To:	Jaclyn Trzaska and Jennifer Senick, Rutgers University
From:	Scott Dimetrosky and Jane Colby, Apex Analytics; Jesse Smith and Steve Morris, Demand Side Analytics
Subject:	New Jersey 2020 and 2021 Retail Lighting Sales Data Analysis
Date:	July 7, 2022

Apex Analytics, along with Demand Side Analytics, developed an analysis of national lighting sales to assess the relative progress of LED market shares in states with retail lighting programs in comparison to non-program states. This memo describes the data sources and findings for the sales data analysis focused on New Jersey.

Executive Summary

Market Trends

The team's research indicates that the lighting market continues to tilt toward LEDs—sales of LEDs have gone from 51% of the national lighting market in 2018 to 60% in 2019, 70% in 2020, and 76% in 2021. Even in states without upstream lighting programs, LED market shares are now around 70%. Other high-level lighting market findings include the following:

- **The LED market share in New Jersey is approximately 69% in 2021.** For each of the past five years, LED market shares in New Jersey have trailed the national LED market share. More recently, this gap has widened. New Jersey also trails states without upstream lighting programs. During the past five years, New Jersey programs have had some interruptions and slowdowns due to budgeting, the COVID-19 pandemic, and changing program administrators. This is likely the cause for trailing market shares.
- **The gap between LED market shares in states with and without upstream lighting programs is narrowing.** The gap between LED market shares in program states and non-program states has decreased from approximately ten percentage points in 2016 to approximately six percentage points in 2021. On a relative percentage basis, the gap has decreased from 45% to 8.6%.[1] The team estimates that seven of every 10 light bulbs sold in a non-program state are LEDs.

NTG Estimates

The evaluation team recommends a 2021 net-to-gross (NTG) ratio of 10.7%. The low ratio is largely tied to the state of the national lighting market, where the market share of LEDs continues to rise across the U.S. As noted above, seven of every 10 light bulbs sold in states without upstream lighting programs

[1] The increasingly high non-program LED share makes the relative difference smaller each year. In 2016, non-program states had an LED share of 20% and program states were at 29% ((29-20)/20 = 45%). In 2021, non-program states had an LED share of 70% and program states were at 76%.

were LEDs. This means that any upstream lighting program in 2021 is bound to produce a high rate of freeridership.

Despite the low NTG ratio, New Jersey's upstream lighting offering continued to have an impact and was an important source of cost-effective savings. For example, the upstream lighting offering led to an additional 1.35 million LEDs sold in New Jersey in 2021, a savings to customers of approximately $7 million[2] on their energy bills.

Absent the recent DOE ruling[3], the evaluation team would expect low NTG ratios to continue for upstream lighting in New Jersey. However, the team cautions against significantly reducing the upstream lighting offering prior to enforcement of the rules; several other jurisdictions have experienced stagnation and backsliding when upstream lighting offerings are simply turned off or budgets are cut substantially.[4] To combat high rates of freeridership prior to the rules being enforced, the team recommends the following:

- **Target styles other than reflectors.** In states without lighting programs, LEDs account for more than 90% of reflector sales. In other words, nine of every 10 reflectors purchased will be LED absent program incentives.
- **Target store types where LED sales are lagging.** The sales data analysis continued to show that retailers in point-of-sale (POS) data—grocery, dollar, drug, discount, and mass merchandiser—have a lower LED market share than the big box and major club stores. Targeting retailers in these distribution channels can maximize program influence.

Once the rules are being enforced, the program may need to shift to target removing or replacing inefficient bulbs installed, in storage or purchasing directly from retailers to avoid having them installed later.

Introduction

The underlying theory behind the national lighting sales data NTG model is that states with strong upstream lighting program activity—compared to those with little to no program activity—should have higher market share (via sales) of efficient lighting. The model relies on full-category lighting sales data to estimate market lift as a function of program activity, while also controlling for other factors (e.g., household and demographic characteristics) that might impact sales of efficient lighting. Based on this modeling, the evaluation team determined a comprehensive NTG estimate that captures freeridership, participant spillover, and nonparticipant spillover/market effects.

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[2] Assuming an average savings of 44 kWh per LED and $.12/kWh retail rate.

[3] The DOE finalized rules to reinstate the previously planned EISA standards. Specifically, the recent rules expand the definition of general service lamps (GSLs) to include reflectors and candelabras that were previously exempt, and then required all GSLs to meet a 45 lumen/watt minimum efficiency

[4] For example, as Massachusetts phased out incentives in 2021, the overall LED market share dropped from 77% in 2020 to 70% in 2021.

Study Objectives

The primary objective of the model is to quantify the relationship between program intensity (e.g., program spending per household) and LED sales (percentage of light bulb purchases that are LEDs), which the model then uses to estimate an NTG ratio for the upstream lighting program. In addition to estimating NTG, the data provide helpful insights into what other factors drive LED purchases and opportunities for benchmarking New Jersey lighting efficiency shares and program spending against other states. This memo presents these additional analyses as well.

Data Sources

The team leveraged a variety of data sources for the analysis but relied primarily on sales data prepared by the Consortium for Retail Energy Efficiency Data (CREED).[5] CREED serves as a consortium of program administrators, retailers, and manufacturers working together to collect the necessary data to better plan and evaluate energy efficiency programs. LightTracker is CREED's first initiative, focused on acquiring full-category lighting data, including incandescent, halogen, CFL, and LED bulb types, for all distribution channels in the entire United States. As a consortium, CREED speaks as one voice for program administrators nationwide as they request, collect, and report on the sales data needed by the energy efficiency community.

The sales data were primarily generated from two sources: point-of-of sale (POS) state sales data (representing grocery, drug, dollar, discount, mass merchandiser, and selected club stores) and National Consumer Panel (NCP) state sales data (representing home improvement, hardware, online, and selected club stores). POS stores account for about 35% of sales nationwide, while NCP or non-POS stores account for 65%. With POS stores including the dollar, discount, and mass merchandise channels, prices for all bulbs as well as LED stocking tend to be lower in these stores relative to the non-POS stores. Raw datasets were purchased from third-party vendors, and through a CREED initiative, the team cleaned and processed the data for analysis.[6,7] Besides the sales data, other data streams included:

- U.S. Census Bureau Import data (LED imports)
- DSM Insights, an E Source database of utility program data
- ENERGY STAR Lighting Program data (utility lighting program budgets)
- ENERGY STAR shipment data (released by the Environmental Protection Agency)
- North American Electrical Manufacturers Association (NEMA) shipment data

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[5] https://www.creedlighttracker.com

[6] The information contained herein is based in part on data reported by IRI through its Advantage service for, and as interpreted solely by Lighttracker, Inc. Any opinions expressed herein reflect the judgment of Lighttracker Inc. and are subject to change. IRI disclaims liability of any kind arising from the use of this information.

[7] Data presented include LightTracker calculations based in part on data reported by Nielsen through its Strategic Planner and Homescan Services for the lighting category for the 52-week period ending approximately on December 31, 2021, for the available state level markets and Expanded All Outlets Combined (xAOC) and Total Market Channels. Copyright © 2021, Nielsen.

- General population surveys, lighting saturation studies, and other secondary data collection made publicly available through evaluation reports
- Program data from NJCEP and New Jersey utilities

Lighting Sales

The LightTracker POS data set includes lighting sales data for grocery, drug, dollar, selected club, and mass market distribution channels. These data represent actual sales that are scanned at the cash register for participating retailers.

The NCP represents a panel of approximately 100,000 residential households that are provided a handheld scanner for their home and instructed to scan in every purchase they make that has a bar code. For New Jersey, the NCP included approximately 1,600 households in 2020 and 2021. The use of a scanner avoids potential "recall bias" that is prevalent in self-report methods that ask about lighting purchases.

Although the dataset included detailed records of lighting data purchases, the evaluation team spent considerable time ensuring data integrity and inclusion of all the necessary bulb attributes. For example, not all records were populated with some of the more critical variables such as bulb type, style, and wattage or the data had clearly erroneous values (e.g., 60-watt LEDs). After thorough review and quality control of the dataset, the evaluation team reclassified, standardized, and populated missing records, created additional variables, and performed general enhancements to the data.

To populate missing records, validate existing records, and include additional bulb attributes, CREED created a Universal Product Code (UPC) database from three sources:

- Product catalogs downloaded from manufacturer and retailer web sites via "web scraping"
- Automated lookups of online UPC databases, such as www.upcitemdb.com
- Bulb attributes entered as part of shelf-stocking studies from research conducted in a number of program and non-program states, including Alabama, California, Florida, Illinois, Maryland, Nebraska, and Tennessee

CREED then merged the UPC database with the POS data, populating fields based on a hierarchy of data sources believed to be most reliable. Prioritization was typically based in the following order: manufacturer specifications, UPC lookups, and original POS-based database values. The team also conducted manual Web lookups on over 200 high-volume bulbs to verify final assignments.

Additionally, CREED investigated the bulb assignment and the quantity of bulbs per package by examining the average price per unit and identifying outliers in terms of per bulb prices. This process helped identify misclassification of certain bulb types (e.g., bulbs that were flagged as low-cost LEDs but were really LED nightlights and needed to be moved to the "other" lamp type bin), bulb counts that sometimes represented box shipments (e.g., a package identified as having 36 bulbs was really a six-pack of LEDs that was shipped with six packages per box), or high-cost LEDs that were really Wi-Fi-enabled smart LEDs. The CREED team also used lumens per watt (LPW) as a check on bulb assignments

(efficient bulbs should have higher LPW values than inefficient bulbs). The sales data analysis is restricted to screw-based bulbs, so any bulbs classified as type "other" were not included in the analysis.

CREED estimated missing lumen values and missing lamp styles. Regarding lumens, CREED leveraged ordinary least squares (OLS) regression models that predicted lumens based on the type of light and the wattage of the bulb. Regarding style (e.g., A-line, reflector, globe, candelabra), CREED leveraged classification and regression trees (CART), a method commonly used for classification problems, to populate the style attribute for lamps that were missing data.

After accounting for the smaller states that lacked sufficient sample size from the panel data or had incomplete program data available, the final dataset contained 44 states.[8] The lighting dataset included these key aspects:

- 2020 and 2021 sales volume and pricing for CFLs, LEDs, halogens, and incandescent bulbs for all channels combined, and broken out by the POS and non-POS channels
- Data reporting by state (with 42 states included in both POS and non-POS) and bulb type
- Inclusion of all bulb styles (A-lamps, reflectors, globes, and candelabras) and controls (e.g., three-way, dimmers, etc.)

As detailed below, the dependent variable of the model was the percentage of LED sales, rather than total LED sales, to normalize for states with greater or lesser bulb sales (LED or standard) because of differences in number of households, number of sockets, existing saturation, and other factors that drive lighting sales.

Program Activity

To research upstream lighting program activity in the 44 states, the evaluation team used internal resources and conducted a literature review of publicly available reports found on the internet or provided by program administrators or their evaluators.[9] The evaluation team contacted local utilities in areas where reports with relevant information were not available. Additionally, the evaluation team accessed DSM Insights, an E Source product that provides a detailed breakdown of program-level spending, including incentives, marketing, and delivery for over 100 program administrators around the country.[10]

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8 The six states that were not included are: Alaska, Hawaii, Iowa, Montana, North Dakota, and Vermont.

