DNV

DRAFT REPORT

New Jersey Non-Residential Lighting Market Characterization

Rutgers University

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1 ABSTRACT

DNV completed the New Jersey Non-Residential Lighting Market Characterization on behalf of the Rutgers Center for Green Building (Rutgers), and the New Jersey Board of Public Utilities (NJBPU). The primary objective of this study was to assess the status of the C&I lighting market in New Jersey. The key output as part of this effort was a set of recommended lighting adjusted measure lives (AMLs) for use in calculating gross lifetime savings. The key focus of this effort was on understanding the linear submarket since it represents the highest opportunity to generate program savings and accounts for the majority of lighting installations; however, DNV also collected qualitative information on the high/low bay submarket and the exterior/outdoor submarket to help inform AMLs for those lighting applications.

To estimate the future baselines required in the AML calculations, DNV completed in-depth interviews with 16 lighting distributors in New Jersey to estimate the trajectory of market share in New Jersey. DNV extrapolated these estimates and leveraged additional assumptions about the New Jersey market to convert a customized AML calculator with New Jersey specific inputs. Lighting distributors indicated that the New Jersey market is already experiencing high rates of LED adoption. Distributors estimated that LEDs already make up about 90% of total sales, and that is expected to continue to grow largely due to demand for LED luminaires. Absent, the program, LEDs would make up a smaller portion of total sales; however, LEDs would still make up approximately about 87% of total sales.

1.1 Recommendations

The DNV team recommends that program administrators in New Jersey, for the 2nd triennium planning cycle, replace the current 15-year AML assumption (as well as the 8-year AML assumption that is in the Draft 2022 Addendum currently under review by the NJBPU staff) and instead adopt the AMLs listed by submarket and technology type in Table 1-1 for all non-new construction measures. For new construction and other code triggering events should continue to use the full rated lifetime of the LED technology.

Table 1-1. Recommended AMLs

Submarket	Technology	Recommended AML
Ambient Linear	TLED	5.2
	LED Luminaire	5.4
	LED Luminaire w/Control	6.6
High/Low Bay	TLED	6.2
	LED Luminaire	6.6
	LED Luminaire w/Control	7.6
Exterior/Outdoor	TLED	6.2
	LED Luminaire	6.6
	LED Luminaire w/Control	7.6

2   INTRODUCTION

Rutgers, NJBPU, and the associated sponsors of the study requested this New Jersey commercial and industrial (C&I) lighting market characterization study to conduct an analysis of the current and future status of the lighting market to better understand the remaining potential for generating lighting program savings. This study was completed by DNV from April through June 2022. The primary data collected as part of this effort was lighting market share estimates and forecasts from lighting distributors in New Jersey.

2.1   Study objectives

The primary objective of this study was to assess the status of the C&I lighting market in New Jersey. The key output as part of this effort was a set of recommended lighting adjusted measure lives (AMLs) for use in calculating gross lifetime savings. To estimate the future baselines required in the AML calculations, DNV completed in-depth interviews with 16 lighting distributors in New Jersey to estimate the trajectory of market share in New Jersey. DNV used these estimates and additional assumptions about the New Jersey market to convert a customized AML calculator with New Jersey specific inputs.
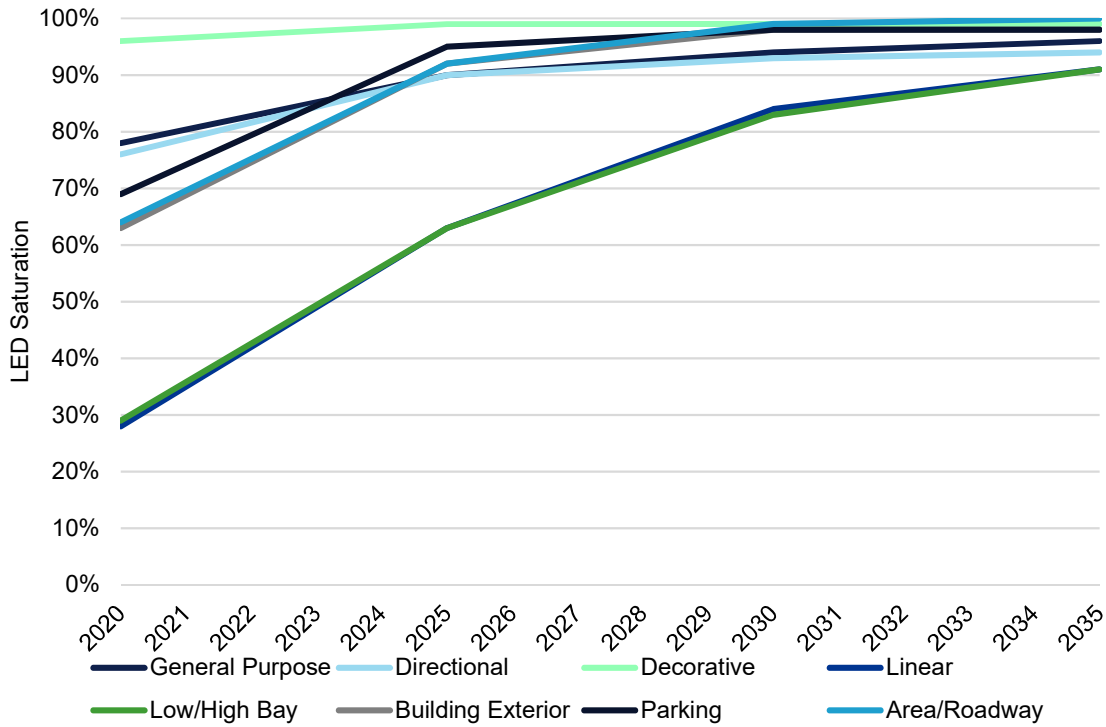
2.2   Background and context

