workbooks
Primary Data	• Captures install tracking data for PY2021 CEP measures • Project specific pre- and post-inspection details • Custom measure inputs and calculations • Historical realization rates for CHP projects • Updated lighting waste heat factors developed by the evaluation team
Secondary Sources	• PSEG LI Technical Reference Manuals 2019-2021 • New York State TRM v9.0 • Department of Energy Codes and Standards • Lighting cut sheets and other manufacturer equipment specifications • PSEG LI Planning documents and workbooks • 2010 LIPA Technical Manual
Net-to-Gross Approach	Stipulated NTG ratios
Other Evaluation Techniques	• Engineering Calculations
Opportunities for Refinement	• **Consider MMBtu impacts at source:** when claiming savings from distributed generation projects. • **Reference the PSEG Long Island TRM:** some program savings algorithms and input assumptions still reference the 2010 LIPA Technical Manual • **Track more project and measure level data in Captures** and make it available to be downloaded for evaluations

B. EEP METHODOLOGY

Evaluation Methodology: Energy Efficient Products	
Key Considerations	• Prescriptive measures with thorough tracking data • Low-to-moderate measure complexity • Moderate uncertainty of key savings parameters • High program contribution to portfolio savings • Program savings highly skewed to two measure categories, namely Lighting and Heat Pump Pool Heaters
General Approach (Ex-post gross)	Engineering calculations rooted in PSEG-LI TRM algorithms and informed by install tracking (Captures) database
Sampling Method(s)	Census of all measure installs
Primary Data	Captures install tracking data for PY2021 EEP measures
Secondary Sources	• PSEG LI Technical Reference Manuals 2019-2022 • New York State TRM v8.0 and v9.0 • ENERGY STAR Qualified Product Lists • Uniform Methods Project for Determining Energy Efficiency Program Savings (UMP) • Department of Energy Codes and Standards • Other manufacturer equipment specifications • PSEG LI Planning documents and workbooks
Net-to-Gross Approach	Stipulated NTG ratios
Other Evaluation Techniques	• Regression analysis, deemed savings used for certain measures • Diverged from TRM algorithm when enough data available • Assumed baseline is federal standard for end-of-life replacement measures • Updated HVAC interactive factors for LED lighting
Opportunities for Refinement	• **Inform savings estimates with supplemental research:** Research pool pumps and assumptions around baseline condition, capacity • **Use UMP regression for measures where install data permits** • **Increase focus on beneficial electrification** (data flow, rigor, and techniques)

C. HOME COMFORT METHODOLOGY

Evaluation Methodology: Home Comfort	
Key Considerations	• Beneficial Electrification measures result in an increase in site-level electric consumption by displacing fossil fuel systems sometimes resulting in negative 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 PY2021 Home Comfort measures
Secondary Sources	• PSEG LI Technical Reference Manuals 2019-2022 • New York State TRM v8.0 and v9.0 • Department of Energy Codes and Standards • Other manufacturer equipment specifications • PSEG LI Planning documents and workbooks • Northeast/Mid-Atlantic Air-Source Heat Pump Market Strategies Report 2016 Update • NYSERDA Heat Pump Study: "Analysis of Residential Heat Pump Potential and Economics" -May 2019
Net-to-Gross Approach	Stipulated NTG ratios
Other Evaluation Techniques	• Engineering Calculations
Opportunities for Refinement	• **Align with PSEG-LI TRM** on Quality Install savings algorithms, full load heating and cooling hours, savings algorithms, and savings estimation methods • **Track preexisting boiler and furnace heating system data** to improve accuracy of ex-ante savings • **Adopt deemed savings values** that vary based on the HVAC equipment controlled by the thermostats

D. REAP METHODOLOGY

Evaluation Methodology: Residential Energy Affordability Partnership Program	
Key Considerations	• REAP Evaluation was a combination of engineering calculations and consumption analysis • Consumption analysis will estimate savings that take in the interactive effects of implementing multiple measures at one location • REAP savings were dominated by lighting measures
General Approach (Ex-post gross)	• Engineering calculations rooted in PSEG-LI TRM algorithms and informed by install tracking (Captures) database. These calculations were used to calculate MMBtu to kWh and kW to kWh ratios. • Consumption analysis rooted in billing data from 2020 and 2021 customers using pre-participation data from 2021 customers as a baseline and post-participation data from 2020 customers as the treatment. Consumption analysis was used to estimate kWh realization rates. • The engineering calculation ratios and kWh realization rate from consumption were then used to estimate energy (MMBtu) and demand (kW) savings.
Sampling Method(s)	• Census of all measure installs from Captures • Matched participants provided in billing data
Primary Data	• Captures install tracking data for PY2021 EEP measures • Billing data from 2020 and 2021 REAP participants
Secondary Sources	• PSEG LI Technical Reference Manuals 2019-2021 • New York State TRM v8.0 and v9.0 • Department of Energy Codes and Standards • Other manufacturer equipment specifications • PSEG LI Planning documents and workbooks
Net-to-Gross Approach	Stipulated NTG ratios
Other Evaluation Techniques	• Engineering Analysis • Consumption Analysis using participant matching and fixed effects panel linear regression model
Opportunities for Refinement	• **Align baseline and installed wattage values** with the assumptions in the PSEG-LI TRM • **Align operating parameters (HOU and CF) and waste heat factors** 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 savings for those measures. • Impact Evaluation values are a combination of engineering calculations and consumption analysis
General Approach (Ex-post gross)	Engineering calculations rooted in PSEG-LI TRM algorithms and informed by install tracking (Captures) database. Consumption calculations were rooted in participant billing data and used to estimate kWh energy efficiency realization rates. Ex-post gross kWh energy efficiency savings were calculated by applying consumption analysis realization rate to EE savings. Ex-post gross kWh beneficial electrification impacts were calculated from engineering analysis. Ex-post gross kW and MMBtu savings were calculated using kW/kWh and MMBtu/kWh ratios from engineering calculations applied to ex-post gross kWh savings.
Sampling Method(s)	• Census of all measure installs from Captures • Matched participants provided in billing data
Primary Data	• Captures install tracking data for PY2020 Home Performance measures • Billing data from 2019 and 2020 Home Performance participants
Secondary Sources	• PSEG LI Technical Reference Manuals 2019-2021 • New York State TRM v7.0 and v8.0 • Department of Energy Codes and Standards • Other manufacturer equipment specifications • PSEG LI Planning documents and workbooks
Net-to-Gross Approach	Stipulated NTG ratios
Other Evaluation Techniques	• Engineering Analysis • Consumption Analysis using participant matching and fix effects panel linear regression model
Opportunities for Refinement	• **Track impacts by fuel:** (positive and negative) rather than zero out negative savings for HPwES projects • **Focused effort on tracking measure-level parameters in Captures**: specifically CFM values and conditioned square footage for duct sealing projects; HVAC system type and fuel type; pre-installation wattages and quantities for direct-install lighting

F. HOME ENERGY MANAGEMENT METHODOLOGY

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

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

I. Approach Overview

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

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

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

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

II. 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 79.

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

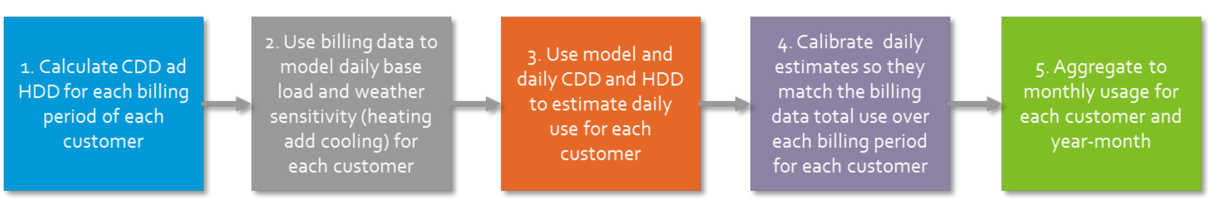
Table 79: Lagged Dependent Variable Model Definition of Terms

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.
$\mathrm{treatment}_{\mathrm{im}}$	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.
$\varepsilon_{\mathrm{im}}$	The error term.

