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Oregon Lighting Market Characterization

Energy Trust of Oregon

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Executive Summary

On behalf of Energy Trust of Oregon, Cadeo Group and Apex Analytics conducted extensive secondary market research to summarize existing data on the residential and nonresidential lighting markets in Oregon. The research team sought to provide insight into both the current and forecasted states of these markets, as well as areas of remaining opportunity for energy efficiency programs. The catalogue of data sources reviewed is available in a workbook available on request from Energy Trust.[1]

This research provided insights into the residential and nonresidential lighting markets in Oregon as of October 2020. Key findings include:

Residential

LED market share has grown rapidly among residential lighting products, with LEDs representing more than 60% of residential bulb sales in 2019. Reflecting this high market share, forecasts predict significant growth in household saturation of LEDs, with estimates of 2020 saturation at 61% overall, more than three times the level reported from the most recent RBSA's 2016/2017 observations (17% overall). Most estimates place both the sales and saturation of LED globe and decorative lamps below that of A-type lamps and reflectors.

LED market share is lower, however, in certain retail channels and among certain demographics. Grocery, dollar, and mass merchandise retailers, which collectively make up 30% of residential lightbulb sales, have a notably lower LED market share than other retail channels. A recently completed Energy Trust Customer Insights study suggests that Black respondents, low- and moderate-income households, and renters were less likely to purchase LEDs than other respondents.

There is considerable uncertainty in the residential lighting market. Recent Department of Energy (DOE) rules rescinded long-anticipated increases to lighting efficiency standards. Lawsuits have sought to reverse those decisions and the results of the 2020 presidential election could alter future regulatory actions. Added to this regulatory uncertainty, the COVID-19 pandemic has affected global lighting supply chains and changed consumer buying practices, potentially with long-term implications. All these factors add uncertainty to future lighting market forecasts.

As a result, niche opportunities for energy efficiency exist throughout the residential lighting market.

- Grocery, dollar, and mass merchandise retailers sell fewer LEDs than hardware and DIY channels. There is an opportunity to incentivize LEDs within these channels to encourage higher sales.

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[1] Contact Phil Degens (phil.degens@energytrust.org) to request the workbook.

- Sales and saturation of LED globe and decorative lamps remain below that of A-type lamps and reflectors. There may be remaining opportunities to encourage LED adoption of these specialty lamp types.
- There may also be remaining opportunities within specific demographic groups. Black, low-income, moderate-income, and renter households purchased LEDs less frequently than other demographic groups.

Nonresidential

In the nonresidential market, the research team found that the rapid proliferation of LEDs across products in the installed stock over time has driven LED saturation[2] toward 100% in many lighting applications. The applications where saturation is lowest, namely in the ambient linear and high/low bay applications, however, are typically the largest applications by volume. This creates an opportunity for eventual replacement of legacy non-LED technologies, especially when including networked lighting controls (NLCs) in LED replacements.

Linear fluorescent 32W T8s remain the most dominant lighting technology in the nonresidential market, particularly in the ambient linear application. The building types where T8s are most prevalent (warehouses, schools, and offices) are also building types that make up the largest portion of commercial floor area. Converting this large volume stock of T8s to LED technologies, and especially LED technologies with NLCs like luminaire level lighting controls (LLLCs), is a likely the largest area of opportunity for energy efficiency remaining in this market.

Niche opportunities for energy efficiency exist throughout the nonresidential lighting market.

- A small but stubborn percentage (8%) of installed stock of inefficient linear fluorescent T12s persists in the nonresidential market, concentrated in small- and medium-sized rural buildings. There is an opportunity to replace these inefficient lamps with more energy efficient LED alternatives, or LEDs with NLCs.
- The indoor agriculture market is growing rapidly, but legacy technologies (including HIDs) make up most of installed stock. Pushing the indoor agriculture market towards more energy efficient lighting solutions represents a large opportunity for energy savings regionally.
- Controls are likely to continue to be part of the conversation. There is no dominant control technology, and 68% of indoor lighting is controlled by manual on/off switches. However, controls can reduce hours of use by up to 38% and NLCs on average can achieve 49% energy savings. We assume there will continue to be innovations in controls that Energy Trust should monitor for opportunities to move the market towards greater adoption of controls.

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[2] For the purposes of this report, the team defines penetration as whether or not LEDs are in a given application, and saturation as the percentage of LED products in a given application.