Lighting savings in New Jersey account for a significant portion of C&I program electric savings, while at the same time, the lighting market around the country has been rapidly transitioning towards LED technologies leading to questions about how much potential there is to continue to generate program savings from lighting measures. In 2020, lighting accounted for 77% of C&I electric annual savings. This includes 87% of electric savings from the Direct Install program, 86% of electric savings in the Custom Tailored program, and 81% of electric saving in the Retrofit program. This program activity combined with increasing rates of natural adoption of LED technology means that there are fewer opportunities to continue to transform the lighting market. The rapid adoption of LED technology impacts the magnitude of the remaining lighting potential in two ways. First, the number of sockets available for implementation is declining each year because the long life of LEDs reduces product turnover and because increasing LED saturations leaves fewer socket with any potential savings. Secondly, the claimable savings per socket is declining because the increasing market share of LEDs leads to more efficient baseline conditions. Lifetime savings are the most impacted since the measure's second baseline must reflect future market conditions, when LED penetration is even higher. This reduced lifetime savings is reflected in an appropriately shortened adjusted measure life (AML).

The primary focus of this study was on the linear submarket, which consists of common recessed, suspended, or surface-mounted fixtures intended to provide ambient lighting. Historically, this lighting application was dominated by fluorescent lighting (T12, T8, and T5), and while the trend had been to replace inefficient T12s with higher-efficiency T8s and T5s, the market is now trending, with help from program-induced acceleration, toward replacing all fluorescents with TLEDs and, most recently, LED luminaires. Nationally, linear fixtures represented approximately 56% of the total installed commercial stock of all lighting equipment in 2020 and had the lowest LED saturation rate of any submarket.[1] Combined with the fact that the largest volume of program incentives has been given to this submarket, we prioritized the linear submarket for detailed research. However, the study also collected some information, mostly of a qualitative nature, for the high bay/low bay and the exterior/outdoor lighting market segments. Figure 2-1 shows the forecasted installed stock of LEDs across the country broken down by submarket.

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[1] https://www.energy.gov/sites/default/files/2020/02/f72/2019_ssl-energy-savings-forecast.pdf

Figure 2-1. National estimates of installed stock of LEDs by submarket[2]
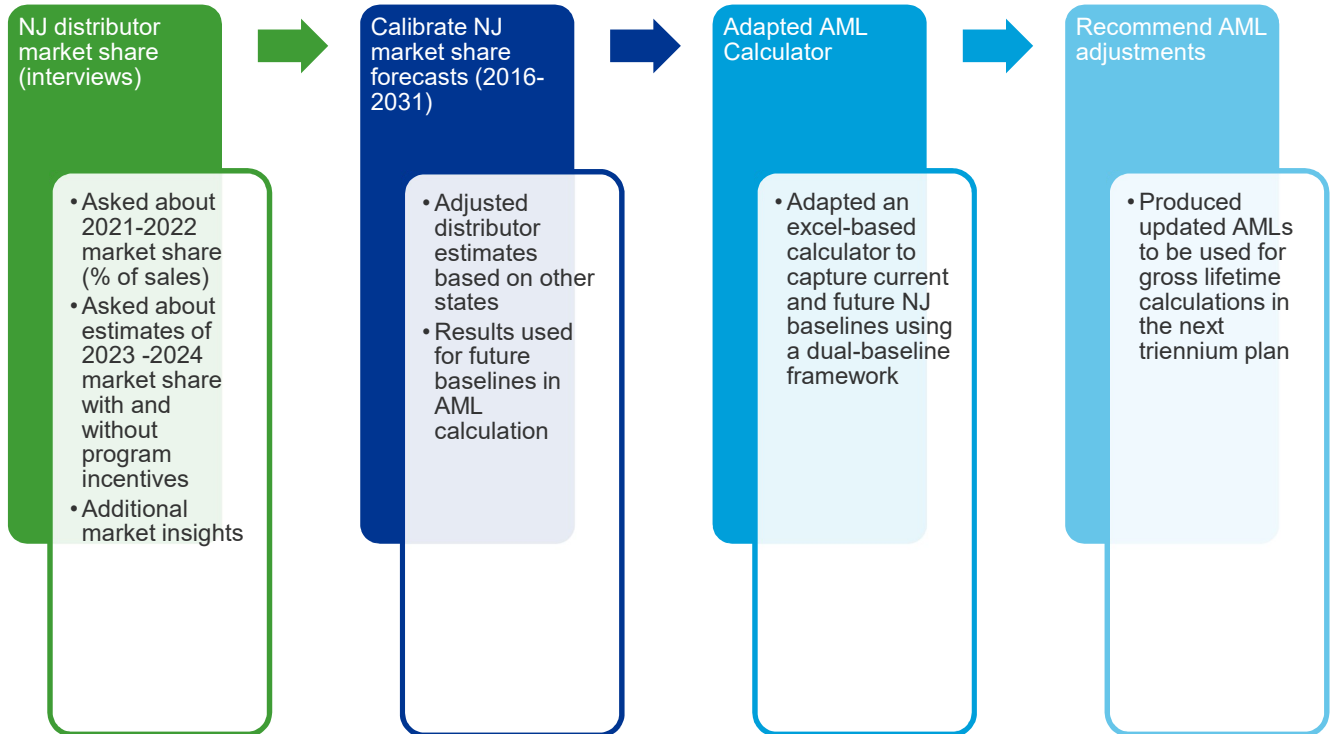
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[2] https://www.energy.gov/sites/default/files/2020/02/f72/2019_ssl-energy-savings-forecast.pdf

3 SUMMARY OF APPROACH

To better understand the linear submarket, we conducted interviews with 16 lighting distributors – 12 that participated in the midstream program and 4 non-participating distributors. Results from these surveys were then used to develop market share trends extending from 2016 through 2033 for both a program and program-ending scenario. To calculate the AMLs, DNV transformed an AML calculator developed for Massachusetts and Connecticut to incorporate New Jersey specific inputs. The year-over-year market share estimates were used as the future baselines. Figure 3-1 shows the steps in this approach.