9 In particular, the evaluation team began by searching the ENERGY STAR website. "ENERGY STAR Summary of Lighting Programs." Accessed February 2021. 2020 ENERGY STAR Summary of Lighting Programs. The team also referenced the DSIRE website. "Database of State Incentives for Renewables & Efficiency." Accessed February 2021. dsireusa.org

10 E Source. "DSM Insights." Accessed February 1, 2021. https://www.esource.com/dsm-insights-and-measure-insights

The evaluation team collected these program data:

- Total number of claimed LED upstream program bulbs reported by each program (where possible, broken out by bulb style and with giveaway bulbs removed)
- Upstream LED incentives
- Total upstream program budget

The evaluation team used actual program expenditures and, where unavailable, used expenditures reported by ENERGY STAR as a proxy.[11, 12] After accounting for the states with incomplete program data, the final model included 44 states (detailed below).

To determine upstream lighting program activity in New Jersey, the evaluation team requested sales data from the statewide implementer for program activity through July 2021 with the remainder of the year provided by the utilities through the New Jersey Board of Public Utilities (Table 1). In some cases the utilities only provided one or two of the data points requested and in each case, the evaluation team estimated the other data point by averaging available data from the other utilities or the statewide program.

Table 1. 2020-2021 New Jersey Upstream Lighting Program Statistics

YEAR	PROGRAM EXPENSES	LED INCENTIVES	LED QUANTITY
2020	$16,021,461	$10,553,568	8,035,553
2021	$29,804,376	$21,867,591	12,620,058

Presence and Absence of Retailers (Channel Variables)

The evaluation team conducted secondary internet research to determine the number and total square footage of store locations in each state for five primary energy-efficient bulb retailers—The Home Depot, Lowe's, Walmart, Costco, and Menards. The evaluation team used these data as explanatory variables in the model since these retailers sell a large quantity of energy-efficient bulbs and the percentage of efficient bulb sales could differ in states with more or fewer retail locations. The non-POS data (derived from the NCP) does include purchases made through online retailers.

State-Level Household and Demographic Characteristics

The evaluation team gathered state-level demographic data from the ACS, including annual state-level data for the population, total number of households, household tenure (own versus rent), home age, education, income, and average number of rooms in the home. As explained below, the evaluation team

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[11] ENERGY STAR. "ENERGY STAR Summary of Lighting Programs: August 2019 Update." 2019. Available online: https://www.energystar.gov/productfinder/downloads/2019/2019%20ENERGY%20STAR%20Summary%20of%20Lighting%20Programs.pdf

[12] Since the ENERGY STAR report included only expenditure ranges, the evaluation team used the midpoints of the ranges to represent the expenditures.

then combined these data with other possible explanatory variables, including political index, average cost of living, and average electric retail rates.

Analysis of the Combined Dataset

As noted above, some of the key attributes the team was able to develop include:

- **Market share distribution**: LED market share distribution for the U.S. as a whole, New Jersey vs. the U.S., as well as across each state and across retail channels
- **Program intensity**: LED lighting market share relative to overall program expenditures per household
- **Program incentives**: Average LED lighting program incentives per bulb
- **ENERGY STAR market share distribution:** LED market share distribution in New Jersey compared to non-program states

Market Trends

Figure 1 shows the national market share of the four bulb types (incandescent, halogen, CFL, and LED) across the past six years. LEDs continue to gain substantial market share, rising from 19% in 2015 to 70% in 2020 and 76% in 2021. From 2015 to 2017, LEDs largely displaced sales of CFLs only. In 2018, LEDs began to displace inefficient bulbs. Even so, inefficient lighting (incandescent bulbs and halogens) still represents about a quarter of the lighting market. The dashed line demonstrates how the combined shares of energy efficient lamps (LEDs plus CFLs) stayed relatively constant between 2015 and 2017 and then increased steadily since 2018.

Figure 1. Year-Over-Year Total US Market Share by Type

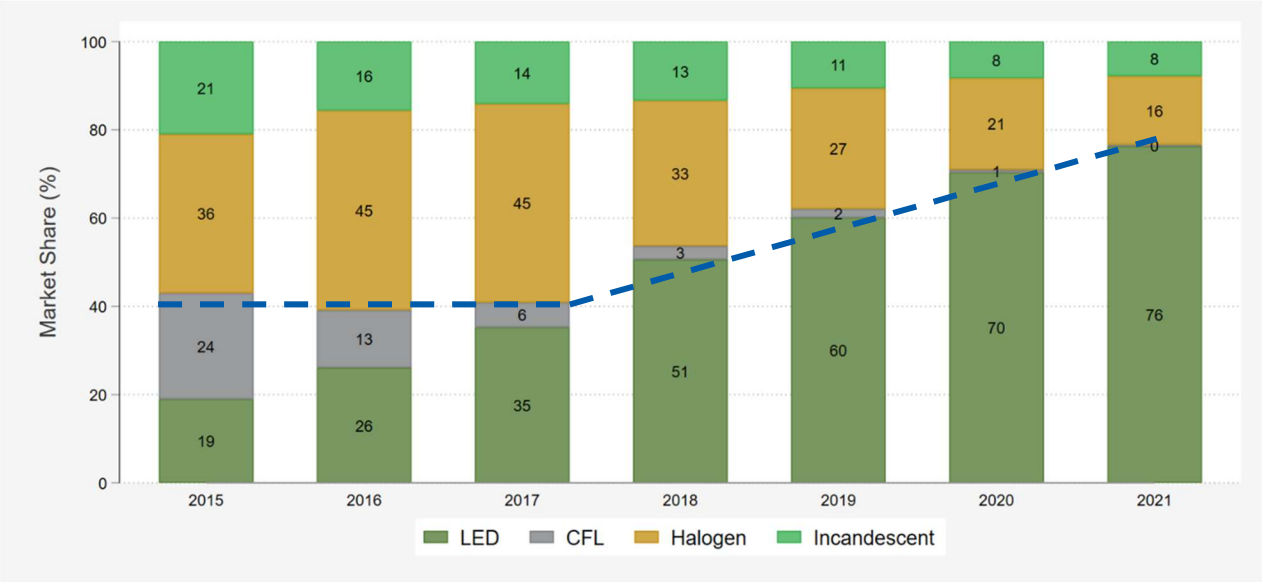


Figure 2 compares the LED market shares in New Jersey with national LED market shares and market shares in states both with and without lighting programs. The figure also shows market shares for states

that adopted EISA standards across all styles, including federally regulated bulbs.[13] LED market shares in New Jersey have been below the national market share every year. In each of the three most recent years, New Jersey also trailed states without lighting programs. As shown in the figure, program activity was interrupted during those years where market shares trailed states without lighting programs. This is likely the reason behind market shares stalling for 2018 and 2020, as according to implementers, the interruptions occurred with little notice to retailers. In non-program states, retailers stock and sell more lower cost non-ENERGY STAR LEDs, while program states sell more discounted ENERGY STAR lamps. With no notice to retailers, there would not be time for retailers to stock and sell the non-ENERGY STAR lamps, when they had ENERGY STAR LEDs in stock. As ENERGY STAR LEDs cost more, without the discount fewer are likely to sell.

[13] Some states adopted EISA for state-regulated bulbs (a subset of reflector and candelabra types) and are not included in this category as market shares did not vary significantly from other states.

Figure 2. LED Market Share by Year, 2015-2021

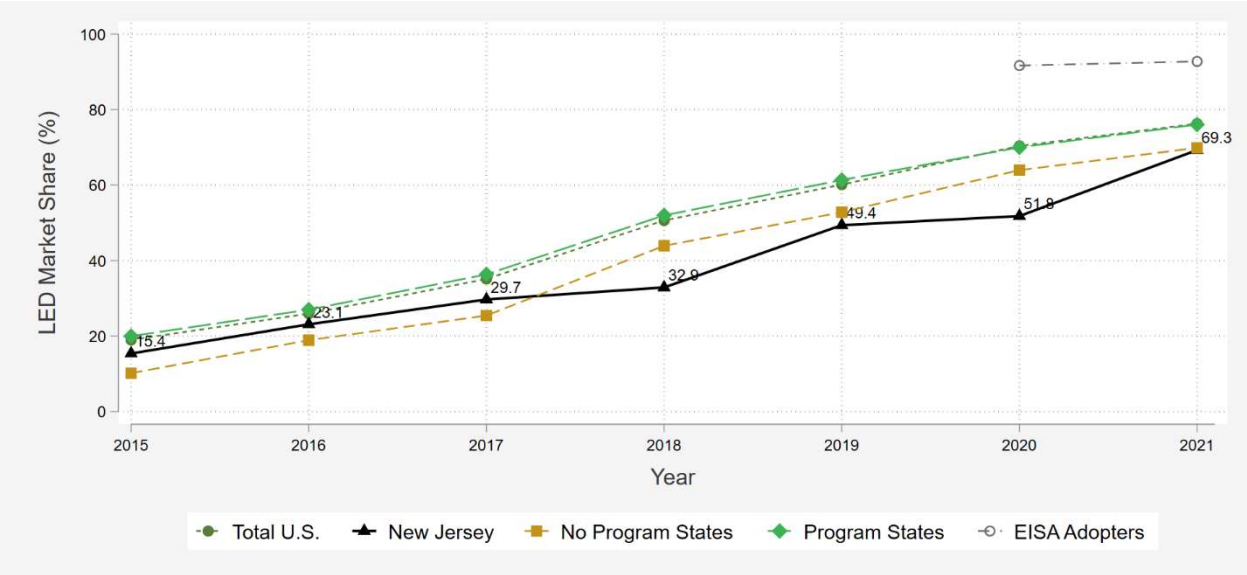


Figure 3 shows the LED market share by lamp style. Breakouts are shown for no program states, program states, and New Jersey for 2020 and 2021.[14] The market shares differ substantially by style, with LEDs representing a majority of all bulb styles in New Jersey. Mirroring Figure 2, LED market shares in New Jersey are closer to those in states without lighting programs in every bulb style. Figure 4 shows the same distribution but just for the POS channel (grocery, drug, dollar, discount, mass merchandiser, and selected club stores). In the POS Channel, LED market shares are lower than non-POS stores[15] and also show the New Jersey POS stores have lower shares than other states, likely due to the program interruptions as noted earlier.

[14] The "no program" states in 2020 and 2021 are Alabama, Kansas, Kentucky, Mississippi, Nebraska, Tennessee, and Wyoming. These are states that have never had upstream lighting programs.

[15] As discussed earlier, POS stores tend to have lower LED market shares than non-POS stores in every state.