III. 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 26 summarizes the process employed to calendarize the data.

Figure 26: Calendarization of Billing Data



IV. 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).

V. 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 80 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 80 relies on a conditional lookup based on the number of years since cohort inception to calculate the reduction factor.

Table 80: Default Upstream Adjustment Factors[17]

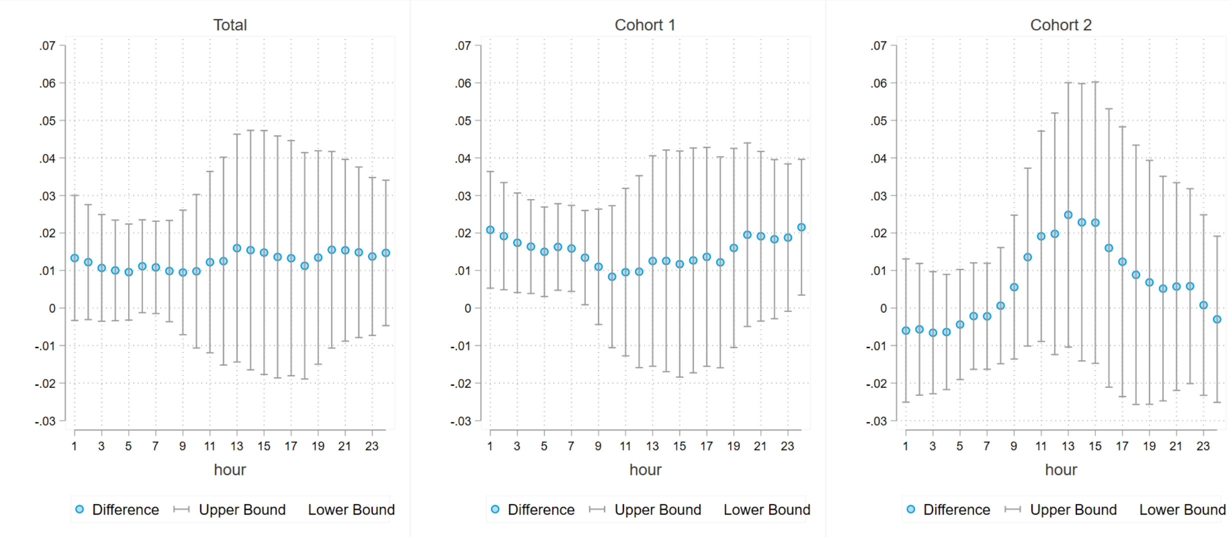
Years Since Cohort Inception	Default Upstream Reduction Factor
1	0.75%
2	1.5%
3	2.25%
4 and beyond	3.0%

VI. 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 2021. Figure 27 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 2021. 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 1 savings are flatter, with slightly higher savings in the morning and evening while Cohort 2 savings are concentrated in the middle of the day.

[17] 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 27: 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 Cohort 1 this pre-treatment difference was 0.26% and for Cohort 2 the pre-treatment difference was 0.25%. Once we adjusted for the pre-treatment difference, we found that the HEM population was able to reduce demand by 8.69 MW between 4 and 5 PM during the summer. Table 81 summarizes the peak demand reduction for each wave.

Table 81: HEM Peak Demand Reduction

Wave	MW Impact
Cohort 1	6.07
Cohort 2	2.62
Total	**8.69**

G. CONSUMPTION ANALYSIS METHODOLOGY FOR REAP AND HOME PERFORMANCE

The consumption analysis relies on a comparison between billed consumption prior to and following the energy efficiency upgrades. In 2021, 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 2020 acted as the "treatment" group and participants from 2021 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.

I. Home Performance with ENERGY STAR Contractor Under Investigation

Due to an ongoing investigation of 2020 and 2021 reporting practices by one of the more active HPwES contractors, PSEG Long Island removed 4,999 MBTU of savings from the HPwES track in its year-end reporting. The evaluation team included all homes serviced by this contractor during 2020 and 2021 in the billing analysis. To the extent that jobs were not completed, or were only partially completed, that finding will be captured in the average reduction in electric consumption.

II. 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 82 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 82: 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	

III. 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 83 contains four months of simulated billing data. The consumption values and time periods are hypothetical and not from an actual customer.

Table 83: 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 84 shows estimated daily usage for each day in December.[18] 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 84: Redistribute December Billing Data

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

To retrieve prorated billing data, simply sum up the estimated daily usage values within each month. This is illustrated in Table 85 for December, January, and February.

Table 85: Calendarized Billing Data

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

[18] 2020 calendar is used for this example

IV. MATCHING

In a matched control framework, each participant is matched to exactly one control home that shows a similar energy-use profile. In our 2021 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 2021 analysis, the best-performing matching model was slightly different for REAP and Home Performance

Figure 28 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 2020 and 2021 show similar distributions and central tendency. Figure 29 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 28: Distribution of Annual Consumption Prior to Matching, REAP