Figure 3-1. Methodological approach.

NJ distributor market share (interviews)	Calibrate NJ market share forecasts (2016-2031)	Adapted AML Calculator	Recommend AML adjustments
• Asked about 2021-2022 market share (% of sales) • Asked about estimates of 2023 -2024 market share with and without program incentives • Additional market insights	• Adjusted distributor estimates based on other states • Results used for future baselines in AML calculation	• Adapted an excel-based calculator to capture current and future NJ baselines using a dual-baseline framework	• Produced updated AMLs to be used for gross lifetime calculations in the next triennium plan

The key objective of the distributor surveys was to determine recent and future market share by equipment technology. To capture recent market activity, we asked distributors to estimate their company's market share for 2021 and 2022.[3] For each of these periods, the distributors were asked to estimate the percentage of their linear lighting sales by equipment category. To understand where the market is headed, distributors were asked to estimate their company's market share projections for 2023 and 2024.[4] The lighting distributors were asked to provide sales projections for two scenarios: a program scenario where the New Jersey C&I lighting incentive programs continued as-is, and a program-ending scenario where the programs ended offering incentives at the conclusion of 2022. In most cases, the distributors were asked to provide projections for their own lighting sales. However, to compare company-reported market share to overall estimates of the market, one question in the survey also asked distributors to provide projections for the whole C&I New Jersey market. In addition to the market share estimates/projections, the study also collected qualitative information about New Jersey C&I lighting market characteristics, drivers, trends, and impacts from COVID-19 that could help explain these estimates/projections.

The results from the distributor interviews were then analyzed and reviewed in combination with research/data from Massachusetts and Connecticut to derive a full set of market share rates going back to 2016 through the forecast period ending in 2033. The DNV team has conducted a multitude of studies in these other states over the last several years, so

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[3] Distributor surveys were completed in May and June of 2022.

[4] The survey include 2023 estimates instead of 2022 estimates to avoid projecting potential lasting impacts from COVID-19 beyond 2022.

information from this extensive body of reaserch was used to capture an accurate understanding of how these markets change over time. Evaluation efforts in Massachusetts have included customer saturation data as part of annual on-site surveys; interviews with lighting distributors, manufacturers, and contractors; and other sources of data to calibrate and inform a stock turnover model that yields estimates of future market baselines and calculates AMLs. To understand differences between states, distributors were asked how the New Jersey market compares to other areas..

To provide multiple scenarios in the model, we derived two sets of market share curves – one with program continuing as-is and one with the program ending after 2022. The magnitude of the difference between the scenarios were based on distributor reported differences in market share.

While the limited data collected as part of effort creates some level of uncertainty around the quantitative assessment of the status of the overall market, the core lifetime savings estimates expressed in the AML findings are highly robust and based on rigorous and proven calculations. The recommended AMLs are a reduction from the current assumption for AMLS, but this is driven by the well-documented fact that the national market is moving rapidly to towards LEDs and by the fact that fluorescent lamps don't last nearly as long as LEDs. The combination of these factors means that, regardless of whether customers replace a fixture or lamp early or on failure, in the baseline scenario, they would be forced onto the market long before the physical failure of the actual LED they installed. Once forced onto the market, they would likely purchase an LED technology, meaning the measure they installed would in effect no longer produce much savings.

4   DISCUSSION OF RESULTS

This section summarizes results from the lighting distributors concerning the characterization of the New Jersey C&I linear submarket as well as qualitative information about the high/low bay and building exterior/outdoor submarkets. This includes a summary of distributor reported market share, a comparison to Massachusetts and National markets, and impacts from COVID-19 on the market.

4.1   Distributor Reported Market Share

Overall, distributors reported the market share of all LED technologies at 89% or higher starting in 2021. Assuming the program continues as-is, they estimated that this would increase to 92% by 2023 as the market reaches nearly complete transformation. LED luminaires make up the large majority of distributor reported sales and are forecasted to continue to gain additional market share, whereas TLED fixtures represent a smaller percentage of total sales and are forecasted to decline slightly. However, distributors reported that if the programs ended starting in 2023, LED luminaires would show a slower growth rate, and TLEDs would continue to gain market share. This indicates that the programs have been successful in pushing customers towards the higher efficiency LED luminaires that still have higher equipment and installation costs. For 2021 and 2022, distributors indicated that for the LED fixtures, approximately 30% of them would include integrated control technologies, and the other 70% would be sold without controls. Fluorescent technologies accounted for about 11% of total sales in 2021, with approximately 7% of that attributed to T8s and the remaining 4% split between T12s and T5s. The proportion of fluorescent T8s is expected to continue to decline, although at a slightly slower pace if program incentives were to disappear. Figure 4-1 below shows the distributor estimates of market share, and Table 4-1 provides the estimates and associated descriptive statistics.