Figure 3. LED Market Share by Lamp Style (2020-2021)

Figure 4. LED Market Share by Lamp Style in POS Channel Only (2020-2021)

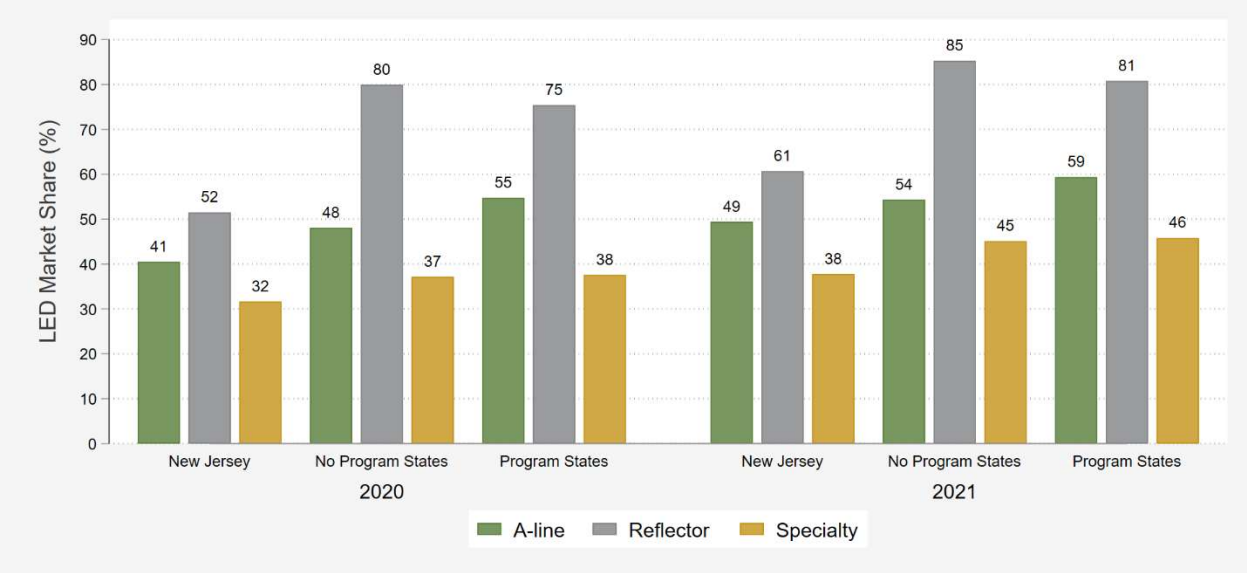
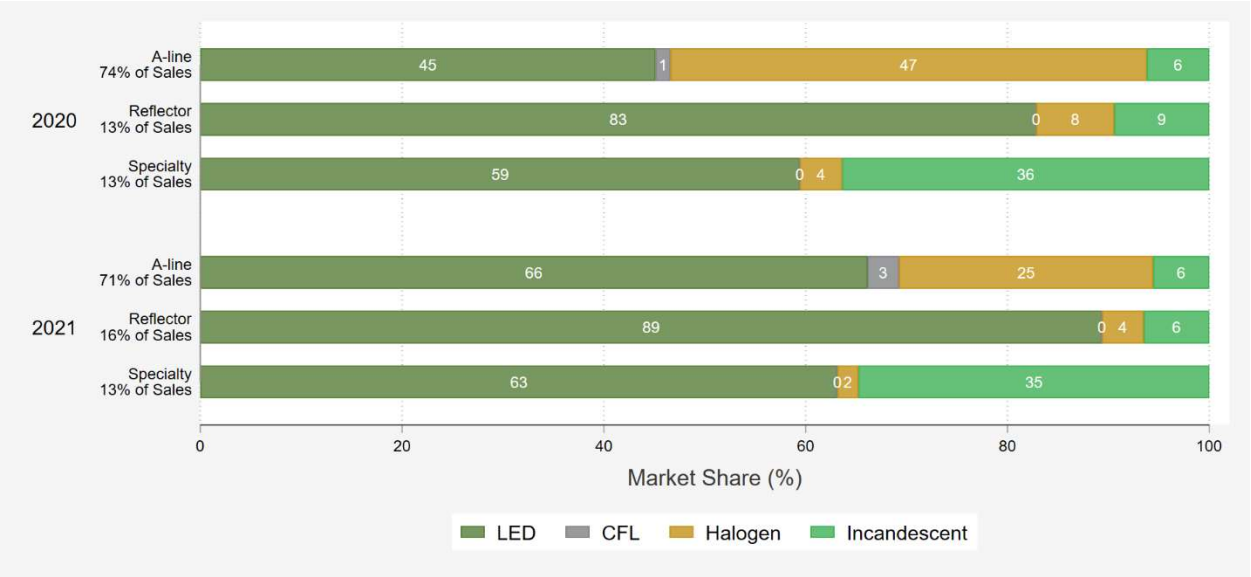


Figure 5 shows the distribution of bulb type by bulb style within New Jersey in 2020 and 2021. For standard lamps, the overwhelming majority of non-LEDs sold are halogen lamps. For specialty and reflector bulbs, the majority of non-LEDs sold are incandescent lamps. New Jersey saw a significant increase in A-line lamp market shares between 2021 (66%) and 2020 (45%), reflecting the greater program spending in 2021 (See Figure 13 and Figure 14).

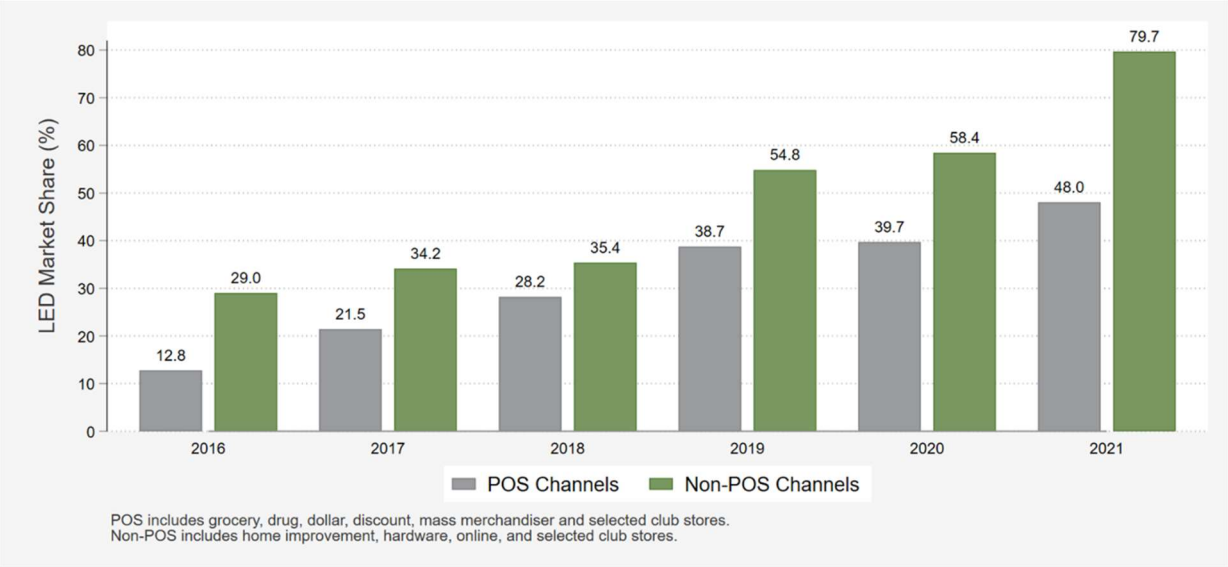
Figure 5. Distribution of Bulb Type by Bulb Style (New Jersey)



Analysis of the sales data shows that market share for LEDs is substantially greater in the non-POS retail channels than the POS retail channels.[16] As shown in Figure 6, LED market share has increased in both retail channels since 2016 (12.8% to 48% in POS channels and 29.0% to 79.74% in non-POS channels). From 2019 to 2020, the increase in LED market share in New Jersey's POS channels was small relative to other year-to-year increases however the increase was larger in 2021. Likewise, the large increase in LED market share in non-POS channels from 2018 to 2019 and from 2020 to 2021 stands out as the periods when program activities restarted after pausing.

[16] In total, approximately 65% of New Jersey bulbs are purchased in the non-POS channels.

Figure 6. New Jersey LED Market Share by Retail Channel Year-Over-Year

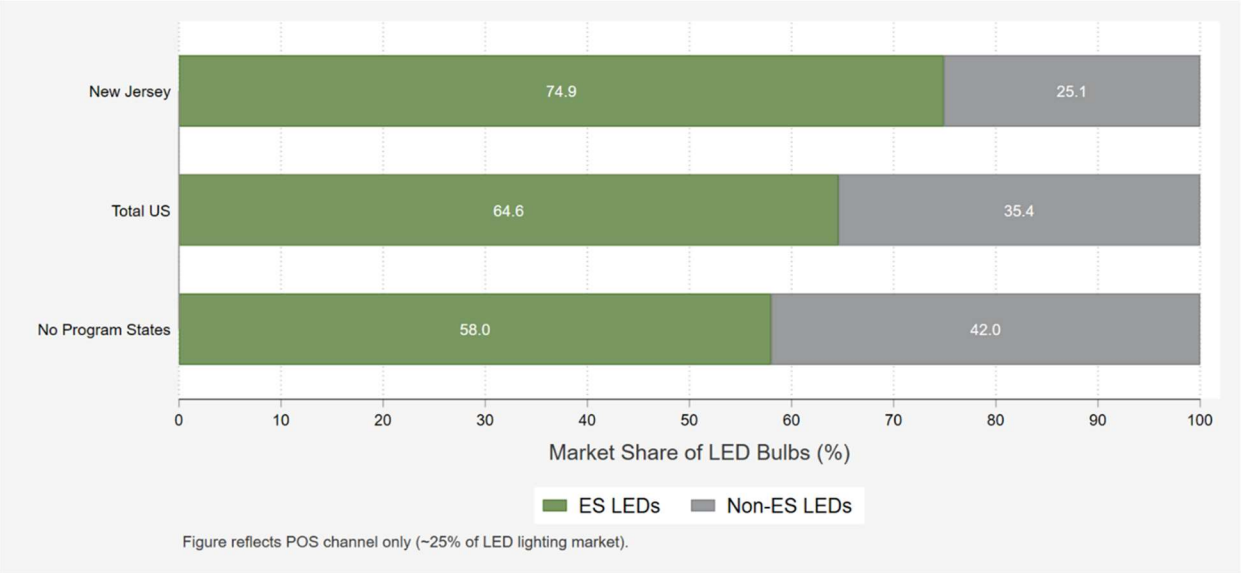


The evaluation team looked at ENERGY STAR LED distribution when there was sufficient resolution.[17] As shown in Figure 7, the POS retail channel shows that approximately 75% of LED purchases in New Jersey are ENERGY STAR LEDs, whereas only about 58% of LED purchases in no-program states are ENERGY STAR LEDs. There are a number of differences between ENERGY STAR and non-ENERGY STAR lamps, but one of the more significant differences is the requirement for ENERGY STAR LEDs of at least a 15,000-hour rated lifetime.[18] ENERGY STAR lamps typically cost more than non-ENERGY STAR lamps which may be why non-ENERGY STAR lamps are more often stocked and sold in non-program states.

[17] Because the ENERGY STAR website does not include the UPCs of *every* qualifying lamp, the team had to identify ENERGY STAR qualified lamps through a make and model lookup. In total, the evaluation team was successful at attributing 97% of LED sales with an ENERGY STAR attribute (whether an LED was designated ENERGY STAR or whether an LED was not designated ENERGY STAR). The remaining 3% of LEDs are excluded in Figure 22Figure 7Figure 7. This analysis is only conducted based on the POS data, as the panel data did not contain sufficient sample size to stratify by ENERGY STAR designation.

[18] Final ENERGY STAR lighting specifications can be found here: https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2.1%20Final%20Specification_1.pdf. Note that non-ENERGY STAR lamps may also meet or exceed the 15,000 hour requirement but lack other requirements.

Figure 7. ENERGY STAR LED Market Share (2021 POS Channels)



Program Activity

Figure 8 shows the state-level LED share as a function of program activity (program state or non-program state). In 2021, there were seven states in the no program bin and 35 states in the program bin (and two other states that have adopted EISA standards were put in an EISA bin, not shown in the figure). The figure shows that LED share is higher in program states, although the gap has decreased slightly from about nine to ten percentage points in 2016 and 2017 to only six percentage points in 2021, with an even steeper drop when the relative percent difference is considered (i.e., as the LED market share for non-program states has increased the relative difference between the non-program and program states has decreased). Additionally, LED share in “no program” states typically lags LED share in program states by about one year (e.g., in 2020 the average program state LED market share was 70%, and in 2021 the no program states had an LED market share of about 70%).