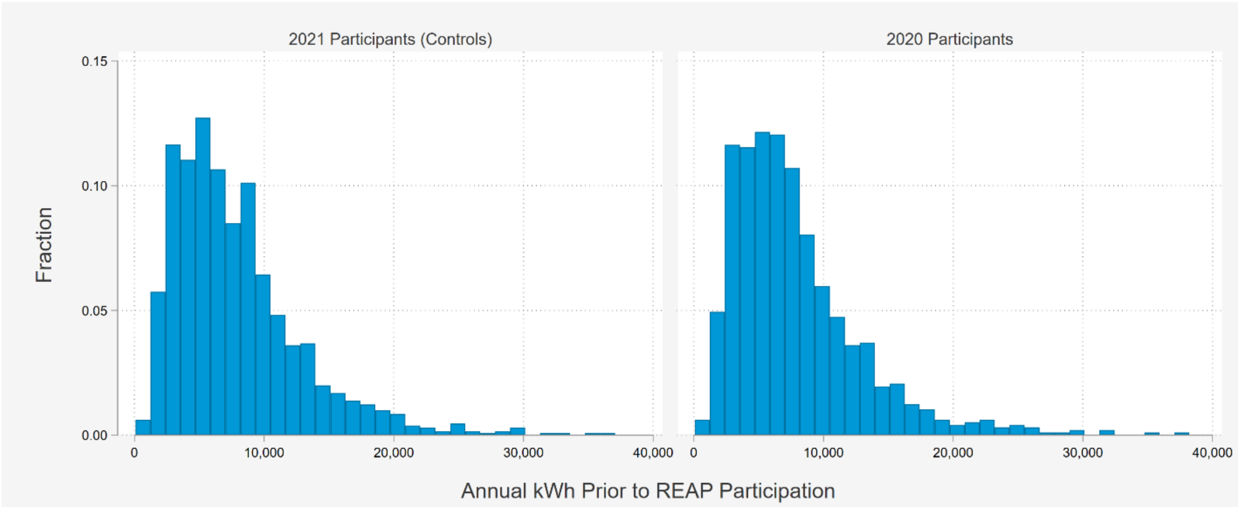


Figure 29: Average Daily Usage of Treatment and Comparison Groups (kWh), REAP

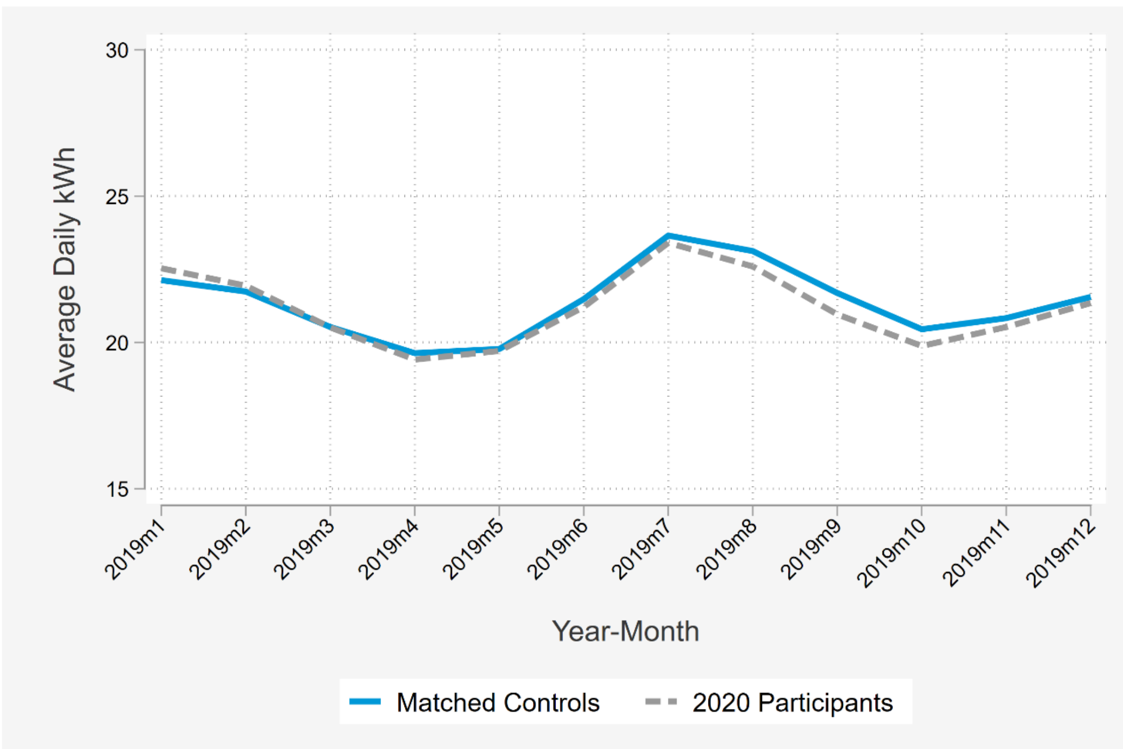


Figure 30 and Figure 31 are similar to Figure 28 and Figure 29 but represent Home Performance treatment and comparison group rather than REAP. The takeaways for Home Performance are the same as REAP – the participant group and the matched control groups are well-aligned in their annual consumption and the seasonality of their consumption trends.

Figure 30: Distribution of Annual Consumption Prior to Matching, Home Performance

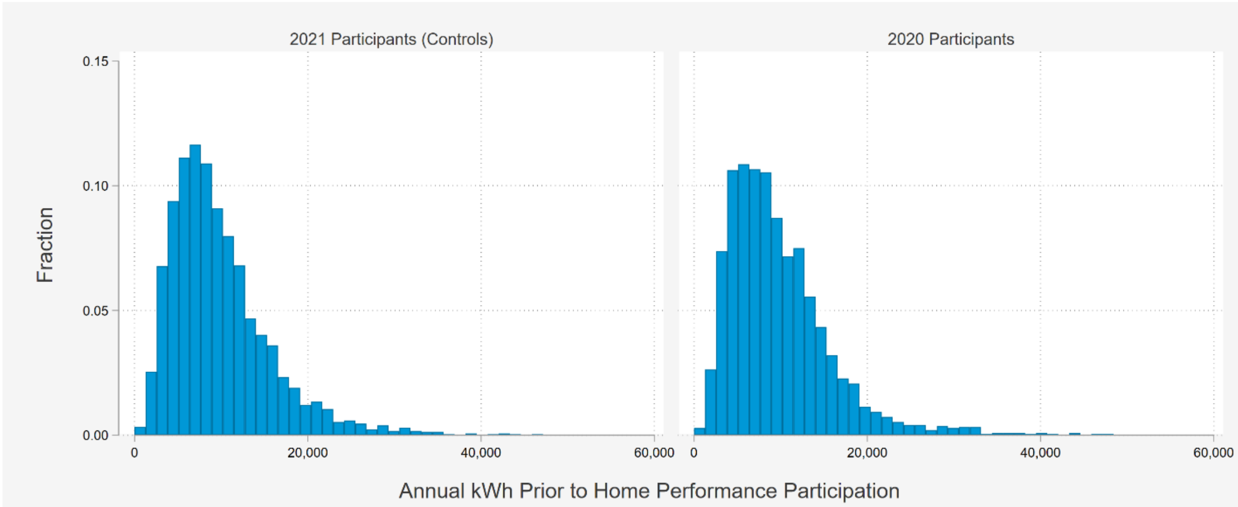
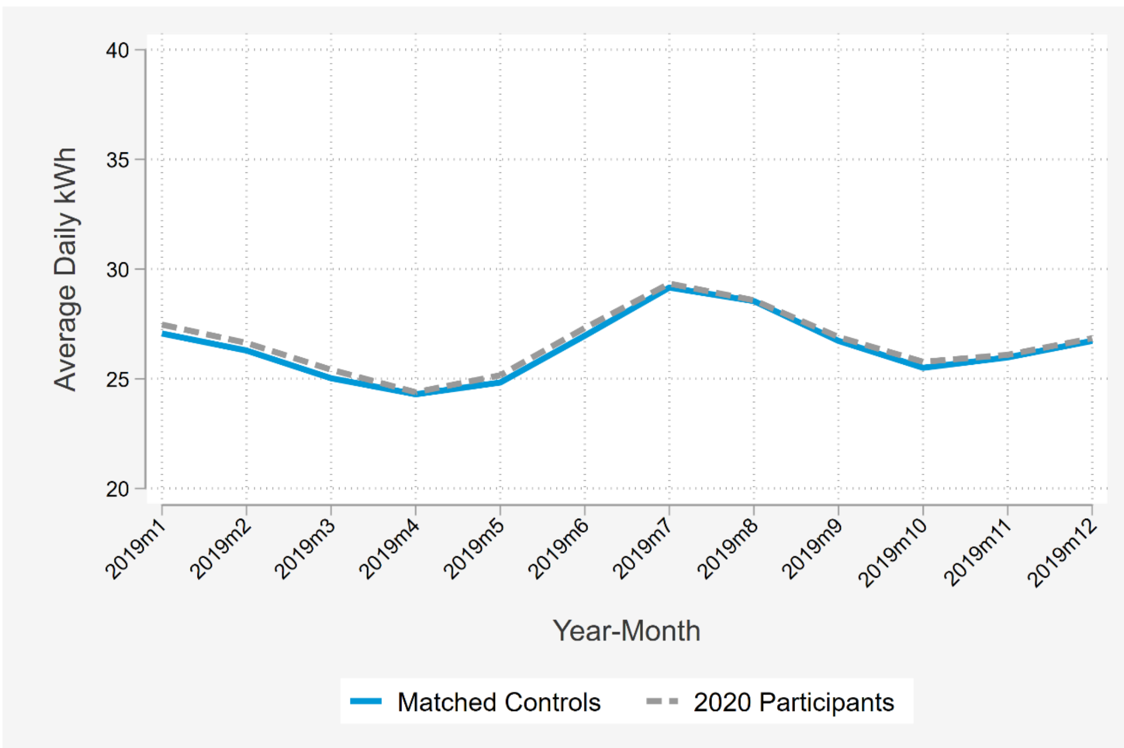


Figure 31: Average Daily Usage of Treatment and Comparison Groups (kWh), Home Performance



V. Impact Analysis

The consumption analysis model is a linear fixed effects panel regression model. A fixed effects model absorbs time-invariant household characteristics via inclusion of separate intercept terms for each account in the treatment and comparison group. Equation 1 shows the full model specification. Inclusion of monthly time effects improves the precision of the base 'difference-in-differences' calculation. We weight the regression model by the number of days of the month. The treatment effect is the difference in daily energy use that is associated with participating in the program. We multiply the treatment effect by the number of days in a year to annualize the savings.