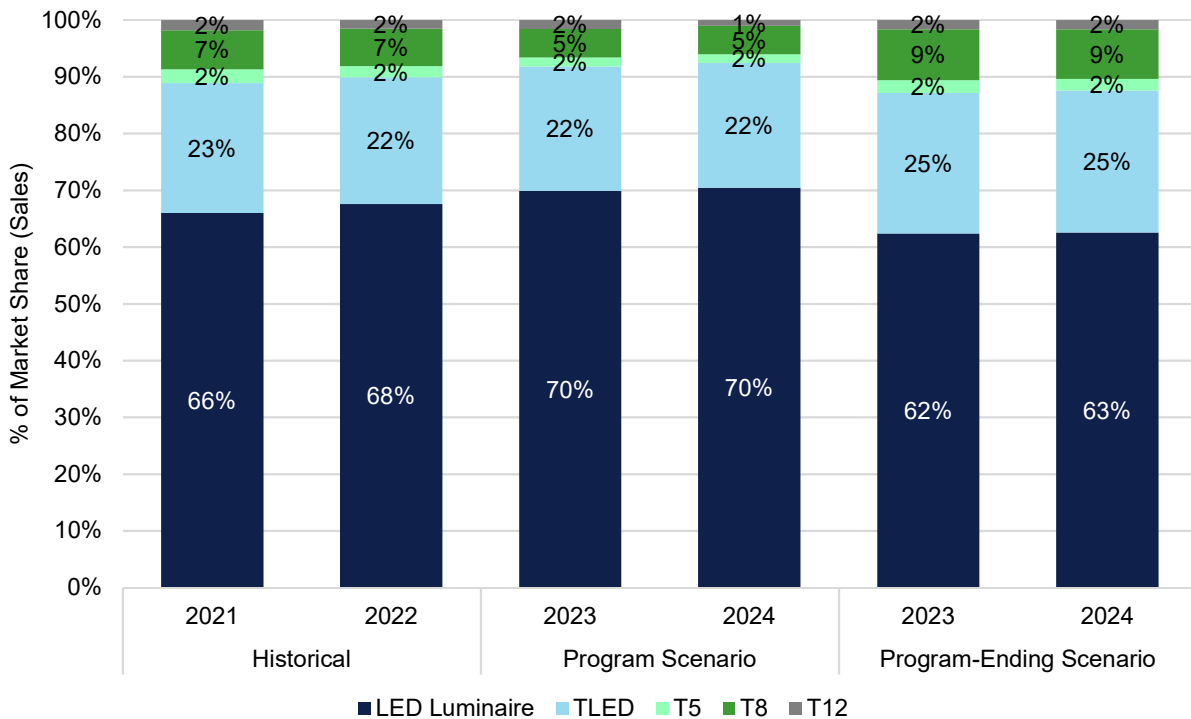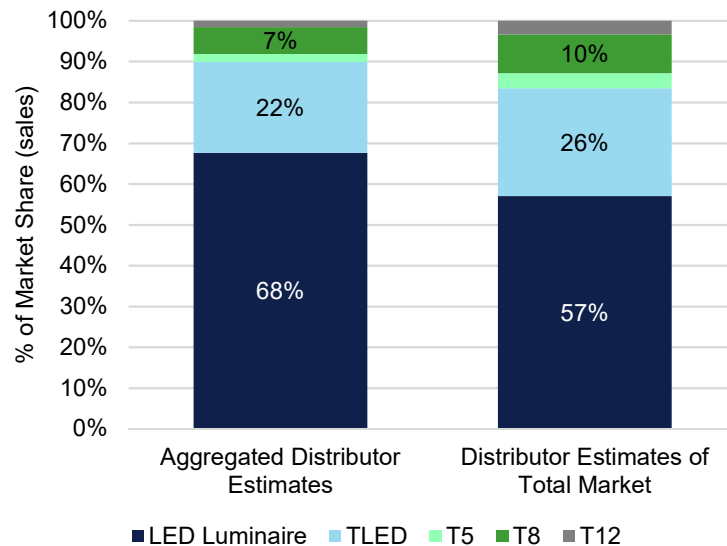**Figure 4-1. Distributor reported estimates of market share(n=16)**

Table 4-1. Distributor reported estimates of LED market share and descriptive statistics

Scenario	Year	Equipment	Sample Size	Estimate	Lower CI	Upper CI	Absolute Precision	Relative Precision
Historical	2021	TLED	16	22.9%	10.47%	35.4%	12.5%	54.7%
		LED Luminaire	16	66.0%	45.2%	86.8%	20.8%	31.6%
	2022	TLED	16	22.3%	9.9%	34.7%	12.4%	55.6%
		LED Luminaire	16	67.6%	47.3%	87.9%	20.3%	30.0%
Program Scenario	2023	TLED	16	21.9%	7.1%	36.8%	14.8%	67.5%
		LED Luminaire	16	69.9%	48.9%	90.8%	21.0%	30.0%
	2024	TLED	16	21.9%	7.1%	36.8%	14.9%	67.7%
		LED Luminaire	16	70.5%	49.6%	91.3%	20.8%	29.6%
Program-Ending Scenario	2023	TLED	16	24.8%	9.2%	40.4%	15.6%	63.0%
		LED Luminaire	16	62.4%	35.6%	89.1%	26.7%	42.8%
	2024	TLED	16	27.2%	9.4%	40.6%	15.6%	62.4%
		LED Luminaire	16	64.1%	35.9%	89.2%	26.7%	42.6%

When asked to estimate what distributors think the total market looks like in 2022 rather than what their own sales look like and then aggregating those estimates, we see that distributors tend to the think the overall market is slightly less efficient – 90% LED versus 83% LED. They also think the market is likely selling more TLEDs than their own sales estimates. Figure 4-2 shows the 2022 comparison of aggregated distributor estimates compares to the estimates of the total market.

Figure 4-2. Comparison of 2022 aggregated distributor estimates versus distributor estimates of total market

It is important to note that these distributors estimates are not direct inputs into the AML calculations but rather are used, along with information from Massachusetts and distributor reported differences between states, to inform the trajectory of market share. We use what we know about distributor reported market share and the likely relationship between interview results and what other sources of data tell us to calibrate the actual market share input into the model. There are several

reasons why it's likely that distributors results overstate the total market share of LEDs and ratio of LED luminaires to TLEDs.