Figure 8. Relationship Between Program Spending and LED Sales

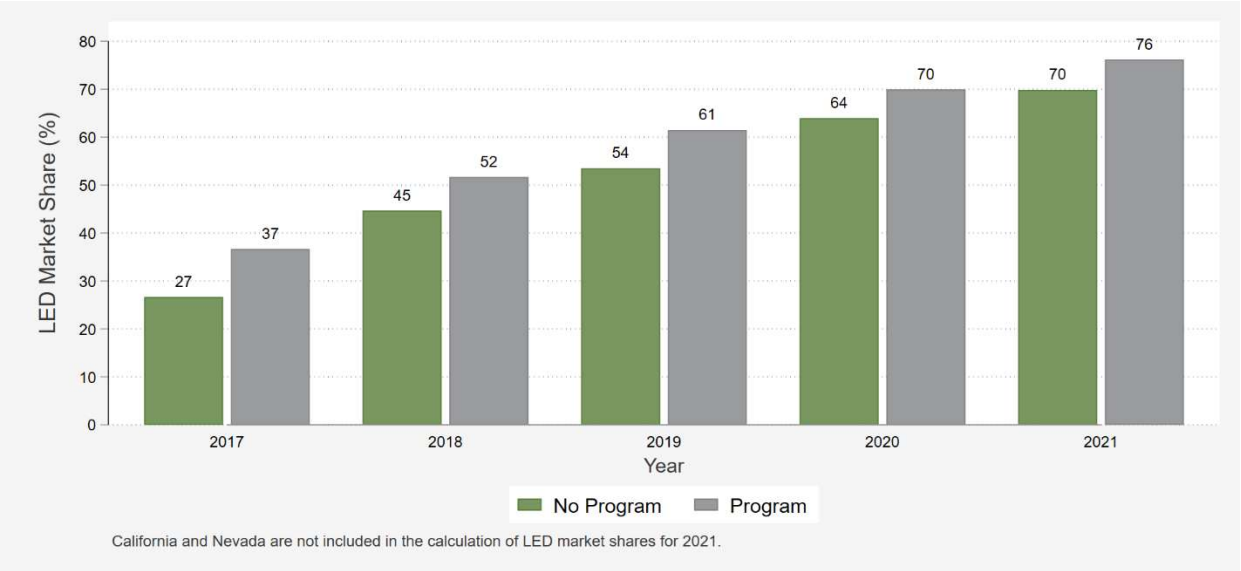


Figure 9 shows where New Jersey is positioned in comparison to the other states when looking at LED sales in 2021. Figure 10 shows the same distribution for 2020. Note that state numbering is unique to the year and the same state does not have the same number in both years. There are a handful of program states (gray bars) with low LED market shares, but states with programs generally have higher LED market shares than states without lighting programs. Most of the non-program states (green bars) have LED market share below 70% (the national average).

Figure 9. LED Market Share by State (2021)

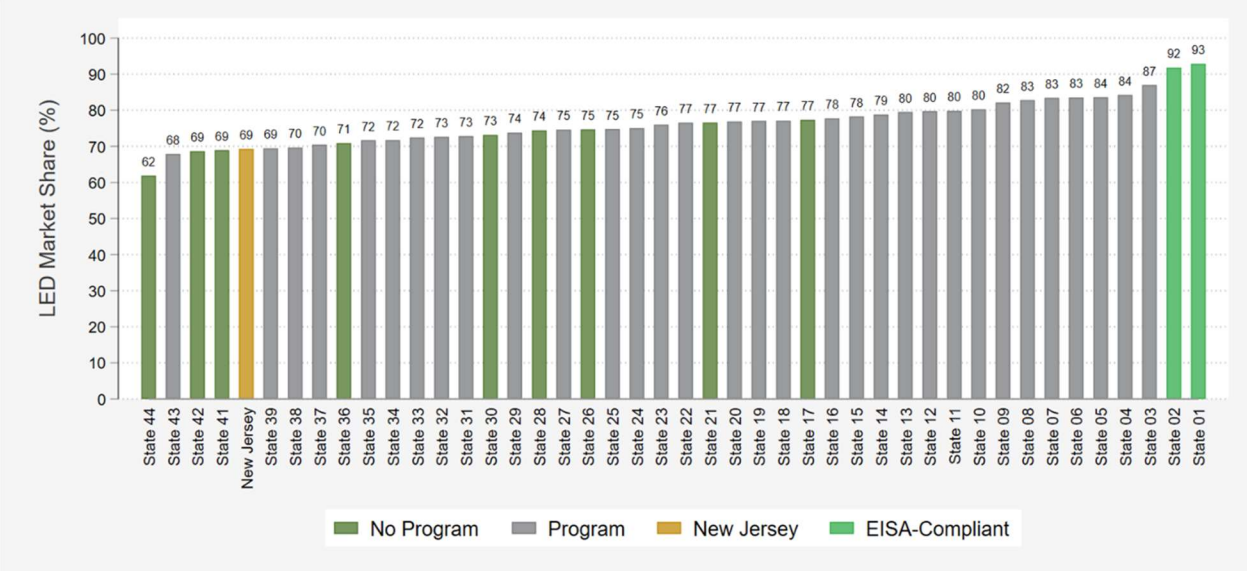
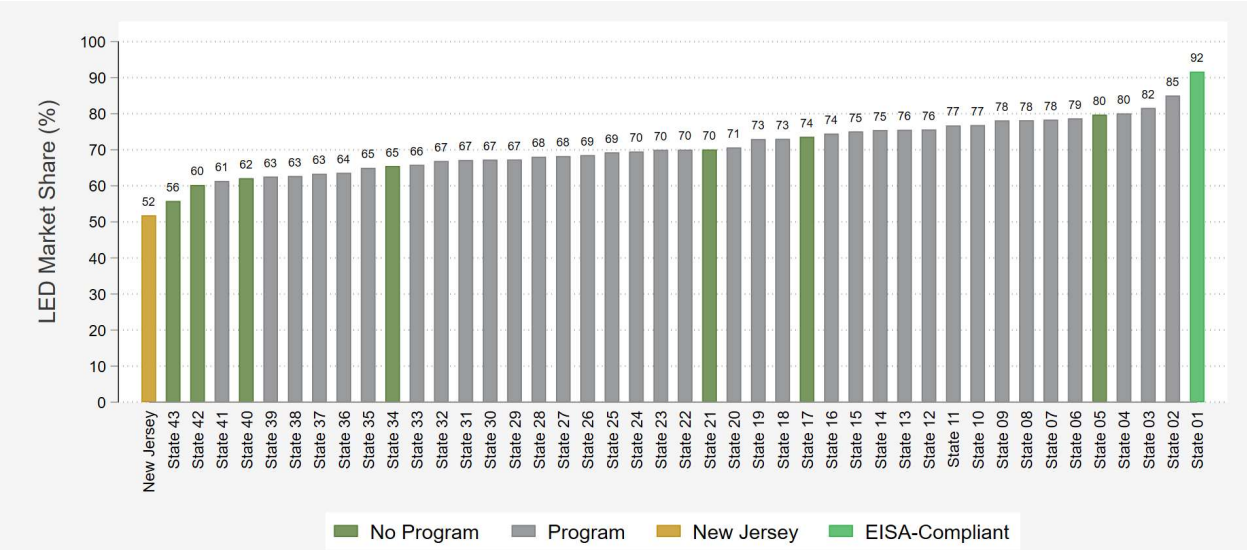


Figure 10. LED Market Share by State (2020)



Program Intensity

Figure 11 and Figure 12 show the distribution of programs lamps per household for states in which the evaluation team had sufficient data. New Jersey's upstream lighting programs incented approximately 3.5 LED lamps per household in 2021 and 2.21 in 2020. Note that state numbering is unique to the year and the same state does not have the same number in both years. The increase from 2020 to 2021 is likely due to the program interruption that occurred in 2020 due to the Covid-19 pandemic. In both years, this is more than the average (1.30 LEDs per household) and median (1.31 LEDs per household) values for the included states.

Figure 11. Average Number of Program Lamps per Household (2021)

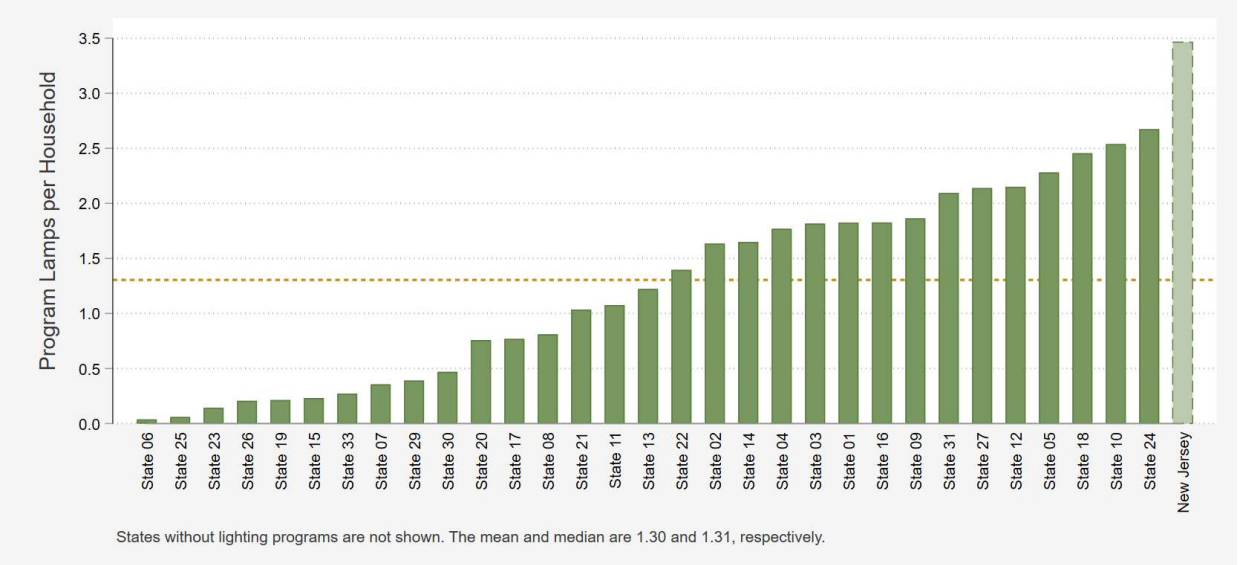


Figure 12. Average Number of Program Lamps per Household (2020)