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Introduction

On behalf of Energy Trust of Oregon, Cadeo Group and Apex Analytics ("the research team" or the "team") conducted extensive secondary market research to characterize the residential (single family, multifamily, and manufactured homes) and nonresidential (commercial, industrial, indoor agriculture, exterior, and outdoor sectors) lighting markets in Oregon. The research team sought to provide:

- A picture of the installed base of lighting technologies
- A snapshot of the current market baseline and sales trends of lighting technologies
- Guidance on what the future state of lighting will be, as well as areas where energy efficiency programs might be effectively deployed

The purpose of this research was to catalog and summarize the existing stock, sales, and forecasting data sources available on the Oregon lighting market, and document gaps in market intelligence. The team prioritized recency and regional coverage when reviewing data sources to ensure data was up-to-date and applicable to the Oregon lighting market. The team did not collect any primary data sources or conduct additional in-depth analysis of available secondary sources.

This report outlines the key findings, summary of gaps, and summary of opportunities in both the residential and nonresidential lighting markets in Oregon. In addition, the research team compiled a workbook cataloging available data sources, source bibliography information, and an assessment of the usefulness of given sources. This catalogue of data sources is available on request from Energy Trust.[3]

[3] Contact Phil Degens (phil.degens@energytrust.org) to request the workbook.

Section 1 Residential Market Research

The residential data review is organized in six sections. The first section describes the sources used in this review. Subsequent sections detail the lighting stock, sales, codes and standards, data gaps, and remaining opportunities. The team includes forecasted estimates in the stock and sales sections.

1.1 Source Overview

The team relied on nine sources, excluding interviews, to inform the residential market research, prioritizing the most recent research from the Pacific Northwest in the review and adding supplemental data from other jurisdictions where valuable.

Residential Building Stock Assessment[4] (RBSA)			
Data Collection Year:	**Geography:**	**Author:**	**Primary Use:**
2016-2017	Northwest region, some findings broken out by state	Cadmus, on behalf of NEEA	Household saturation

The RBSA included onsite data collection in approximately 2,000 single family, multifamily, and manufactured homes across the Northwest to gather data on the installed stock of energy-using equipment, including lighting, in the region. The RBSA is the most comprehensive source of regional lighting stock data available, and RBSA data serve as an input into other data sources. Nonetheless, given the pace of change in the lighting market, the installed stock of lighting technologies in the Northwest has likely changed significantly since the RBSA site visits took place in 2016 and 2017. A new RBSA study is expected to launch in late 2020 or early 2021, with data likely becoming available by the end of 2022.

4 Residential Building Stock Assessment

BPA Residential Lighting Market Model[5] (The Stock Turnover Model)			
Data Collection Year:	**Geography:**	**Author:**	**Primary Use:**
Uses annual lighting sales data as input (2018 most recent in reviewed tables), calibrated to reflect 2016-2017 RBSA data	Northwest region	Created by BPA, currently maintained by NEEA	Current household saturation, current sales, forecasted saturation and sales

The Stock Turnover Model draws on RBSA data as well as annual lighting sales data in the Northwest to forecast lighting shipments and stock by bulb application and technology from 2012 to 2025. The model's forecasting approach is based on theories about the diffusion of innovations and uses assumptions about consumers' technology preferences and price sensitivities to predict lamp replacement purchases. The model provides granular forecasts of lighting shipments and stock, although it is important to note that a key input to these forecasts is the RBSA installed stock data, which are somewhat outdated.

CREED LightTracker[6]			
Data Collection Year:	**Geography:**	**Author:**	**Primary Use:**
2016-2019	Oregon, national, and non-program states	Consortium for Retail Energy Efficiency Data (CREED)	Current sales

LightTracker data consolidates point of sale (POS) data, covering drug stores, dollar stores, mass merchandisers, and grocery stores, with data from a consumer panel covering all retail channels to estimate lighting sales (dollars and bulb counts) for all retailers. It breaks out sales by technology, bulb shape, lumen bins, and ENERGY STAR status. LightTracker also analyzes LED market share relative to lighting program activity.

NEEA Long Term Monitoring and Tracking (LTMT) Study[7]			
Data Collection Year:	**Geography:**	**Author:**	**Primary Use:**
2012-2019	Northwest region	Apex Analytics, on behalf of NEEA	Current sales

The LTMT Study estimates the market share of efficient lighting technologies in the Northwest. It combines shelf survey data from do-it-yourself hardware, small hardware, and membership club stores with CREED LightTracker point-of-sale data covering drug, grocery, and mass

[5] BPA Residential Lighting Market Model
[6] CREED LightTracker is a proprietary report. Contact Energy Trust for further information.
[7] NEEA Long Term Monitoring and Tracking (LTMT) Study

merchandise stores. The study provides a granular analysis of LED market share by bulb type and retail channel. It also tracks lamp prices. NEEA has conducted similar LTMT studies annually since 2012, allowing the studies to track trends over time.