One of the main reasons that distributors may overstate the total LED market share across that market is that distributors tend to serve larger businesses and customers interested in lighting retrofit projects and new construction projects. While distributors also serve customers replacing burned out or failed lighting systems, there are also other actors outside of the traditional sales that also offer lamp replacement options. These actors include big box stores, home improvement stores, online retailers, and energy service companies (ESCOs). The lamp replacement market likely includes a higher rate of non-LED technologies and a smaller ratio of LED luminaires to TLEDs.

Another reason why distributors may overstate LED market share is because distributors that responded to this survey were dominated by participating distributors that likely sell a higher proportion of LEDs than non-participating distributors. While we assume that most of the LEDs in the market are sold through participating distributors, we know that there are at least several non-participating distributors; however, it is difficult to understand how much non-participating distributors contribute to the total number of lamps sold in the program.

Given these caveats, distributors still provide the best source of information on the direction of the sales market. Because of that, we used these results to inform the shape of the market share curves in the model and to estimate the differences in market share between the program and program-ending scenario. This resulted in shifting overall LED market share down to correct for the likely overstatement of LEDs from distributors. Section 4.3 details this correction factor and approach.

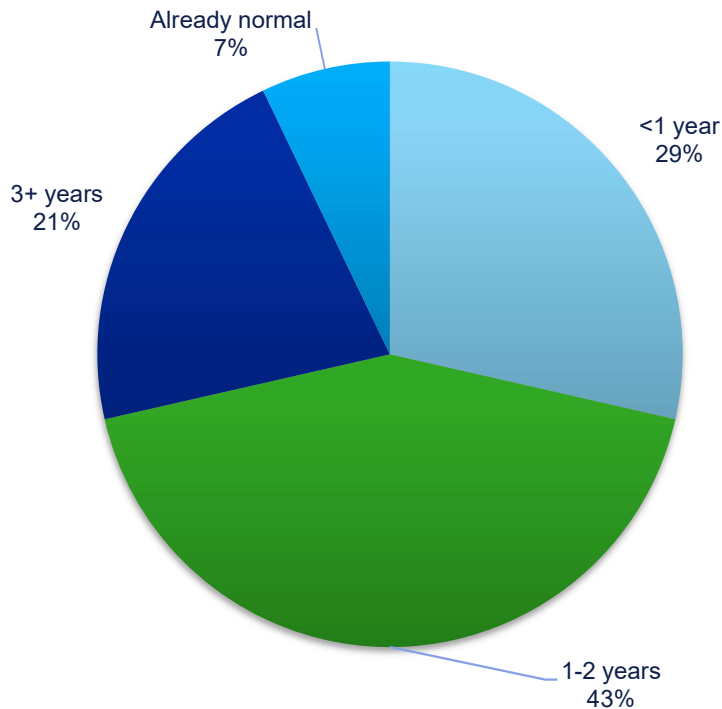## 4.2   COVID-19 Impacts on the New Jersey Market

The COVID-19 pandemic disrupted lives and businesses, and New Jersey distributors indicated that the lighting market did not escape these impacts. However, these distributors report a mix of impacts on business. Four distributors that provided quantitative estimates of the impacts on sales reported a range of sales decrease between 10% and 40% for C&I linear equipment from 2020 through 2021 due to the pandemic. However, the impacts varied a lot from distributor to distributor. The market share curves input into the AML calculations account for the impacts described below based on the percent of sales and how the sales were allocated between technologies. This means that the AMLs account for the impacts of COVID-19. For the AML calculations, the first forecast year that is needed is in 2023, which is the time at which most distributors expect conditions to have returned to normal.

Some distributors reported new sales opportunities during the pandemic which helped offset the decline in their normal New Jersey sales. For example, one distributor observed that they are coming out of the pandemic with a large pipeline of leads as more customers with unoccupied buildings are taking the opportunity to make upgrades. Another distributor noted an increase in sales in UV-C lighting. However, two respondents said that office space projects slowed down as no one knows when people will be returning to those spaces.

Six distributors cited supply chain issues impacting sales. China manufactures most C&I lighting products, and the pandemic has caused labor shortages that have impacted production levels. Labor shortages have also impacted the importation of these lighting products to the United States including both the shipping of the products and the unloading of containers at California ports.

Some distributors reported having to do work furloughs during the pandemic but most of these were only a few weeks long. However, there was other evidence of longer lasting impacts from the pandemic. The distributors were asked how long they expected the impacts of the pandemic to impact their company's operations. Figure 3-2 shows that only 7% of the distributors said that their operations were back to normal and almost three fourths said that it will be 1-2 years before their operations normalize, with the remaining 21% saying it will take three or more years.

Figure 4-2. When distributors expect their operations to return to normal (n =14)

4.3   Forecasting Market Share

To estimate the future baselines required for the AML calculations and to better understand the future trajectory of the market, DNV extrapolated the distributor estimates of market share in New Jersey to represent the full history of linear market share from 2016 through 2033. To do this, we relied on both benchmarks against other jurisdictions and the known relationship between distributor reported estimates of market share and the actual market share.

4.3.1   Comparison to the Other Market

To benchmark the information collected in New Jersey, DNV asked distributors how they think the New Jersey market compares to the national market and the Massachusetts market. This information is used to understand how the New Jersey market is performing and to develop the full market forecasts described in the following subsection. We asked about Massachusetts so that we could leverage the large volume of data collected in Massachusetts to help inform New Jersey estimates.