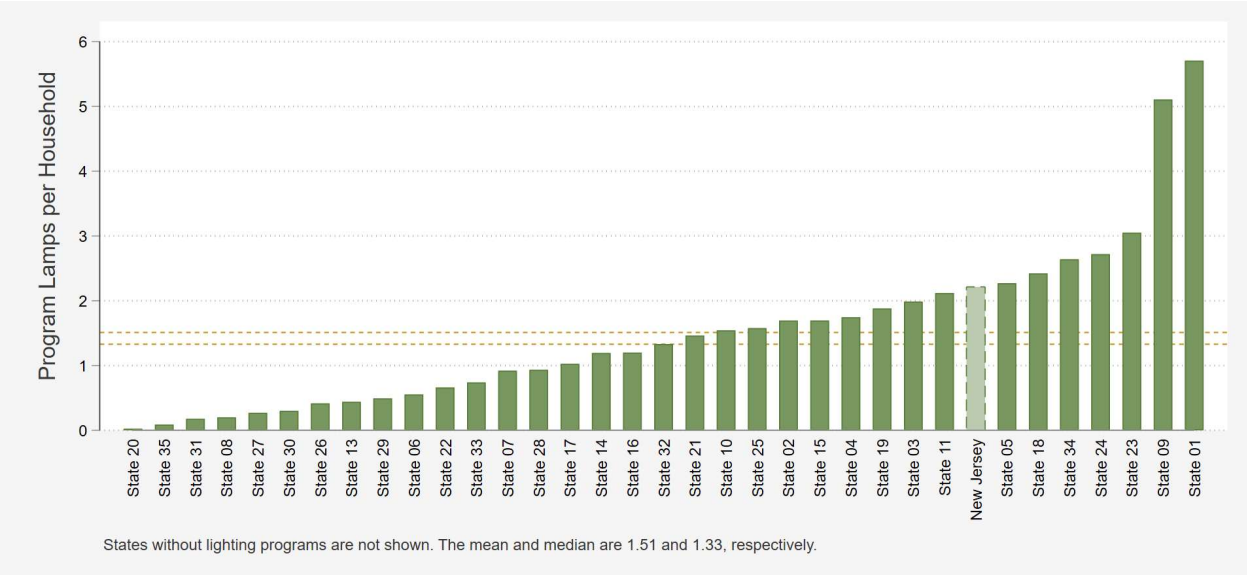


Figure 13 and Figure 14 shows the distribution of program spending per household for states in which the team had sufficient data for 2021 and 2020, respectively. Note that state numbering is unique to the year and the same state does not have the same number in both years. In most states, upstream lighting programs spend fewer than $5 per household. Across states, the average and median values were $2.99 and $2.49 per household. New Jersey's upstream lighting program falls at the top of the distribution at approximately $8.00 per household in 2021 and lower than two other states at $4.42 in 2020. The top two states in 2020 both ended their programs in 2021. Although New Jersey 2021 spending is higher than elsewhere, as mentioned above, the LED market share for NJ is likely lower than other states due to the program interruptions discussed regarding Figure 2. Further insight can be seen in Figure 17 which shows that New Jerseys LED sales overall consist of a higher proportion of program sales relative to non-program LED sales than other states. While program incentives motivate purchases, the interruptions which could be causing a loss of momentum for LEDs being sold outside the program.

Figure 13. Average Program Spending per Household (2021)

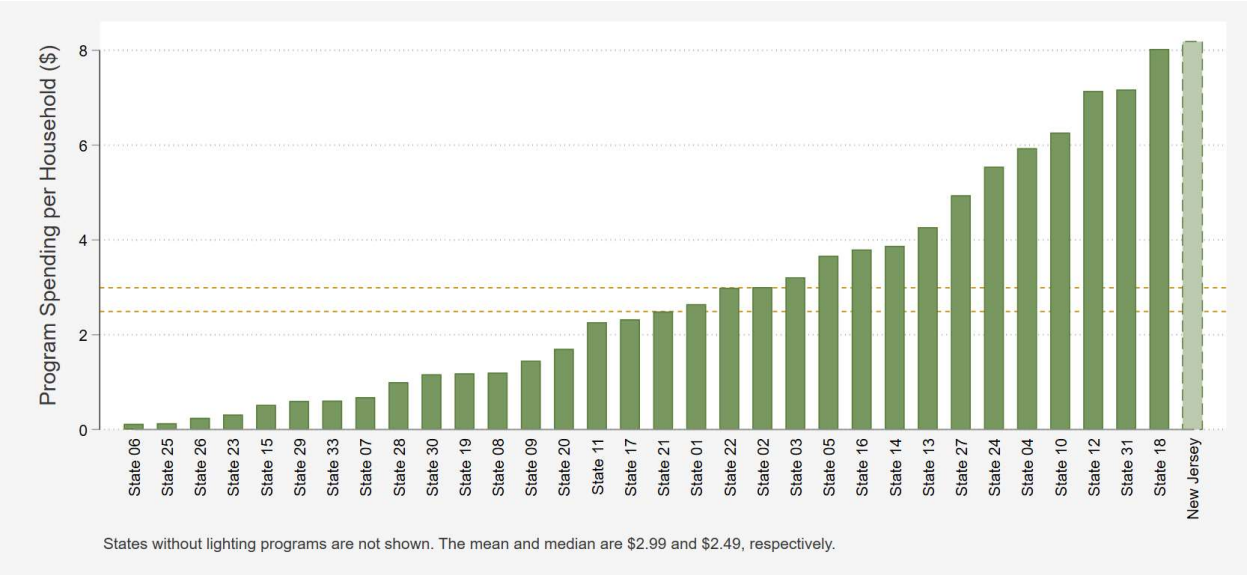
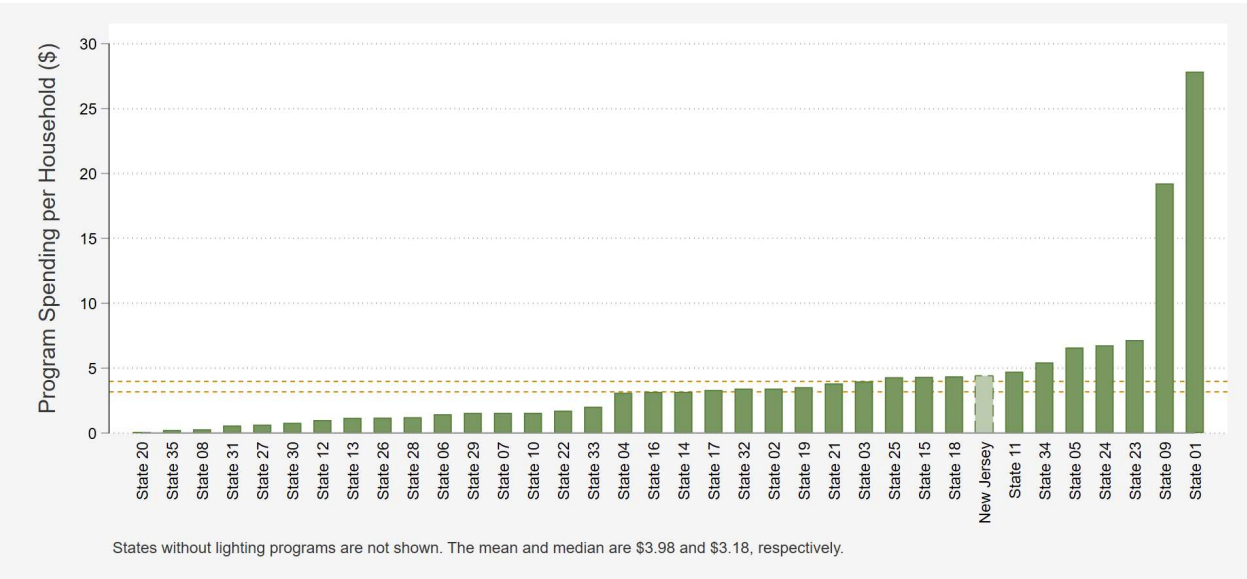


Figure 14. Average Program Spending per Household (2020)



As shown in Figure 15 and Figure 16 for 2021 and 2020, respectively, the evaluation team also compared the average incentive offered per LED across states in which LED incentive information was collected. A simple calculation of incentive dollars divided by bulb units yielded average incentives per state. In the states that had sufficient data, LED incentives ranged from approximately $0.75 to $4.50 per LED bulb, with most of these states offering between $1 and $2 per LED. The mean and median LED incentive are $1.71 and $1.69, respectively. At $1.73 per LED in 2021 and $1.31 in 2020, New Jersey falls in line with the national average incentive.

Figure 15. Average Upstream Lighting Incentive Per LED (2021)

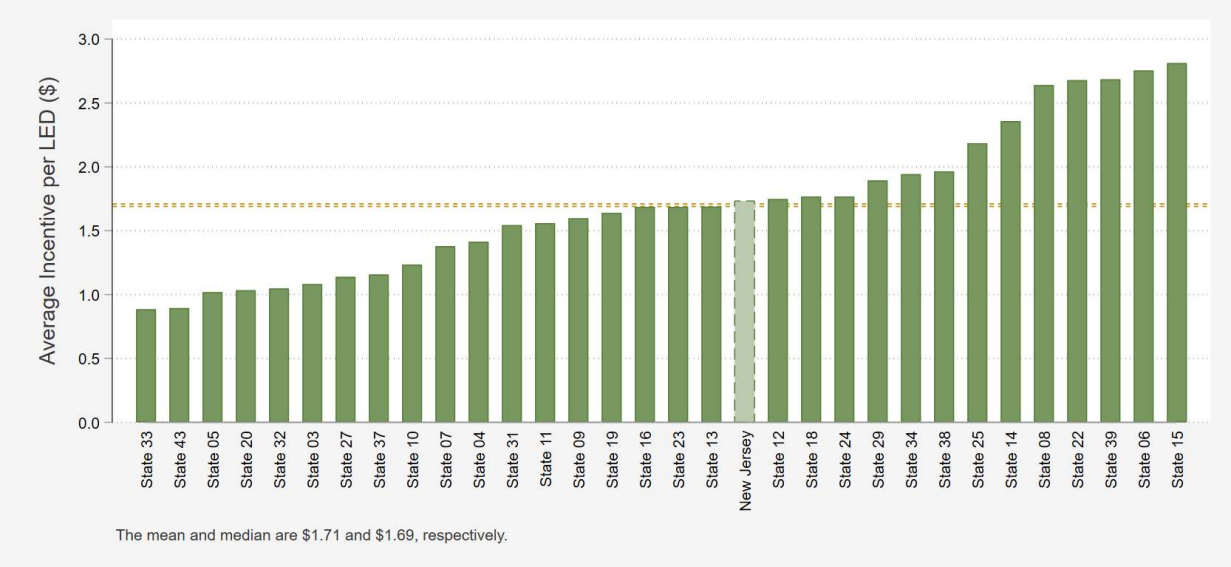


Figure 16. Average Upstream Lighting Incentive Per LED (2020)

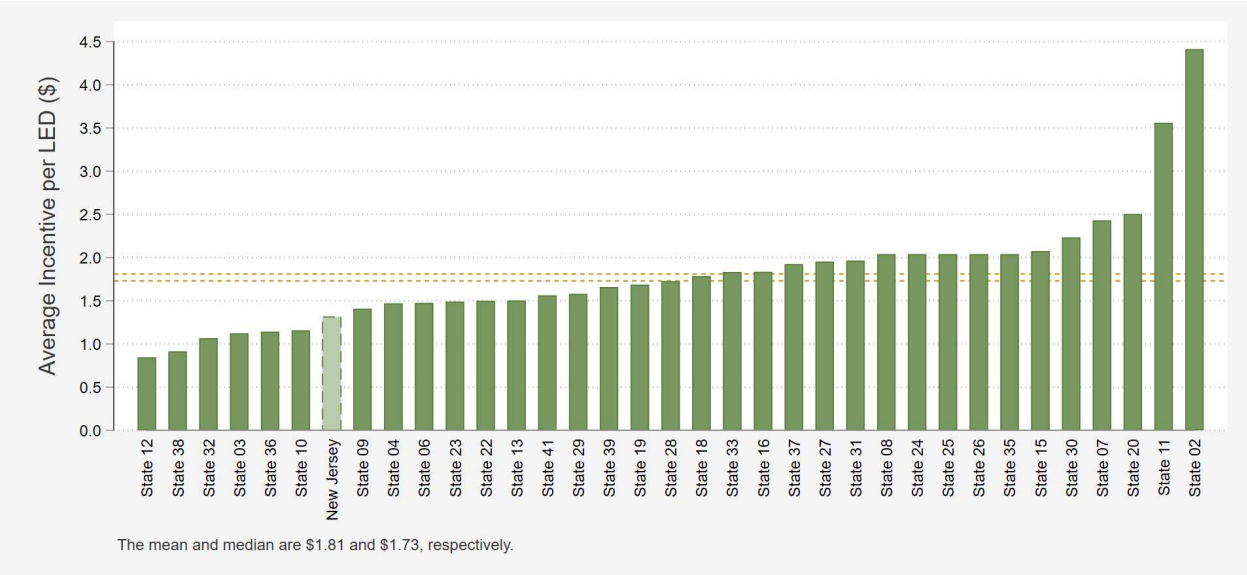


Figure 17 and Figure 18 show the percentage of LED sales, by state, that were incented by an upstream lighting program. This percentage is calculated by dividing the number of incented LED bulbs by the total LED bulbs sold in the state. Across all states, the average percentage was 22.6% and the median was

20.6%. New Jersey falls at the high end of the distribution at 64% in 2021 and 55% in 2020. It is likely that the program interruptions may have resulted in New Jersey lagging in its overall market transformation to LEDs. Since there was not significant warning to retailers for the interruptions, they would not have restocked with the cheaper, non-ENERGY STAR LEDs that are more often sold in non-program states. As such, without program incentives, LEDs would not be competitive with the inefficient lamps available.