Equation 1: Linear Fixed Effects Regression Model Specification

$$\mathrm{kWh}_{\mathrm{imy}} = \beta_{\mathrm{i}} + \beta_p * Post_{imy} + CDD_{my} * \beta_{\mathrm{CDD}} + HDD_{my} * \beta_{\mathrm{HDD}} + \tau_{my} * Post_{imy} * \mathrm{treatment}_{\mathrm{i}} + \varepsilon_{\mathrm{imy}}$$

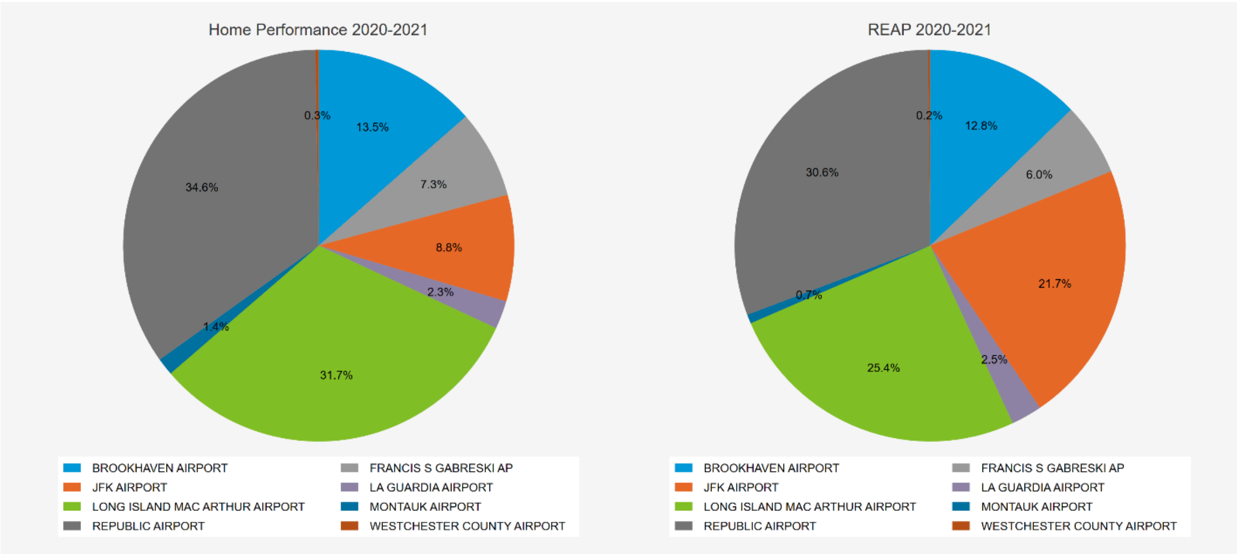
Table 86 defines the model terms and coefficients in Equation 1.

Table 86: Regression Model Parameter Definitions

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

The Evaluation Team used service zip code to map each participating household to one of eight weather stations. Figure 32 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 32: Weather Station Mapping by Program



The REAP consumption analysis returned an annual savings estimate of 713 kWh (95% confidence interval: 615 kWh/year, 811 kWh/year), and the Home Performance analysis returned an annual savings estimate of 345 kWh (95% confidence interval: 256 kWh/year, 434 kWh/year). Savings for REAP and Home Performance are visualized in Figure 33 and Figure 34, respectively. Statistical regression output for the REAP and Home Performance models is shown in Figure 35 and Figure 36, respectively. The key term in the regression output is the coefficient for the "treatpost" term, which represents the change in average daily consumption for the treatment group in the post period.