Of the distributors that were somewhat or very familiar with the national market (n=10), eight distributors indicated that they think the New Jersey market is either slightly ahead (n=4) or consistent with the national market (n=4). Only two distributors believe that the New Jersey is currently lagging the national market. This indicates that the New Jersey market is likely similar in the adoption pathway as the rest of the country where there have been high rates of LED saturation in most submarkets with opportunities remaining to generate program savings in the linear and high/low bay submarket as shown in Figure 2-1. Distributors were fairly split on how the incentive levels compare to the rest of the country with some indicating the incentives were higher than the national average and others indicating that the incentives are lower than other areas. One distributor reported that New Jersey "has been slow to adhere to these programs, but now everyone is more involved, and the word has gotten around about how the programs work."

Of the distributors that were somewhat or very familiar with the Massachusetts market (n=8), the majority (n=6) thought that New Jersey was likely slightly behind the Massachusetts market that has seen significant program activity in the LED market over the last decade. Only two distributors thought that New Jersey was either similar or slightly ahead of Massachusetts. This information helps to benchmark the forecasted market share estimates through the full forecast period. Most distributors indicated that Massachusetts has been more aggressive in the past and that Massachusetts has been pushing more LED projects with integrated controls.

4.3.2   Forecasts for AML Calculations

Distributors provide key insights into the market share curves input to the AML calculations, but the distributor results are not direct inputs into the model. We use the market share estimates and qualitative information from distributors along with information from research conducted in Massachusetts[5] and in the Pacific Northwest (PNW)[6] to help derive the shape of these curves.
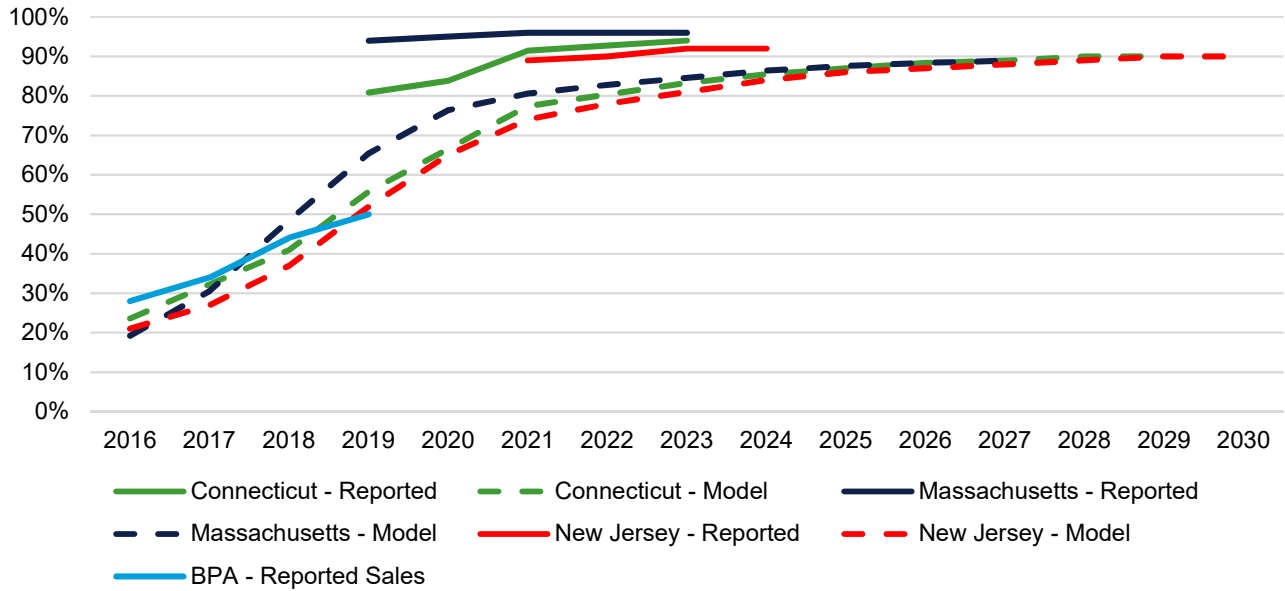
In the early years (2016-2018), we don't have distributor results in New Jersey, but we assume that the market share of LEDs is likely similarly to Massachusetts and the PNW since these years had low rates of LED market share and LED sales were driven by early adopters that were less influenced by program incentives. For the middle years (2019-2024), we assumed that the actual LED market share was less than that reported by distributors due to the potential for distributor self-selection effects and the non-distributor-based sales discussed earlier. The specific magnitude of the assumed gap is based on the difference between Massachusetts distributor reported market share and Massachusetts derived market share. The outcome from this adjustment aligns with qualitative responses from distributors that market share in New Jersey historically lagged slightly behind Massachusetts. For the later years (2025-2033), there is limited information to know what the future looks like, so we assumed a declining rate of increase as market share approaches 100% LED.

Figure 4-1**Error! Reference source not found.** shows the overall LED market share curves derived for the program scenario compared to existing sources of data. The red lines show new Jersey-specific data while the dark blue lines show the Massachusetts data, and the green lines show Connecticut. The light blue line is also overlayed on the graph to show distributor sales in the PNW. The graph also shows both distributors reported results as well as derived LED market share curves in New Jersey, Massachusetts, and Connecticut with the solid lines showing distributor reported estimates and the dashed lines showing the derived curves.