Figure 17. Percentage of LED Sales Supported by Upstream Lighting Program (2021)

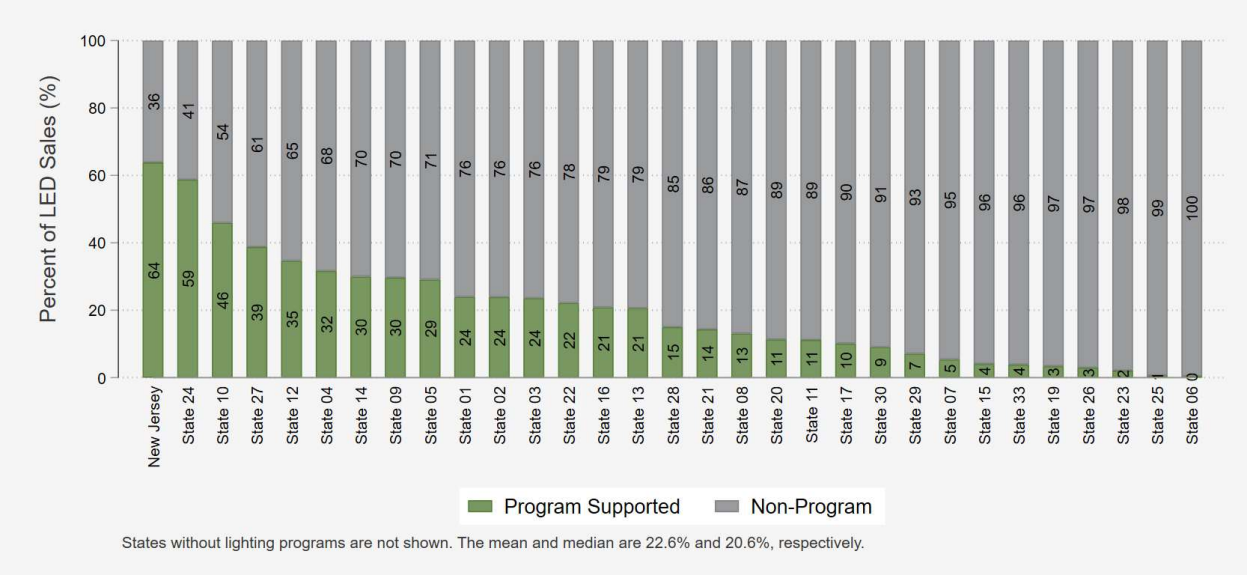
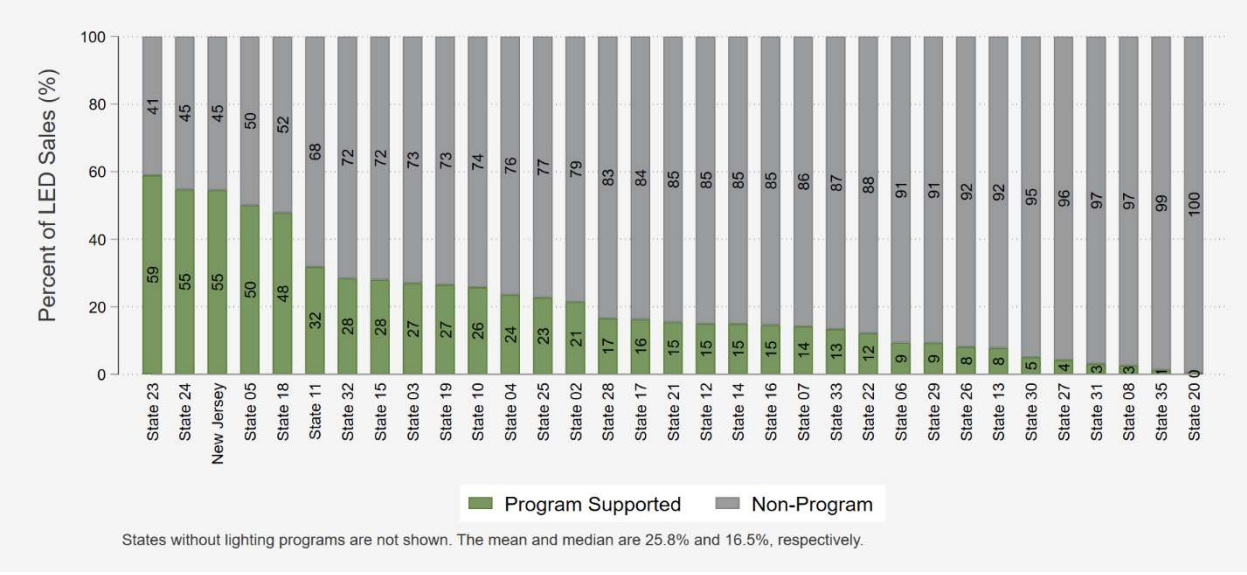


Figure 18. Percentage of LED Sales Supported by Upstream Lighting Program (2020)



New Jersey 2020 and 2021 Pricing Snapshot

For the POS channels[19], Table 2 shows lamp type market share and sales-weighted average price per bulb in New Jersey. Note that Wi-Fi enabled "smart" lamps are included in the LED market share but not in the average LED price. The 2021 LED market share (48%) ranks last across the 44 states for which POS data are available and is approximately 10 percentage points below the national LED market share (58.1%) – see Figure 2. However, New Jersey POS market shares increased from 39.7% in 2020 to 48% in 2021. Regarding prices, the sales-weighted average price per LED bulb in New Jersey is $2.59, slightly above the national average ($2.51). This may be due to the higher shares of ENERGY STAR LED lamps (which tend to cost more) sold in New Jersey as shown in Figure 7.

Table 2. New Jersey at a Glance, POS Channel, 2020 and 2021

LAMP TYPE	MARKET SHARE (%)		AVERAGE PRICE PER BULB ($)	
	2020	2021	2020	2021
CFL	0.7%	0.3%	$3.80	$3.83
Halogen	37.0%	30.5%	$1.58	$1.66
Incandescent	22.6%	21.1%	$2.07	$2.08
LED	39.7%	48.0%	$2.59	$2.26

Figure 19 and Figure 20 show the average sales-weighted price per bulb in the POS channels for LED, halogen, and incandescent bulbs in New Jersey and no program states for 2020 and 2021, respectively. (Halogen and incandescent bulbs are binned together as "Inefficient" bulbs in the figure.) Results are broken out by style. For Reflectors, LEDs – with the incentives factored in – have achieved price parity with inefficient lighting technologies. For MSB A Lamps and Specialty bulbs (Candelabras and Globes), LEDs remain the more expensive option, however it should be noted that New Jersey has a higher share of the more expensive ENERGY STAR LEDs than the average of program and non-program states which likely contributes to its higher prices.

[19] Pricing data is only available for lamps sold through POS channels. As a reminder 35% of lamps are sold through POS channels which consist of grocery, drug, discount, mass merchandise and select club stores, while the remainder are sold through home improvement, hardware, online, and selected club stores. The pricing data reported is only a subset of bulbs sold and tend to be from stores with lower prices and lower selection of LEDs than the other channels.

Figure 19. LED Incremental Costs by Style, POS[20] Channel, 2020

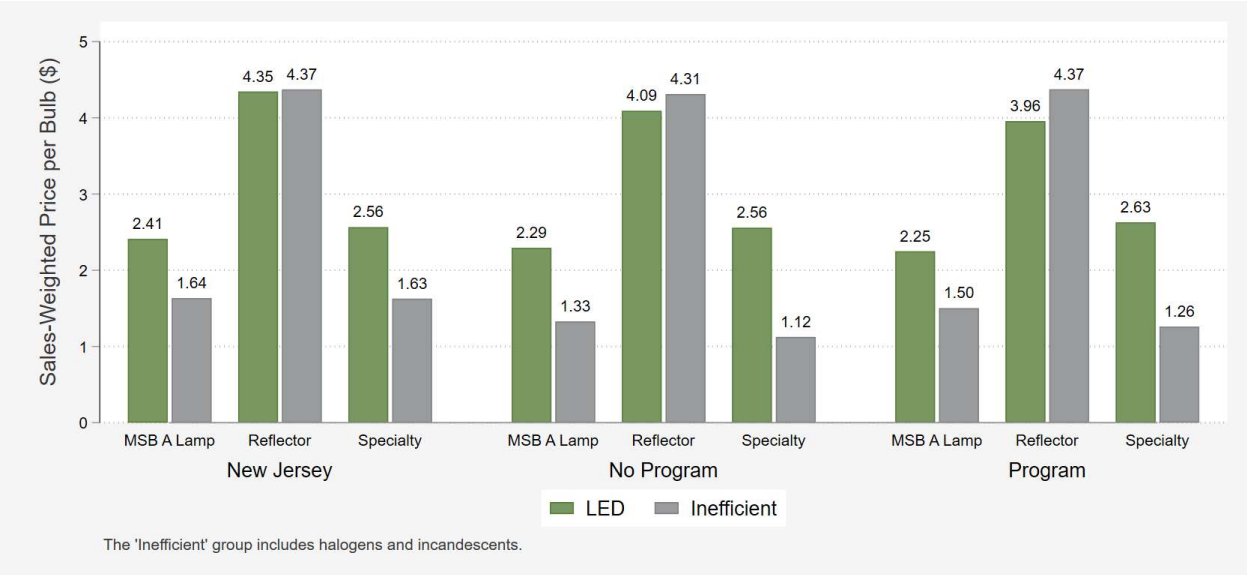
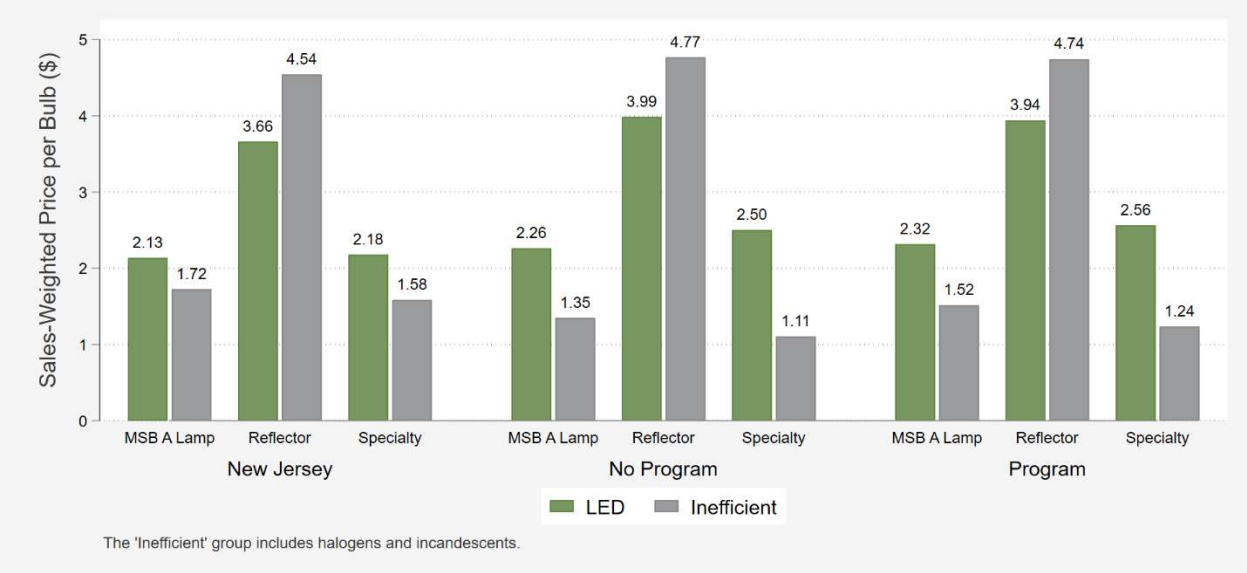