DOE's Energy Savings Forecast of Solid-State Lighting in General Illumination Applications (DOE Lighting Market Model)[8]			
Data Collection Year:	**Geography:**	**Author:**	**Primary Use:**
Draws on a variety of secondary sources dated from 2010-2015, with estimates calibrated to market data through 2017	National	Navigant, on behalf of the U.S. Department of Energy (DOE)	Current and forecasted household saturation

The DOE Lighting Market Model draws on a range of secondary sources to estimate a national lighting inventory and calibrates these estimates based on more recent lighting sales data. It then forecasts changes in installed lighting stock based on an analysis of competing technologies, lighting stock turnover, and market growth. It breaks out findings by bulb type and market sector. The DOE Lighting Market Model's estimates of LED stock appear somewhat conservative, likely reflecting both the somewhat outdated sources at the root of its stock estimates and its national focus, including states that have historically had little lighting program activity.

DOE 2020 LED Adoption Report[9]			
Data Collection Year:	**Geography:**	**Author:**	**Primary Use:**
Data sources used to calibrate model from 2018	National	Guidehouse, on behalf of the U.S. DOE	Current and projected connected bulb saturation

The 2020 LED Adoption Report draws on the U.S. DOE Lighting Market model to provide updated estimates of LED and connected lighting energy consumption, saturation, and energy savings for 2018. The report updates and calibrates DOE Lighting Market Model results to reflect sales and financial reports from manufacturers, retailers, industry experts, and utilities as well as shipment data from NEMA, ENERGY STAR, and retailer POS data.

[8] DOE's Energy Savings Forecast of Sold-State Lighting in General Illumination Applications
[9] DOE 2020 LED Adoption Report

Massachusetts Residential Lighting On-sites[10]			
Data Collection Year:	**Geography:**	**Author:**	**Primary Use:**
2019-2020	Massachusetts	NMR and Guidehouse on behalf of Massachusetts Program Administrators	Reference for lighting saturation projections

This Massachusetts study provides findings on LED saturation from on-site visits to households. Households participating in this study were part of a panel that had participated in two previous studies, in 2017 and 2018, allowing for direct observation of changes in lighting technology over time. These studies build on prior studies conducted nearly annually dating back to 2009. While the geography differs from the Northwest, these studies provide a reference point for changes in LED stock over time in a territory with significant program activity.

Energy Trust Customer Insights Study[11]			
Data Collection Year:	**Geography:**	**Author:**	**Primary Use:**
2020	Oregon	Energy Trust of Oregon	Lighting sales differences by demographic variables

The Energy Trust Customer Insights Study is a survey of more than 5,000 Oregonians, including both program participants and non-participants. Survey respondents reported details of their lighting purchases in the past year. While the reliability of self-reported data is limited, these survey responses provide some insight into differences in LED uptake across demographic groups.

[10] This study has not yet been published. The team is confirming the timeline of publication and whether this information can be shared ahead of publication. Please do not share outside of Energy Trust and approved reviewers until we receive confirmation. Previous year's studies can be found by visiting Massachusetts Residential Lighting On-sites.

[11] The team reviewed pre-publication, draft results of the Energy Trust Market Insights Study. The team only had access to the results, not the full report. Final report expected Q1 2021. Contact Energy Trust for further information.

Annual Distributor Nonresidential Lighting Sales Data Collection[12]			
Data Collection Year:	**Geography:**	**Author:**	**Primary Use:**
2019	Northwest region	Cadeo Group on behalf of the Bonneville Power Administration	Lighting sales through distributor channel

BPA gathers annual sales data from lighting distributors, which it uses to estimate regional sales by lamp type and technology. While most of these sales are for commercial applications, BPA assumes that a portion are installed in residential buildings. The share of residential lighting sales that passes through lighting distributors is small, but these data compliment other data sources, focused on sales through more traditional retail channels.

NEMA Shipment Data[13]			
Data Collection Year:	**Geography:**	**Author:**	**Primary Use:**
Quarterly, most recent update reflects Q4 2019[14]	National	National Electrical Manufacturers Association (NEMA)	Current lighting sales

NEMA provides quarterly shipment data for A-line lamps, including CFLs, halogens, and LEDs. As of 2017, the data no longer included incandescent lamps, and, beginning in 2018, NEMA began eliminating lamps with very high or very low lumen outputs that are not subject to the Energy Independence and Security Act (EISA) from its dataset. As a result of these decisions, NEMA shipment data tends to estimate a higher LED market share than other sources.