Figure 33: REAP Consumption Analysis Results Visualized

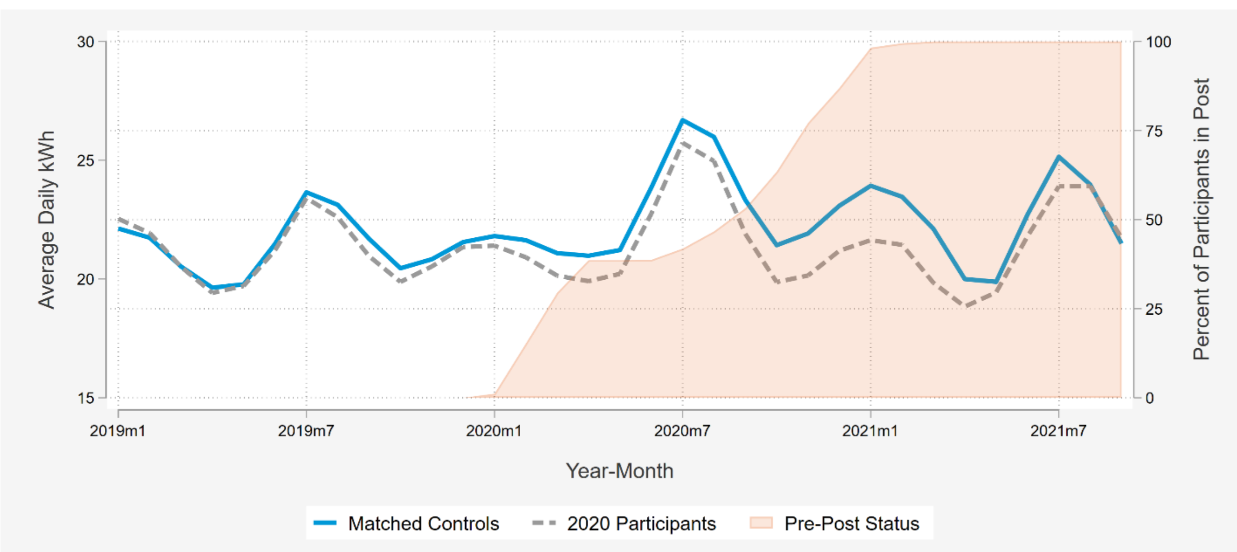


Figure 34: Home Performance Consumption Analysis Results Visualized

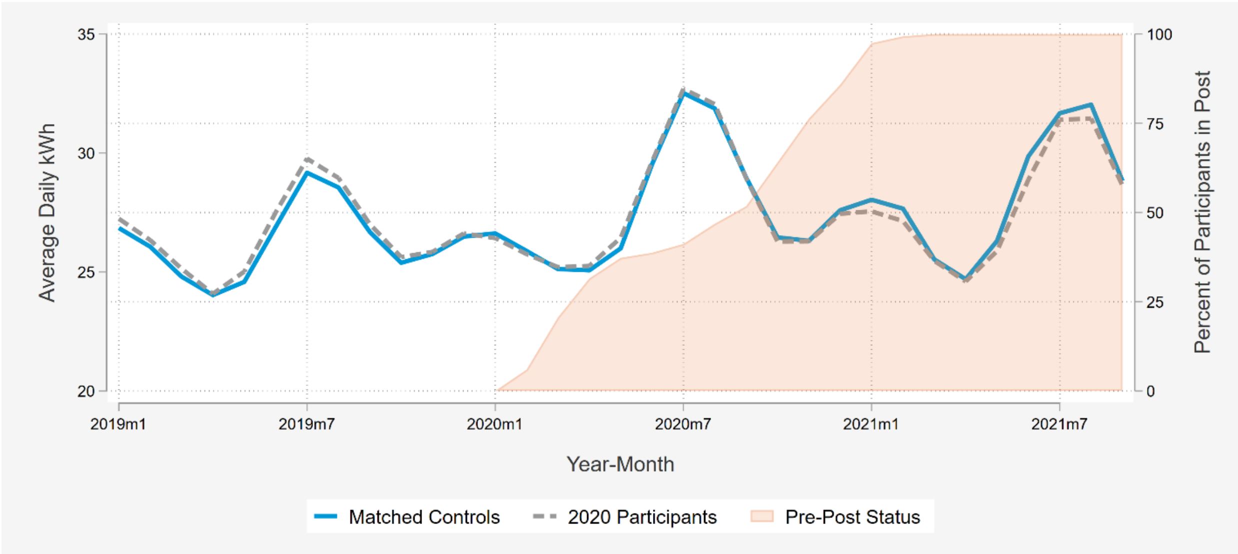


Figure 35: Regression Output – REAP

```
Linear regression, absorbing indicators         Number of obs     =     59,380
Absorbed variable: id                           No. of categories =      1,932
                                                F(   4,  57444)   =     524.73
                                                Prob > F          =     0.0000
                                                R-squared         =     0.7815
                                                Adj R-squared     =     0.7742
                                                Root MSE          =     7.6164
```

daily_kwh	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
post	1.574008	.1102308	14.28	0.000	1.357955	1.79006
treatpost	-1.954334	.1391372	-14.05	0.000	-2.227043	-1.681624
daily_cdd60	.3644474	.0083491	43.65	0.000	.3480832	.3808116
daily_hdd60	.1200602	.0046734	25.69	0.000	.1109003	.1292201
_cons	18.61081	.0801488	232.20	0.000	18.45371	18.7679

Figure 36: Regression Output – Home Performance

```
Linear regression, absorbing indicators         Number of obs     =    127,618
Absorbed variable: id                           No. of categories =      4,170
                                                F(   4, 123444)   =     872.82
                                                Prob > F          =     0.0000
                                                R-squared         =     0.7633
                                                Adj R-squared     =     0.7553
                                                Root MSE          =     9.8667
```

daily_kwh	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
post	1.250756	.0975341	12.82	0.000	1.059591	1.441921
treatpost	-.9458997	.1242154	-7.61	0.000	-1.18936	-.7024395
daily_cdd60	.4074097	.00737	55.28	0.000	.3929646	.4218547
daily_hdd60	.0967861	.0040489	23.90	0.000	.0888504	.1047219
_cons	24.13187	.071879	335.73	0.000	23.99099	24.27275

APPENDIX B VERIFIED EX-ANTE MEMO

MEMORANDUM 2021 VERIFIED EX-ANTE SAVINGS

Date: January 31, 2022

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

From: 2021 Evaluation Team (Demand Side Analytics, DNV, and Mondre Energy)

Re: 2021 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 2021 energy efficiency and beneficial electrification programs. This memorandum defines "verified ex-ante" (VEA) savings and presents the 2021 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 contractor (TRC). The ratio of these two values is the verified ex-ante realization rate.

The details of the verified ex-ante calculations vary by program and measure. Some measures were assigned static per-unit impacts in the 2021 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. Additionally, throughout the program year improvements to the assumptions were proposed by TRC and approved by PSEG-LI. These new assumptions were used to calculate verified ex-ante where applicable.

The verified ex-ante savings are the first milestone of the 2021 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

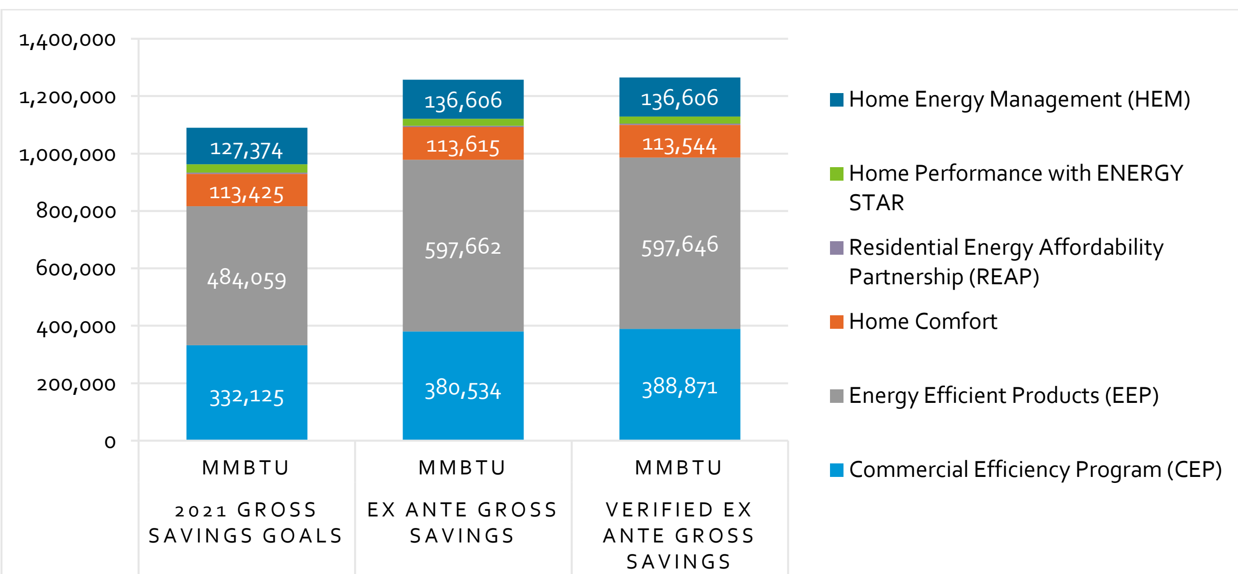
Table 1 summarizes the 2021 verified ex-ante savings for MMBtu. The verified ex-ante savings were 100.7% of the claimed ex-ante gross savings. The evaluation team's independent measure counts were nearly identical to the claimed measure counts. Per-unit MMBtu savings calculations and assumptions matched the approved values almost perfectly for nearly all measures. In 2021, 6,722 heat pumps were claimed to be installed through the Home Comfort, EEP, Home Performance, and CEP programs. We can confirm that we have counted the same number of heat pumps as TRC.

TABLE 1: SUMMARY OF 2021 VERIFIED EX-ANTE MMBTU SAVINGS AND GOALS

Program		2021 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)	332,125	380,534	388,871	102.2%	117.1%
Residential	Energy Efficient Products (EEP)	484,059	597,662	597,646	100.0%	123.5%
	Home Comfort	113,425	113,615	113,544	99.9%	100.1%
	Residential Energy Affordability Partnership (REAP)	4,532	4,648	4,650	100.0%	102.6%
	Home Performance	28,760	24,307	24,307	100.0%	84.5%
	Home Energy Management (HEM)	127,374	136,606	136,606	100.0%	107.2%
Total Commercial:		**332,125**	**380,534**	**388,871**	**102.2%**	**117.1%**
Total Residential:		**758,150**	**876,838**	**876,753**	**100.0%**	**115.6%**
Total Energy Efficiency and Beneficial Electrification:		**1,090,275**	**1,257,372**	**1,265,623**	**100.7%**	**116.1%**

Figure 1 below shows that the Energy Efficiency Program, Commercial Efficiency Program, and Home Energy Management program were the top three contributing programs, together comprising 89% of verified ex-ante savings in 2021.