Figure 20. LED Incremental Costs by Style, POS Channel, 2021



Top Inefficient Bulbs

Four inefficient lamps accounted for nearly 10% of the overall POS market share in New Jersey. Table 3 and Table 4 show the brand of these bulbs as well as some characteristics, the average price per bulb, and the market share for 2020 and 2021, respectively. The difference in the prices of these four bulbs may be explained by brand (the third is GE and the others are Sylvania) and bulb lifetime (the fourth bulb has an expected life of 2,000 hours, twice as long as the other bulbs). The lamps are the same, however prices and market shares changed slightly between the two years.

[20] Pricing data is only available from POS channels which represent only 35% of total lamps sold.

Table 3. High Volume Inefficient Bulbs, POS Channel, 2020

BRAND	LAMP TYPE	LAMP STYLE	WATTS	LUMENS	LIFE (HOURS)	AVERAGE PRICE PER BULB	MARKET SHARE
Sylvania	Halogen	MSB A Lamp	43	750	1,000	$0.87	3.15%
Sylvania	Halogen	MSB A Lamp	72	1490	1,000	$0.83	2.54%
GE	Halogen	MSB A Lamp	43	620	1,000	$2.10	1.93%
Sylvania	Halogen	MSB A Lamp	43	610	2,000	$1.70	1.61%
The European Article Numbers (EANs) for these bulbs are 0046135500053, 0046135500060, 0043168662475, and 0046135500466.							

Table 4. High Volume Inefficient Bulbs, POS Channel, 2021

BRAND	LAMP TYPE	LAMP STYLE	WATTS	LUMENS	LIFE (HOURS)	AVERAGE PRICE PER BULB	MARKET SHARE
Sylvania	Halogen	MSB A Lamp	43	750	1,000	$0.95	2.53%
Sylvania	Halogen	MSB A Lamp	72	1490	1,000	$0.93	1.93%
GE	Halogen	MSB A Lamp	43	620	1,000	$2.22	1.66%
Sylvania	Halogen	MSB A Lamp	43	610	2,000	$1.71	1.45%
The European Article Numbers (EANs) for these bulbs are 0046135500053, 0046135500060, 0043168662475, and 0046135500466.							

NTG Modeling Methods

As previously stated, the primary objective of the model was to quantify the impact of state-level retail lighting program activity on the sales of LEDs, while controlling for demographic, household characteristics, and retail channel variables that could affect consumers' uptake of efficient lighting.

The general form of the model is specified below, followed by a more detailed discussion of the data sources for each variable. The evaluation team considered the comprehensive set of variables listed below; the final model, presented in Table 8, lists the variables ultimately selected for inclusion based on

their statistical significance and ability to improve the model specification (see the *Multivariate Regression Model* section under *Key Findings* for more information).

$$LED\ Market\ Share_i = \beta_0 + \beta_1 * Program\ Spending\ Variable_i + \beta_2 * \sum_1^3 Channel\ Variables_i + \beta_3 * \sum_1^7 Demographic\ Variables_i + \epsilon_i$$

Where:

$LED\ Market\ Share_i$	=	Proportion of total LED sales in state 'i'. Equal to [LED sales/total bulb sales]
β_0	=	The model intercept
β_1	=	The primary coefficient of interest. This represents the marginal effect of program intensity
Program Spending Variable$_i$	=	A numeric variable that summarizes state-level retail lighting program dollars per household in state 'i'. Two different program spending variables were tested; Table 5 lists additional detail.
B_2 *and* β_3	=	Array of regression coefficients for the channel and demographic variables
Channel Variables	=	Numeric variables summarizing state-level retailer characteristics. Table 5 lists additional detail
Demographic Variables	=	Numeric variables that summarize state-level population, housing, and economic attributes. Table 5 lists additional detail.
ϵ_i	=	Error term

Table 5. Program Intensity, Channel, and Demographic Variable Descriptions

TYPE OF VARIABLE	DESCRIPTION
Program Intensity Variables	
Program Spending per Household$_i$	Total upstream program budget in state 'i' divided by the number of households in state 'i'.
SQRT (Program Spending per Household)$_i$	Square root of the program spending per household.
Channel Variables	
NonPOS Sqft per HH$_i$	Average non-POS retail square footage per household in state 'i.' Equal to non-POS square footage divided by the number of households in state 'i'.
POS Sqft per HH$_i$	Average POS retail square footage per household in state 'i.' Equal to POS square footage divided by the number of households in state 'i'.
Percent Sqft NonPOS$_i$	Percentage of total retail square footage belonging to non-POS retailers in state 'i.' Equal to non-POS square footage divided by (POS sqft + non-POS sqft).
Demographic Variables	
Political Index$_i$	A state-level partisan voter index developed by Gallup[1] using presidential election voting results as a state-level partisan proxy. A higher than 1.0 value represents greater democratic influence and a value less than 1.0 indicates greater republican influence.[1]

TYPE OF VARIABLE	DESCRIPTION
Average Electricity Cost$_i$	State-level average residential retail rate of electricity sourced directly from the Energy Information Agency.[2]
Cost of Living$_i$	State-level cost of living indices developed by the Missouri Economic Research and Information Center.[3]
Percentage of Renters Paying Utilities$_i$	All state-level demographic and household variables were derived from the most current U.S. Census ACS.[4]
Median Income$_i$	
Percentage Owner Occupied$_i$	
Percentage of Population with College Degree$_i$	

[1] Gallup. "State of the States." Accessed February 2022: news.gallup.com/poll/125066/state-states.aspx
[2] US Electricity Information Association. "Electricity." Accessed February 2022: https://www.eia.gov/electricity/data/state/
[3] Missouri Economic Research and Information Center. "Cost of Living Data Series 2020 Annual Average." Accessed February 2022: https://meric.mo.gov/data/cost-living-data-series
[4] American Community Survey. Accessed February 2022: https://data.census.gov/cedsci/all?q=S25&d=ACS%201-Year%20Estimates%20Subject%20Tables&tid=ACSST1Y2019.S2504

Correlation of the Independent (Explanatory) Variables

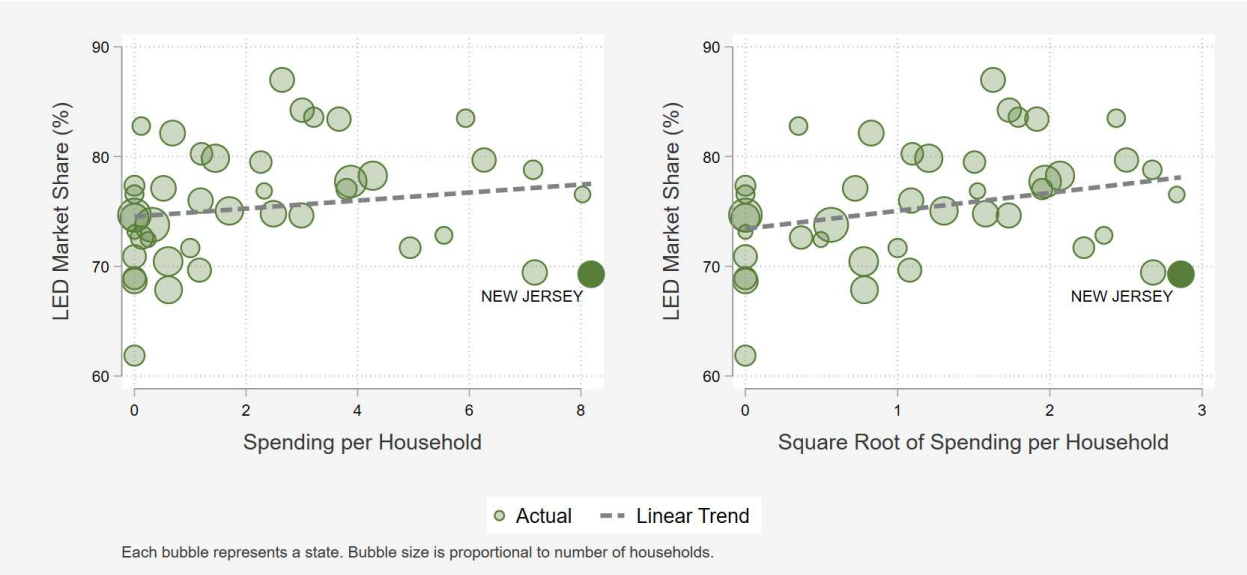
Table 6 shows the correlation between the dependent variable (LED market share) and 12 potential explanatory variables—the two program intensity variables (spending per household and square root of spending per household) and the 10 channel and demographic/household variables. Nine of the variables are positively correlated with LED market share (green bars) and three are negatively correlated (red). The absolute value of the correlation coefficient indicates the strength of the linear correlation. States that have fully adopted EISA standards were not included in the calculation of these correlations.

Table 6. Independent Variable Correlation Table

Explanatory Variable	Correlation with LED Market Share
Spending per Household	0.173
Square Root of Spending per Household	0.297
Non-POS Square Footage per Household	0.043
POS Square Footage per Household	-0.202
Percentage of Square Footage in Non-POS	0.187
Political Index	0.256
Median Income	0.241
Average Electricity Cost	-0.029
Cost of Living	0.164
Percentage of Renters Paying Utilities	-0.294
Percentage Owner Occupied	0.029
Percentage of Population with College Degree	0.326

As expected, program spending shows a positive correlation with LED market share (i.e., higher LED market shares typically occurring in states with more program spending and longer-running programs). Notably, the square root transformation of program spending shows greater correlation with LED market share than the non-transformed version. The square root transformation was tested because it reflects diminishing returns in terms of market share as program spending increase. Figure 21 visualizes the correlation between these key variables and LED market share.

Figure 21. LED Market Share against Program Intensity



In addition to being correlated with LED market share, many of the explanatory variables were correlated with each other. Table 7 shows a pairwise correlation matrix among the potential independent variables. Including multiple independent variables that are correlated with one another in a regression model causes the model to have difficulty precisely estimating the effect of the correlated terms. This issue was further compounded in this analysis by the relatively low number of observations in the dataset.