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[5] https://ma-eeac.org/wp-content/uploads/MA19C14-E-LGHTMKT_2019-CI-Lighting-Inventory-and-Market-Model-Report_Final_2020.04.06.pdf
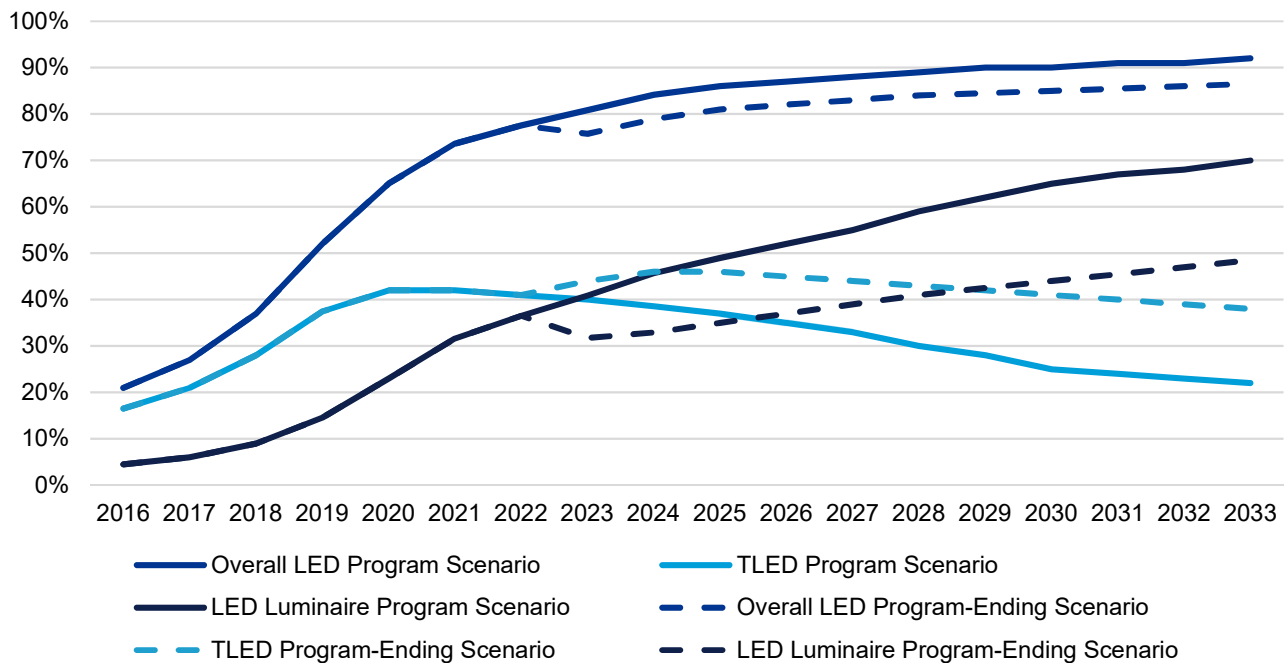[6] https://www.bpa.gov/EE/Utility/Momentum-Savings/Pages/Lighting.aspx

Figure 4-3. Forecasted LED market share in the program scenario by state overlaid with distributor estimates

In addition to the program scenario overall LED market share curve, Figure 4-4 also compares the program scenario overall LED market share to the program-ending scenario overall LED market share. It also breaks down the split in overall LED market share between LED luminaires and TLED fixtures. The overall LED market share grows from 80% in 2023 to 92% by 2033 in the program scenario, but in the program-ending scenario to only grows to 87% in 2033. Much of the growth in the program scenario is attributed to an increase in the LED luminaires while TLEDs decline. In the program-ending scenario, the growth in market share is attributed to TLED fixtures with a smaller contribution from LED luminaires.

Figure 4-4. Forecasted LED market share: program vs. program-ending scenario

4.4 Opportunities Beyond Linear Submarket

While this study did not collect quantitative market share estimates for non-linear submarkets, distributors were asked to characterize the New Jersey market for lighting in high bay/low bay and building exterior/outdoor applications. Nationally, these applications combined to account for approximately 21% of the total installed stock of fixtures, but they are also higher output systems making them candidates for larger savings relative to their share of fixtures. The high/low bay market across the country was estimated to be at about 29% LED saturation in 2020, whereas the exterior and outdoor submarkets were over 60% LED saturation already.[7]

4.4.1 High and Low Bay Lighting

The high bay/low bay lighting submarket includes pendent, recessed, or surface-mounted fixtures used in indoor high ceiling spaces. The term "high bay" is traditionally used to describe bay lighting installed in ceilings that are 25 feet or higher while "low bay" traditionally refers to bay lighting installed in high ceilings that are lower than 25 feet. Eight of the 14 respondents to this question indicated that without the presence of program incentives, there would be a significant decline in LED sales, and another two respondents indicated that there would be a slight decline. Only four respondents suggested there would be little to no change. This qualitative information suggests that there should be slightly longer AMLs for measures in this market. This is reflected in the extra year added to the recommended AMLs. In the absence of more specific quantitative information, DNV made this adjustment based on distributors indicating there would be decline in LED sales absent the program. However, quantitative estimates of the linear market from distributors showed there would be minimal decline in the absence of the program and these markets have seen similar transformation trajectories over the last few years, so we only recommend a slight (1 year) increase to the AMLs for lighting in this submarket.

4.4.2 Building Exterior and Outdoor Lighting

The exterior/outdoor lighting market segment includes high-output lights or fixtures for use outdoors or in locations open to elements like building exteriors, parking garages, or wide-open spaces. For the purposes of this study, this segment does not include street or stadium lighting. Most distributors noted that exterior fixtures represent a smaller portion of the total volume of sales, but the fixtures offer greater opportunities for savings. Several distributors pointed out that many of the exterior fixtures have already been upgraded to LED technology, but there is still some non-LED stock out there that can be converted. This aligns with national forecasts that estimated this submarket is already highly saturated with LEDs. However, 10 of the 14 distributor respondents indicated there would be significant decline in LED sales in the absence of program incentives, while the other four indicated that there would be a slightly decline. Again, this qualitative information suggests that there should be slightly longer AMLs for measures in this market. This is reflected in the extra year added to the recommended AMLs. Similar to the high/low bay market, we made this adjustment based on minimal evidence from distributors. The exterior market, nationally, is already heavily saturated with LEDs, so its unlikely that there would be a major decline in LED sales without the program. This lead DNV to increase the AML by only one year.