FIGURE 1: MMBTU CONTRIBUTIONS BY PROGRAM



Additionally, we developed a verified ex-ante savings metric for comparison with the established annual savings goals. The portfolio verified ex-ante gross savings were 116.1% of the 2021 savings goals, exceeding PSEG Long Island's goals by 175,348 MMBtu. Home Performance with ENERGY STAR is the only program that fell short of planning goals. There is an ongoing investigation into the HPwES projects claimed by one contractor. Those projects were removed from both the verified and claimed ex ante savings bringing the overall program savings below planning goals.

Appendix A: MWh and MW VEA Results

As previously explained, 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 2021 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 2 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. MWh Beneficial Electrification (MWh_{be}) impacts 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 2: SUMMARY OF 2021 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)	109,320	108,472	99.2%
Residential	Energy Efficient Products (EEP)	224,228	224,225	100.0%
	Home Comfort	2,544	2,540	99.8%
	Residential Energy Affordability Partnership (REAP)	1,618	1,619	100.1%
	Home Performance	1,602	1,602	100.0%
	Home Energy Management (HEM)	40,037	37,331	93.2%
	Total Commercial:	**109,320**	**108,472**	**99.2%**
	Total Residential:	**270,030**	**267,317**	**99.0%**
	Total Energy Efficiency and Beneficial Electrification:	**379,350**	**375,789**	**99.1%**

Table 3 below reports claimed ex-ante and verified ex-ante peak demand (MW) values. Ex-ante MW values are not scaled for transmission and distribution losses.

TABLE 3: SUMMARY OF 2021 VERIFIED EX-ANTE MW SAVINGS

Program		Claimed Ex-Ante Gross[a] Savings	Verified Ex-Ante Gross[a] Savings	Verified Ex-Ante Realization Rate
		MW	MW	%
Commercial	Commercial Efficiency Program (CEP)	19.72	20.36	103%
Residential	Energy Efficient Products (EEP)	34.61	34.61	100%
	Home Comfort	0.53	0.53	100%
	Residential Energy Affordability Partnership (REAP)	0.28	0.27	98%
	Home Performance	0.49	0.49	100%
	Home Energy Management (HEM)[b]	n/a	n/a	n/a
	Total Commercial:	**19.72**	**20.36**	**103%**
	Total Residential:	**35.90**	**35.90**	**100%**
	Total Energy Efficiency and Beneficial Electrification:	**55.63**	**56.26**	**101%**

[a] Line Loss Factors are not applied in claimed or verified ex-ante MW.
[b] 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.

Appendix B: Supplemental Detail

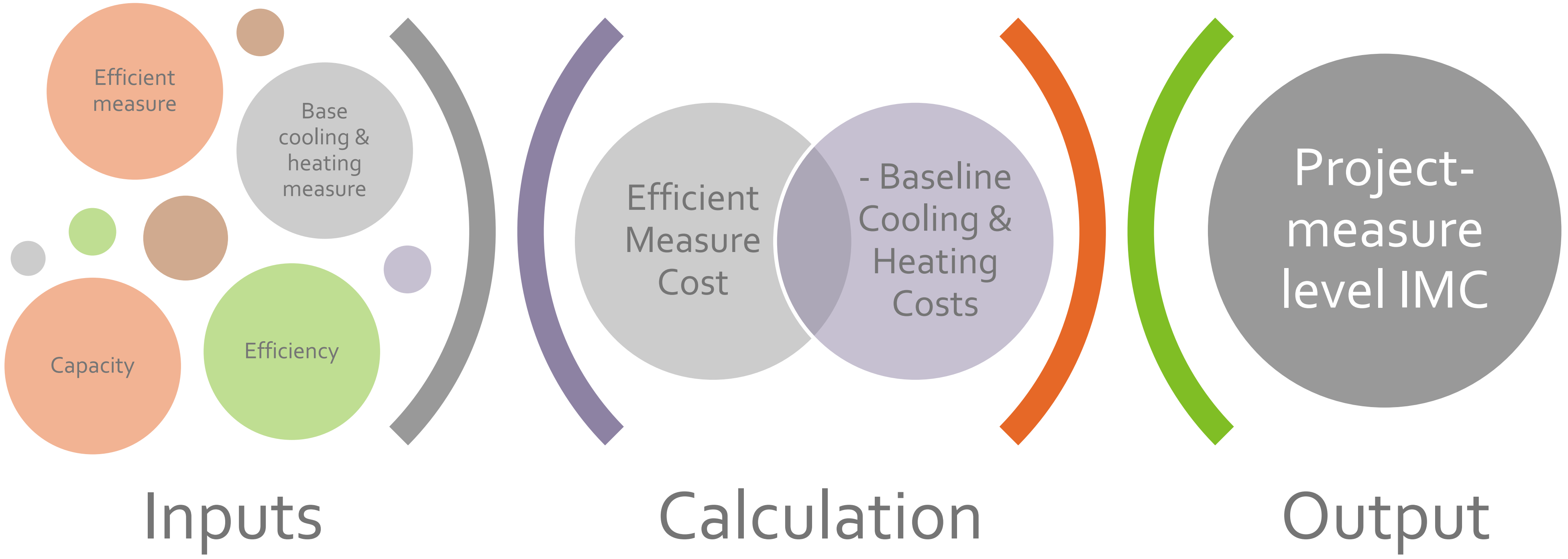
The evaluation team verified the calculations and inputs for hundreds of measures and inputs. The below table includes additional detail on nuances observed in the Captures data as well as the calculations and assumptions used.

Program	Sub-Component	Description	Implications
Commercial Efficiency Program	Comprehensive Lighting	▪ In the 2020 ex post evaluation, we developed HVAC interactive factors for PSEG LI. In Q4, TRC started to apply these HVAC interactive factors resulting in a decrease in claimed savings for that quarter. We calculated verified ex-ante savings using the planning assumptions, which did not include waste heat factors.	▪ A 106% MMBtu realization rate for comprehensive lighting measures.
	Fast Track Lighting	▪ TRC's calculation workbook applied both demand and energy waste heat factors to energy savings calculations (both kWh and MMBtu) for over 70% of projects. This issue was fixed in 2021 Commercial Master Internal Workbook v1.1 and later.	▪ Fast Track Lighting MMBtu realization rate of 84%.
	Refrigerated Case Lighting	▪ TRC applied PSEG 2010 assumptions, based on the 2010 NYS Tech Manual. Planning spreadsheet recommended an algorithm based on NYS TRM v7.	▪ Refrigerated Case Lighting constituted 2% of overall CEP lighting savings.
	Custom Projects	▪ In 2015/2016, ODC conducted a review of CEP Custom projects and produced a deemed realization rate of 96% for kWh. For 2021 VEA, we decided not to apply legacy adjustments.	▪ A 100% MMBtu realization rate.
		▪ 70% of custom MMBtu comes from one project. The claimed savings for that project is 50% of its total expected contribution with the full balance to be claimed in 2022.	▪ We will want to work with TRC on the M&V approach for this project.

Program	Sub-Component	Description	Implications
EEP	LED Standard and Specialty Lighting	▪ Lighting in-service rate is applied in a different stage of the planning calculations workbook for MMBtu, kWh EE, and kW metrics, and the kW calculations differ between Standard and Specialty LEDs.	▪ No impact on VEA as ISRs are eventually applied correctly to all metrics. We recommend a minor update to standardize ISR calculations to minimize chances of errors in future planning tasks.
Home Performance	Home Performance with ENERGY STAR	▪ There were 510 projects by Green Seal Weatherization in 2021. 504 of these projects are still under investigation, so their savings (4,999 MMBtu) were removed from KPI totals.	▪ If these savings are ultimately included in ex-ante, the Home Performance program would exceed goals for 2021.
	Home Performance with ENERGY STAR	▪ Savings calculations for HPwES measures require home heating system/fuel. This information is not available as a query field in Captures, only available in individual project workbooks.	▪ Line-by-line savings replication is not feasible. We assigned HPwES measures 100% VEA realization rates after reviewing the savings calculations in a sample of application workbooks.
	HPDI Lighting	▪ Approved TRC workbook assumptions were used to calculate claimed ex-ante savings. These new assumptions increased calculated lighting savings by 16% compared to planning assumptions.	▪ HPDI program exceeds program savings goals.
REAP	Lighting	▪ Approved TRC workbook assumptions were used to calculate claimed ex-ante savings rather than planning assumptions. If planning assumptions were used, REAP lighting savings would have been 20% lower.	▪ REAP program exceeds program savings goals.