The team interviewed four market informants in addition to these secondary data collected. The market informants included staff from NEEA, BPA, and the Northwest Power & Conservation Council. These interviews focused on lighting trends and industry forecasts, the most valuable lighting data available, and the remaining gaps in the data.

1.1.1 Disruptions and Uncertainties

Market trends in 2020 have likely shifted from previous years due to a global pandemic and resulting economic recession. All the referenced data collection activities occurred prior to the full impact of 2020 disruptions, and even the best models could not account for these unforeseen circumstances. As such, lighting sales trends summarized here may not be indicative

[12] Results from collected distributor sales are primarily featured in Nonresidential Market Research.
[13] NEMA Shipment Data
[14] As of October 2020, partial 2020 data is available but not included.

of the near future. At this point, there is not enough data to estimate impacts from this unprecedented time.

Uncertainty around EISA legislation has also altered expected lighting sales. Before 2020, many in the industry expected the EISA backstop provision to be enacted, which would essentially limit available lighting to LEDs and CFLs for general service lamps (GSLs). Additionally, in early 2017, the Department of Energy revised the definition of GSLs to effectively include decorative and reflector shape lamps, potentially subjecting them to the EISA backstop provision. In December 2019, the EISA backstop provision was rescinded,[15] and in September 2019, the expanded GSL definition was rescinded.[16] However, these changes are still in litigation and uncertainty remains as to if these will eventually be enforced.[17]

1.2 Residential Lighting Stock

The Residential Building Stock Assessment (RBSA) is the primary source of data about lighting stock[18] in Northwest households. Data for the most recent RBSA were collected in 2016 and 2017, years in which LED market share was only beginning to rise, and CFL saturation still exceeded LED saturation. The Residential Lighting Market Model, originally created by BPA and currently maintained by NEEA, uses the installed stock shown by the RBSA as a starting condition for 2016. It then uses market sales data and a stock turnover function to estimate how lighting stock may have shifted since the RBSA was conducted and forecast lighting stock into the future. The RBSA is also one of several secondary data sources that inform the U.S. Department of Energy's Lighting Market Model, which forecasts LED saturation by lamp type across the US.

There is considerable uncertainty in both the Stock Turnover Model and DOE Lighting Market Model forecasts. The DOE Lighting Market Model is largely based on secondary data and includes the whole country, including areas with little or no history of lighting program activity. The Residential Lighting Market Model is more granular and Northwest-focused, but, as discussed further below, its forecasts likely overestimate LED saturation.

Table 1 lists RBSA findings on LED saturation by bulb style in Oregon, as well as the Residential Lighting Market Model and DOE Lighting Market Model forecasts for saturation LED saturation in 2020 in the Northwest and nation-wide, respectively.

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[15] Energy Conservation Standards for General Service Incandescent Lamps

[16] Energy Conservation Program Definition for General Service Lamps

[17] Additional information on the status of the EISA legislation is offered in Section 1.4.2.

[18] The RBSA includes data on both stored and installed lamps. Unless specifically noted, RBSA analyses in this report include installed lamps only.

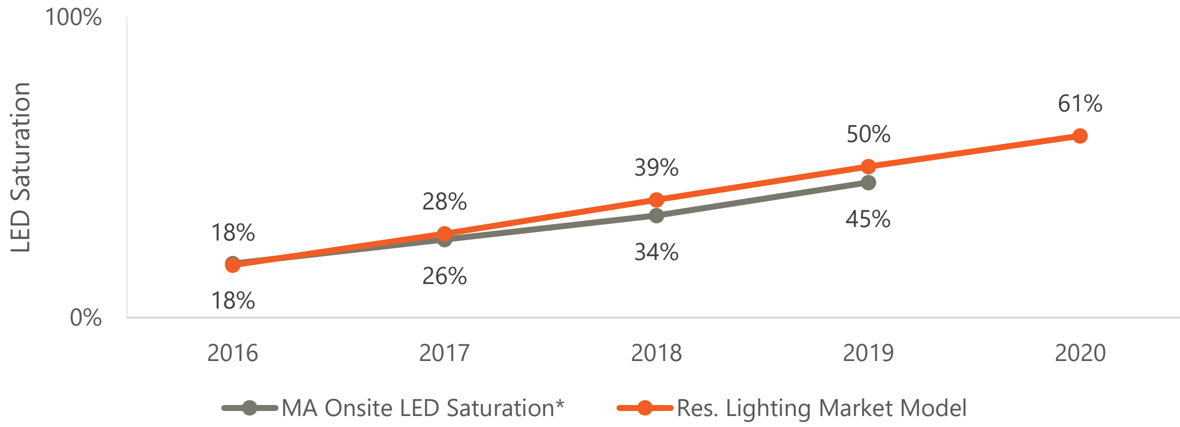
Table 1. Historical and Predicted LED Saturation by Bulb Style