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[7] https://www.energy.gov/sites/default/files/2020/02/f72/2019_ssl-energy-savings-forecast.pdf

5   AML RECOMMENDATIONS

Gross lifetime savings for the C&I lighting programs are assessed as a product of the first-year annualized savings and the measure life. Lighting is subject to dual-baseline principles, so the easiest way to handle these different baselines is through an AML. To calculate the AML, we take the ratio of lifetime savings to first-year savings (delta watts). As lifetime savings and delta watts change, the AML changes. For a full description on how we calculated the AML, see the associated AML calculator workbook and the write-up in Appendix A.

The DNV team recommends that program administrators in New Jersey, for the 2nd triennium planning cycle, replace the current 15-year AML assumption (as well as the 8-year AML assumption that is in the Draft 2022 Addendum currently under review by the NJBPU staff) and instead adopt the AMLs listed by submarket and technology type in Table 5-1 for all non-new construction measures. For new construction and other code triggering events should continue to use the full rated lifetime of the LED technology.

Table 5-1. Recommended AMLs

Submarket	Technology	Recommended AML
Ambient Linear	TLED	5.2
	LED Luminaire	5.4
	LED Luminaire w/Control	6.6
High/Low Bay	TLED	6.2
	LED Luminaire	6.6
	LED Luminaire w/Control	7.6
Exterior/Outdoor	TLED	6.2
	LED Luminaire	6.6
	LED Luminaire w/Control	7.6

6 APPENDIX A: AML METHODOLOGY

The AMLs are the ratio of lifetime gross savings and the first-year annual savings, accounting for both early replacement (ER) and replace-on-failure (ROF). ER is a market event where the customer replaces the lighting before the installed technology burns out or fails. In this case, the baseline is the installed technology that is being replaced. For ROF, the customer would have to replace the lamp/fixture no matter what meaning that they are exposed to the market conditions. IN this case the baseline is whatever the market share is in that year. To calculate the AMLS, the algorithm uses the standard wattage and rated lifetime assumptions for lamp technologies and the market share forecasts in the program-ending scenario.[8] The formulas for calculating AMLs are included below.

Table 6-1. AML equation input definitions

Input	Definition	Assumption
%ROF	% of lamps installed that replace-on-failure versus early-replacement[9]	29%
Watts$_F$	Weighted average wattage of equipment sold without program-eligible technology	Based on market share forecasts
Watts$_{PM}$	Wattage of program measure (TLED or LED Luminaire)	TLED fixture = 36 watts. LED luminaire = 32 watts
Watts$_A$	Average wattage of all measures sold in year	Based on market share forecasts
Watts$_I$	Average wattage of all measures installed that are being retrofitted	Based on market share forecasts
EUL$_F$	Weighted average rated lifetime of non-program measure	Rated lifetime of non-LED equipment divided by 4,400 average hours of use per year.
EUL$_{PM}$	Weighted average rated lifetime of program measure	Rated lifetime of LED equipment divided by 4,400 average hours of use per year = 50,000 hours/4,400 HOU = 11.4 years
RUL$_I$	Remaining useful life of measures installed that are being retrofitted	1/3 of rated lifetime
Y	Year (future baseline)	N/A

6.1 Program Savings

$$Adjusted\ Measure\ Life\ = \frac{Lifetime\ Savings_{Program}}{First\ Year\ Savings_{Program}}$$

$$Lifetime\ Savings_{Program} = (Lifetime\ Savings_{ROF} * \%ROF) + (Lifetime\ Savings_{ER} * (1 - \%ROF))$$

$$First\ Year\ Savings_{Program} = (First\ Year\ Savings_{ROF} * \%ROF) + (First\ Year\ Savings_{ER} * (1 - \%ROF))$$

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[8] We use the program-ending ending scenario to avoid overlap with net-to-gross impacts.

[9] https://ma-eeac.org/wp-content/uploads/MA19C14-E-LGHTMKT_2019-CI-Lighting-Inventory-and-Market-Model-Report_Final_2020.04.06.pdf

6.2 Replace on Failure

$$First\ Year\ Savings_{ROF} = (Watts_F - Watts_{PM})$$

$$Lifetime\ Savings_{ROF} = First\ Period\ Savings_{ROF} + Second\ Period\ Savings_{ROF}$$

$$First\ Period\ Savings_{ROF} = (Watts_F - Watts_{PM}) * (EUL_F)$$

$$Second\ Period\ Savings_{ROF} = (Watts_{A,Y} - Watts_{PM}) * (EUL_{PM} - EUL_F)$$

6.3 Early Replacement

$$First\ Year\ Savings_{ER} = (Watts_I - Watts_{PM})$$

$$Lifetime\ Savings_{ER} = First\ Period\ Savings_{ER} + Second\ Period\ Savings_{ER}$$

$$First\ Period\ Savings_{Er} = (Watts_I - Watts_{PM}) * (RUL_I)$$

$$Second\ Period\ Savings_{ER} = (Watts_{A,Y} - Watts_{PM}) * (EUL_{PM} - RUL_I)$$

About DNV

DNV is a global quality assurance and risk management company. Driven by our purpose of safeguarding life, property and the environment, we enable our customers to advance the safety and sustainability of their business. We provide classification, technical assurance, software and independent expert advisory services to the maritime, oil & gas, power and renewables industries. We also provide certification, supply chain and data management services to customers across a wide range of industries. Operating in more than 100 countries, our experts are dedicated to helping customers make the world safer, smarter and greener.