APPENDIX C HEAT PUMP IMC UPDATE

INCREMENTAL MEASURE COST (IMC) IS A FUNCTION OF THE COST OF BOTH THE EFFICIENT AND BASELINE EQUIPMENT



UPDATED IMC REFLECTS ACTUAL PROJECT COSTS, BASELINE ASSUMPTIONS

Extract efficient & baseline measure capacity & efficiency (heating, cooling, efficient) for each project-measure used for savings calculation

Vet baseline measure efficiencies and capacities assumptions

Sample 100 heat pump projects for detailed review of invoices to vet efficient measure costs, efficiencies, and capacities, adjust as needed

Base measure cost models based on:

- ✓ PA TRM IMC Database (CAC & HPs)
- ✓ Big box website desk research (boilers, furnaces, baseboard heat, room AC)

Apply IMC models to granular project data, iterate, incorporate into future cost-effectiveness, summarize IMC for planning measures

Align w/ PSEG-LI on capacity efficiency modeling assumptions by measure and installation type

Demand Side Analytics
DATA DRIVEN RESEARCH AND INSIGHTS

DNV

MONDRE ENERGY, INC.

PROJECT COST REVIEW: ONLY GEOTHERMAL NEEDED ADJUSTMENT

Measure	Projects sampled	Projects needing adjustment	Comments
Ducted	42	1	1 project included costs for gas boiler & hot water tank
Ductless	42	1	1 project included extensive refrigerant pipe runs
Geothermal	16 (census of those provided)	2	Adjustments made: ▪ -20% for radiant heating systems & new plumbing throughout the residence ▪ -10% for boiler room & new basement zones

- Sometimes invoiced cost included non-measure related costs
- Invoices for a sample of 100 projects were reviewed in detail
- Results:
  - Adjustments required for geothermal. Applied directly to cost model inputs. Equated to -2% adjustment
  - Adjustments identified were minor, do not merit adjusting cost model for ductless & ducted

MEASURE LEVEL IMC HIGHER THAN PREVIOUS PLANNING ASSUMPTIONS

Heat Pump Type	Units installed in 2020	Mean unit capacity (kBTU/hour)	Mean Unit Project Cost	Mean Unit Base Heating Cost	Mean Unit Base Cooling Cost	Mean Unit IMC (updated)	Mean Unit IMC (old)	Ratio (new IMC / old IMC)
Ducted	822	37	$10,926	$1,212	$3,335	$6,379	$2,764	2.3
Ductless	2,837	23	$7,222	$1,185	$3,945	$2,092	$1,425	1.5
Geothermal	55	33	$32,151	$1,277	$2,467	$28,407	$13,551	2.1

- IMC are 1.5-2x higher than those previously used
  - Ratio reflects a weighted average for the same installs
- Home Comfort is still cost effective; but the 2020 program SCT drops from 2.71 to 1.85

APPENDIX D LIGHTING WASTE HEAT FACTORS

A. SUMMARY

This section summarizes the evaluation team's comparison of commercial and residential lighting HVAC interaction factors provided in the NY TRM with those from other jurisdictions and recommends factors to be incorporated in PSEG Long Island's PY2022 TRM. Rather than adopt assumptions directly from another jurisdiction, we recommend that PSEG Long Island adopt the HVAC interaction effects calculation framework from the Efficiency Maine TRM. We've estimated new factors using the Efficiency Maine TRM methodology with Long Island weather and HVAC fuel shares and Pennsylvania 8760 commercial lighting profiles. Table 87 summarizes the recommended HVAC interaction factors for peak demand ($HVAC_d$), electric energy ($HVAC_e$), and fossil fuel heating ($HVAC_{ff}$).

Table 87: Recommended HVAC Interaction Factors

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

B. BACKGROUND

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

The 2020 PSEG Long Island Technical Reference Manual (TRM)[19] savings assumptions for PSEG Long Island's commercial interior lighting measures (LED lamps and fixtures) accounted for energy savings associated with cooling load reduction but did not account for increased fossil fuel heating consumption. To improve the accuracy of lighting program savings, all changes in HVAC usage associated with the installation of efficient lighting should be accounted for. While the residential assumptions did include penalties associated with increases in fossil fuel heating consumption, it was important to produce methodologically analogous waste heat factors for both sectors. The scope of this analysis is to benchmark existing values and methods for calculating waste heat factors, as well as to construct defensible factors specific to PSEG Long Island's territory, for both residential and commercial sectors. These factors estimate the lighting measures' fossil fuel heating increases and

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

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

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

C. LIGHTING SAVINGS ALGORITHMS

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

Summer coincident peak demand savings:

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

Annual electric energy impacts:

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

Annual fossil fuel energy impacts:

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

where,

$HVAC_d$ = HVAC interaction factor for summer peak demand

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

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

D. HVAC INTERACTION FACTORS - COMPARISON ACROSS TRMS

We compared the HVAC interactivity factors used for PSEG Long Island's commercial and residential lighting in PY2020 planning with methodologies and assumptions in NY TRM, Mid-Atlantic TRM, Massachusetts TRM and Efficiency Maine TRM. The comparisons for the commercial sector are shown in Table 88, while residential results are in Table 89.

Table 88: Comparison of Commercial HVAC Interaction Factors across East Coast States

Source	$HVAC_d$	$HVAC_e$	$HVAC_{ff}$ (MMBtu/kWh)
2020 Planning	1.320	1.130	0
NY TRM v8	1.175	1.080	-0.00200
Pennsylvania TRM and TRC Order	1.192	1.031	-0.00179
Mid-Atlantic TRM Method	1.350	1.080	-0.00077
Massachusetts TRM[20]	N/A	N/A	-0.00069
Efficiency Maine SBDI Evaluation[21]	1.075	1.022	-0.00110
Final PSEG Long Island Method	**1.18055**	**1.05894**	**-0.00077**

Table 89: Comparison of Residential HVAC Interaction Factors across East Coast States

Source	$HVAC_d$	$HVAC_e$	$HVAC_{ff}$ (MMBtu/kWh)
2020 Planning	1.07301	1.03776	-0.00181
NY TRM V8[22]	1.0850	1.0770	-0.0020
Pennsylvania TRM and TRC Order[23]	1.1729	0.9914	-0.00117
Mid-Atlantic TRM[24]	1.1700	1.0770	-0.00123
Massachusetts TRM[25]	1.2000	1.0100	-0.002295
Efficiency Maine Retail Lighting Evaluation[26]	1.0611	1.0086	-0.00130
Final PSEG Long Island Method	**1.14226**	**1.01587**	**-0.00148**

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

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

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

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

E. EVALUATION TEAM RECOMMENDATION

Our recommended factors follow the HVAC interaction factor calculation algorithms from the Efficiency Maine TRM, adjusted for Long Island-specific inputs. This approach was selected because it combines a transparent calculation method, reliance on an empirical approach, and the ability to easily update underlying data. The commercial and residential lighting profiles are taken from a 2015 Pennsylvania statewide lighting metering study[27]. We use the Pennsylvania study because it is geographically close, methodologically robust, and the 8760 load shapes, by building type, are publicly available. We use TMY3 weather for McArthur Islip airport on Long Island to identify concurrent operation of lighting and HVAC systems, and HVAC fuel mix and efficiency assumptions from the 2019-2038 PSEG Long Island Potential Study. The Efficiency Maine TRM provides the following HVAC interaction factor algorithms for both residential and commercial interior lighting.