Table 7. Covariance Table of Potential Independent Variables

	LED Market Share	Spending per Household	Square Root of Spending per Household	Non-POS Square Footage per Household	POS Square Footage per Household	Percentage of Square Footage in Non-POS	Political Index	Median Income	Average Electricity Cost	Cost of Living	Percentage of Renters Paying Utilities	Percentage Owner Occupied
Spending per Household	0.17											
Square Root of Spending per Household	0.30	0.95										
Non-POS Square Footage per Household	0.04	-0.08	-0.05									
POS Square Footage per Household	-0.20	-0.47	-0.44	0.20								
Percentage of Square Footage in Non-POS	0.19	0.55	0.53	-0.02	-0.96							
Political Index	0.26	0.63	0.63	-0.15	-0.84	0.83						
Median Income	0.24	0.69	0.67	0.10	-0.68	0.76	0.79					
Average Electricity Cost	-0.03	0.66	0.59	-0.30	-0.68	0.70	0.62	0.54				
Cost of Living	0.16	0.54	0.52	-0.46	-0.79	0.77	0.72	0.64	0.73			
Percentage of Renters Paying Utilities	-0.29	-0.57	-0.55	0.37	0.61	-0.57	-0.51	-0.55	-0.65	-0.70		
Percentage Owner Occupied	0.03	-0.21	-0.20	0.55	0.40	-0.36	-0.48	-0.34	-0.37	-0.69	0.32	
Percentage of Population with College Degree	0.33	0.57	0.57	0.18	-0.56	0.61	0.70	0.89	0.42	0.49	-0.41	-0.28

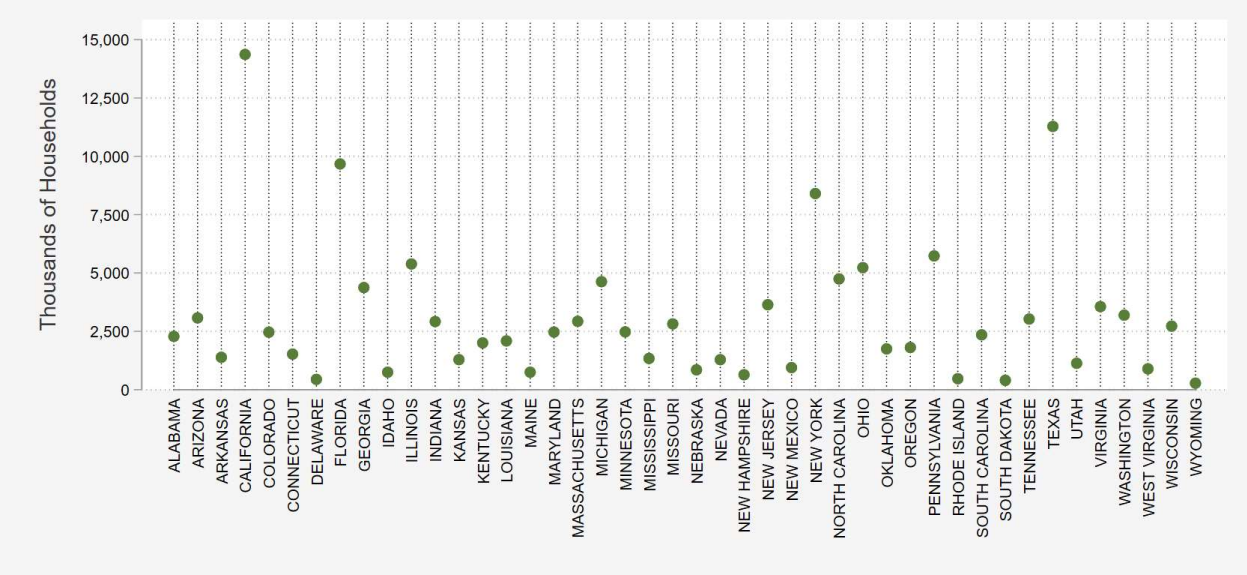
Model Weighting

Another key consideration in developing the model was how to weight each of the states. Each state is a single observation in the model, but the data for that state comprise summarized observations from sales and panel data. Weighting each state equally would not have accounted for larger states having larger sample sizes in the panel data and bigger impacts on the lighting market as a whole. To capture these differences, the evaluation team considered using either the number of households or total bulb sales as the weight. The evaluation team determined that using total bulb sales as analytic weights in the model was inappropriate because sales are correlated with the dependent variable. Specifically, states with high LED market share tend to have lower total lamp sales because efficient lamps have longer measure lives than inefficient lamps so the sockets turn over less frequently.

In the NCP data, the sample size was generally proportional to number of households, and large states represented a larger share of the overall U.S. lighting market than smaller states. Given the difference in panel sizes, the average lighting share in large states was based on more measurements than small states, with a commensurate increase in aggregate measurement precision. Therefore, the evaluation team used number of households per state as the weight.

Figure 22 shows the distribution of households for each of the 44 states in the model.

Figure 22. Number of Households by State



Model Functional Form

Another critical decision in the modeling process is the selection of the functional form of the model. LED market share is constrained by 0 and 1. In other words, it cannot be less than 0% and it cannot be greater than 100%. The evaluation team looked at functional forms that impose these limits to produce the top half of an S-curve. Since the LED market share values only ranged from 62% to 93%, and much of

that variation is explained by program intensity, the evaluation team elected to estimate the model using OLS regression. Using OLS did not result in any unrealistic predictions (e.g., predicted marked share less than 0% or greater than 100%).

NTG Estimates

Using the results of the regression models, efficient bulb sales data, and the program tracking databases, the evaluation team estimated NTG ratios for LEDs in 2021. The evaluation team derived NTG ratios by first using the model to predict the share of efficient bulbs with and without a program (determining the counterfactual of no program activity by setting the program spending variable to zero). This change in share represents the program lift, or net increase in the share of efficient bulbs resulting from program activity.

To then calculate NTG, the evaluation team multiplied the change in share by the total number of bulbs—for all bulb types—sold in 2021, as determined by the sales data analysis described above. This value represents the net impact of the program (i.e., the total lift in the number of LEDs sold), which the evaluation team then divided by the total number of program bulbs sold (the gross number of bulbs) to determine NTG:

$$NTGR = \frac{(\#\ LED\ bulbs\ sold\ with\ program - \#\ LED\ bulbs\ sold\ with\ no\ program)}{\#\ of\ program\ incented\ LED\ bulbs\ sold}$$

Key Findings

The following section presents the findings from applying the multivariate regression model.

Multivariate Regression Model

The regression coefficients for the program intensity variables, and subsequent estimates of the NTG ratio, proved relatively stable across a number of model specifications. Ultimately, the evaluation team decided to use the square root of program spending (rather than just program spending) as the program intensity variable since the square root of program spending has a stronger correlation with LED market share than program spending does. Regarding channel variables, none of the variables tested proved to be statistically significant predictors of LED market share. Still, the evaluation team decided to include one channel variable (the square footage of non-POS stores per household) as an explanatory variable on a theoretical basis to control for factors beyond program intensity variables (as well as to account for the observed higher LED market shares in the non-POS data). The evaluation team also decided to not include any of the demographic variables, as these variables are highly correlated with program spending, and multicollinearity can lead to imprecise estimates and understated standard errors. Another practical concern was overfitting – including highly correlated independent variables can result in a situation where the regression model predicts poorly out of sample because the model essentially memorizes the data set rather than finds a pattern. This issue is exacerbated by the relatively small data set (n = 44).

Table 8 displays the relevant statistics for the 2021 model. The explanatory variables included in the model are (1) the square root of program spending per household, (2) non-POS retail square footage per household, and (3) an EISA indicator variable. This indicator variable measures the effect of EISA

adoption on LED market share. The positive and significant coefficient for program spending indicates that program activity does positively influence efficient LED market share. The adjusted R^2 value for this model is 62.3%.[21]

Table 8. Model Summary Statistics (n = 44 States)

Independent Variables	Model Coefficient	P-Value of Coefficient
Intercept	0.7146	0.000
Program Spending per Household (square root)	0.0165	0.053
Non-POS Square Feet per Household	0.0053	0.700
EISA Indicator Variable	0.1926	0.000
Model Adjusted R-squared	**62.3%**	

There are a few potential limitations to the model that are worth noting. It is possible that the model omitted variables that might better explain LED market share. In addition, the use of comparison states in the baseline will not reflect any potential influence that upstream lighting programs being offered throughout the country have had on non-program states. In other words, if New Jersey's upstream lighting program, combined with the millions of dollars spent on lighting in other program states, has impacted the retailer sales of lamps in non-program and moderate program states, that impact would increase the baseline/comparison area sales and mean that the program spending coefficient was being underestimated, thus resulting in a conservative NTG.

NTG Estimates

Table 9 shows the NTG calculations. The counterfactual LED market share is 73.6% (Row D), implying that LED share would be slightly less than three-fourths of all bulbs sold if New Jersey's upstream lighting programs had not operated in 2021 (or 20,999,892 LEDs as shown in Row F). With the program, however, predicted LED market share is 78.3% (Row E), with a total of 22,351,055 LEDs sold (both program and non-program LEDs, Row G). The lift resulting from the program is the difference of these two figures, or 1,351,163 LEDs (Row H). Since the program claimed 12,620,058 LEDs in 2021, the NTG is 10.7% (the net lift in LED sales divided by the gross number of bulbs claimed).[22]

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[21] In the context of this research, R^2 represents the percentage of the variation in LED market share that can be explained by the model. Higher values are better, as they indicate the model does a better job of predicting LED market share.

[22] Note the evaluation team also attempted to run NTG by style using an alternative method based on the difference in LED share between New Jersey and non-program states. However, with New Jersey have a lower LED market share across all styles (Figure 3), this method would have produced negative NTG values that were inconsistent with the modeling approach.

Table 9. New Jersey NTG Calculations

Calculation Term	Value
Total (All technologies) New Jersey Bulbs 2021 (A)	28,541,596
Program $ per HH Actual (B)	$8.18
Program $ per HH Counterfactual (C)	$0.00
LED Market Share Counterfactual (D)	73.6%
LED Market Share Modeled (E)	78.3%
LED Qty Counterfactual (F = A * D)	20,999,892
LED Qty Modeled (G = A * E)	22,351,055
Net LEDs Modeled (H = G - F)	1,351,163
Program Bulbs 2021 (I)	12,620,058
NTGR Modeled (J = H / I)	**10.7%**

Comparison to Prior Years

Table 10 shows NTG values and inputs for 2020 and 2021. Program activity was much larger in New Jersey in 2021 relative to 2020. The NTG value decreased from 16.4% to 10.7%. The relatively low NTG values reflect the lighting market, where more and more consumers are purchasing LEDs even without program discounts.

Table 10. CY 2020 – CY 2021 Program Intensity and NTG Results

Value	CY 2020	CY 2021
Program Intensity		
Program $ per Household	$4.42	$8.18
Gross Program LEDs	8,035,553	12,620,058
Net-to-Gross		
LED Counterfactual Share	66.4%	73.6%
LED Modeled Share	71.0%	78.3%
Lift in LED share	4.6%	4.7%
NTG Ratio	**16.4%**	**10.7%**

Conclusions

While LED market shares in New Jersey and across the U.S. continue to increase, New Jersey market shares lag other states with long-running programs. This occurred despite 2021 and 2020 New Jersey program spending and program lamps sold per household being higher than most other areas. In the past five years the program had some interruptions and slowdowns due to budgeting, the COVID-19 pandemic, and changing program administrators which likely caused this lag and inhibited New Jersey's market transformation. The New Jersey program incentivizes ENERGY STAR lamps, as do most other

programs. However, as shown in Figure 7, New Jersey ENERGY STAR shares are higher than both program and non-program states. When incentives are in place, sales increase. When the incentives are interrupted, retailers may not have changed their inventory to the less expensive non-ENERGY STAR lamps causing LED sales to plummet because the price differential is so high.