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

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

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

Where,

- Internal Gain Contribution, IGC (%): the percent of waste heat that remains inside the building, contributing to the increased or decreased need for heating or cooling from the HVAC system.
- Applicability, %A (%): the percentage of lighting that is installed in spaces that are heated or cooled by the HVAC system.

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

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

Note that for fossil fuel HVAC factor, the applicable share is the % of fossil fuel *heating*. To compute the energy interactive effects, we first compute cooling-related HVACe (where % electric is assumed to be 100% as only electric impacts apply for cooling) then heating-related HVACe (where the relevant % of electric heat is assumed) and then combined according to 1 + $HVAC_e^c$ - $HVAC_e^{h.}$ Table 90 summarizes the factors calculated for each of the three interaction effect values.

Table 90: Interactive Factor Calculations

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

APPENDIX E COST-EFFECTIVENESS EX-POST NET TABLES

Table 91: CEP Ex-Post Net Data for Cost Effectiveness

Resource		Measure	Ex-Post Gross Savings	Net-to-Gross Ratio	Line Loss Factor	Ex-Post Net
MMBtu	Lighting	Comprehensive Lighting	185,568	72%	1.00	132,773.90
		Fast Track Lighting	15,425	72%	1.00	11,036.57
		Refrigerated Case Lighting	6,263	72%	1.00	4,481.11
		Lighting Subtotal	207,256			148,291.58
	Distributed Generation	CHPa	53,772	100%	1.00	53,772.00
	Standard	Refrigeration	8,370	72%	1.00	5,988.63
		Motors & VFDs	2,527	72%	1.00	1,808.12
		Compressed Air	6,143	72%	1.00	4,394.97
		Other Comm. Equipment	1,617	72%	1.00	1,156.97
		Standard Subtotal	18,656			13,348.68
	Custom	Custom	35,578	72%	1.00	25,455.99
	HVAC	HVAC	5,834	72%	1.00	4,174.02
		MMBtu Total:	**321,096**			**245,042.27**
MWh	Lighting	Comprehensive Lighting	67,686	72%	1.06	51,340.61
		Fast Track Lighting	5,740	72%	1.06	4,353.89
		Refrigerated Case Lighting	1,836	72%	1.06	1,392.28
		Lighting Subtotal	75,262			57,086.79
	Distributed Generation	CHP	15,718	100%	1.06	16,662.43
	Standard	Refrigeration	2,471	72%	1.06	1,874.14
		Motors & VFDs	744	72%	1.06	564.24

		Compressed Air	1,800	72%	1.06	1,365.52
		Other Comm. Equipment	0	72%	1.06	0.31
		Standard Subtotal	5,015			3,804.20
	Custom	Custom	5,881	72%	1.06	4,460.54
	HVAC	HVAC	1,380	72%	1.06	1,046.49
		MWh Total:	**103,255**			**83,060.45**
kW	Lighting	Comprehensive Lighting	13,842	72%	1.08	10,719.28
		Fast Track Lighting	1,481	72%	1.08	1,147.15
		Refrigerated Case Lighting	439	72%	1.08	339.84
		Lighting Subtotal	15,763			12,206.26
	Distributed Generation	CHP	1,876	100%	1.08	2,020.90
	Standard	Refrigeration	157	72%	1.08	121.40
		Motors & VFDs	49	72%	1.08	38.00
		Compressed Air	352	72%	1.08	272.50
		Other Comm. Equipment	3	72%	1.08	2.27
		Standard Subtotal	561			434.16
	Custom	Custom	817	72%	1.08	632.96
	HVAC	HVAC	388	72%	1.08	300.62
		kW Total:	**19,405**			**15,594.91**

Table 92: 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	365,456	55%	1.00	201,001
	Heat Pump Pool Heaters	54,968	90%	1.00	49,471
	Pool Pumps	44,474	90%	1.00	40,027
	Thermostats	42,719	77%	1.00	32,894
	Appliances	8,459	90%	1.00	7,613

	Recycling	9,893	57%	1.00	5,639
	Water Heaters	2,048	100%	1.00	2,048
	Lawn Equipment	797	90%	1.00	718
	Other (APS, Storm Windows, Exhaust Fan)	410	100%	1.00	410
MMBtu Total:		**529,226**			**339,821**
MWh	Lighting	162,138	55%	1.06	94,536
	Heat Pump Pool Heaters	2,379	90%	1.06	2,270
	Pool Pumps	13,035	90%	1.06	12,436
	Thermostats	1,528	77%	1.06	1,247
	Appliances	1,659	90%	1.06	1,583
	Recycling	2,900	57%	1.06	1,752
	Water Heaters	-98	100%	1.06	-104
	Lawn Equipment	-53	90%	1.06	-50
	Other (APS, Storm Windows, Exhaust Fan)	120	100%	1.06	127
MWh Total:		**183,607**			**113,797**
kW	Lighting	23,564	55%	1.08	13,964
	Heat Pump Pool Heaters	0	90%	1.08	0
	Pool Pumps	3,228	90%	1.08	3,131
	Thermostats	0	77%	1.08	0
	Appliances	333	90%	1.08	323
	Recycling	438	57%	1.08	269
	Water Heaters	-9	100%	1.08	-9
	Lawn Equipment	0	90%	1.08	0
	Other (APS, Storm Windows, Exhaust Fan)	13	100%	1.08	14
kW Total:		**27,568**			**17,692**

Table 93: 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	Air-source Heat Pumps (Ductless mini-splits and Ducted)	96,274	90%	1.00	86,647
	Geothermal Heat Pumps	8,149	100%	1.00	8,149
	Smart Thermostats	90	90%	1.00	81
	Heat Pump Water Heaters	124	100%	1.00	124
	MMBtu Total:	**104,455**			**95,001**
MWh	Air-source Heat Pumps (Ductless mini-splits and Ducted)	(7,868)	90%	1.06	(7,507)
	Geothermal Heat Pumps	(453)	100%	1.06	(480)
	Smart Thermostats	26	90%	1.06	25
	Heat Pump Water Heaters	(5)	100%	1.06	(5)
	MWh Total:	**(8,352)**			**(7,966)**
kW	Air-source Heat Pumps (Ductless mini-splits and Ducted)	138	90%	1.08	134
	Geothermal Heat Pumps	142	100%	1.08	153
	Smart Thermostats	-	90%	1.08	-
	Heat Pump Water Heaters	(0.50)	100%	1.08	(0.54)
	kW Total:	**279**			**286**

Table 94: REAP Ex-Post Net Data for Cost Effectiveness

Resource	Ex-Post Gross Savings	Net-to-Gross Ratio	Line Loss Factor	Ex-Post Net
MMBtu	4,089	100%	1.00	4,089
MWh	1,366	100%	1.06	1,448
kW	211	100%	1.08	227

Table 95: 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	29,435	80%	1.00	23,449
MWh	885	80%	1.06	747
kW	754	80%	1.08	647

Table 96: HEM Ex-Post Net Data for Cost Effectiveness

Resource	Ex-Post Gross Savings	Net-to-Gross Ratio	Line Loss Factor	Ex-Post Net
MMBtu	106,447	100%	1.00	106,447
MWh	31,198	100%	1.06	33,073
kW	8,692	100%	1.08	9,365