Bulb Style	RBSA 2016-2017 (Oregon)	2020 Saturation Forecasts	
		Res. Lighting Market Model (NW Region)	DOE Lighting Market Model (National)
Standard A Lamp	19%	66%	38%
Reflector/Flood	21%	68%	38%*
Decorative	14%	61%	16%
Globe	9%	63%	Not Specified
Linear	2%	17%	19%
Overall	**17%**	**61%**	**33%**

* Category listed as "directional" lamps.

Among the sources that forecast household saturation of LEDs for 2020, the Residential Lighting Market Model is the most granular and the most directly focused on the Northwest region. As a result, the team views this as the more reliable of the two sources in estimating current LED saturation in Oregon homes. Nonetheless, the Residential Lighting Market Model forecasts may be somewhat optimistic. The model predicts a more than three-fold growth in LED saturation in the three years since RBSA data collection was completed. As a point of comparison, Massachusetts program administrators have conducted annual onsite saturation studies with a panel of households since 2012. While those studies indicated an equivalent LED saturation to the Northwest in 2016, they have since found slower growth in saturation than the Stock Turnover Model forecasts (Figure 1). One cause of this lower growth in LED saturation may be a longer than expected lifetime of remaining inefficient lamps, which may be concentrated in lower-use fixtures.

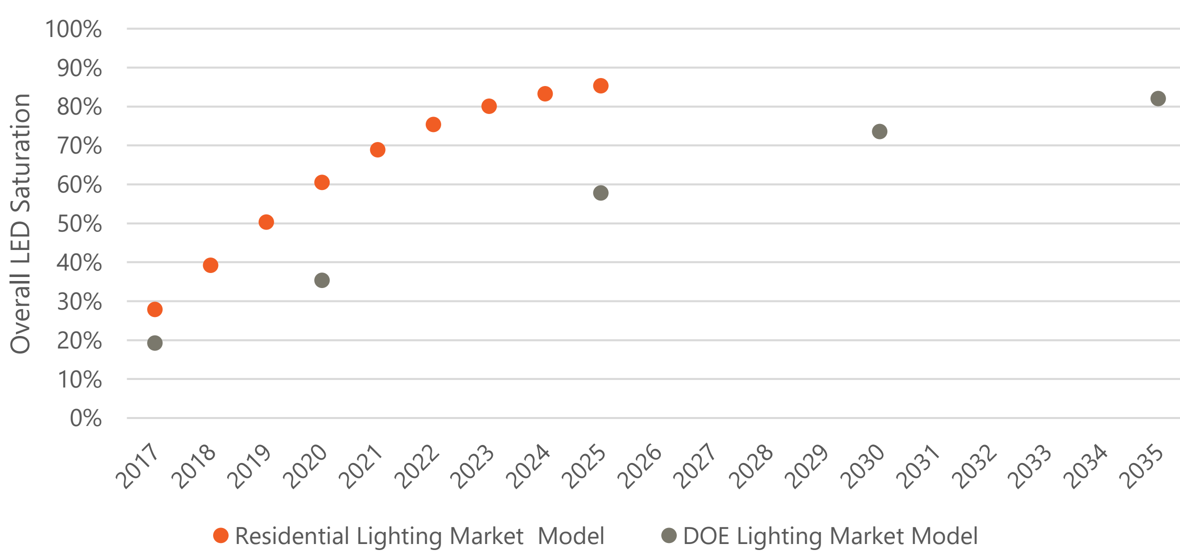
Figure 1. Residential Lighting Market Model LED Saturation Estimates Compared to Massachusetts Annual Onsite Study Findings



Source: Unpublished 2020 Massachusetts Residential Lighting On-sites

The Residential Lighting Market Model and the DOE Lighting Market Model both extend their forecasts beyond 2020. As reflected in each source's 2020 forecasts (Figure 2), the Residential Lighting Market Model anticipates a considerably more rapid adoption of LEDs than the DOE Lighting Market Model.

Figure 2. Residential Lighting Market Model and DOE Lighting Market Model Forecasted LED Share of Overall Residential Lighting Stock



The Residential Lighting Market Model forecasts that saturation will exceed 90% for each bulb style with the exception of linear lamps by 2025. The DOE Lighting Market Model anticipates slower growth in LED saturation in most bulb styles, particularly for decorative lamps (Table 2).

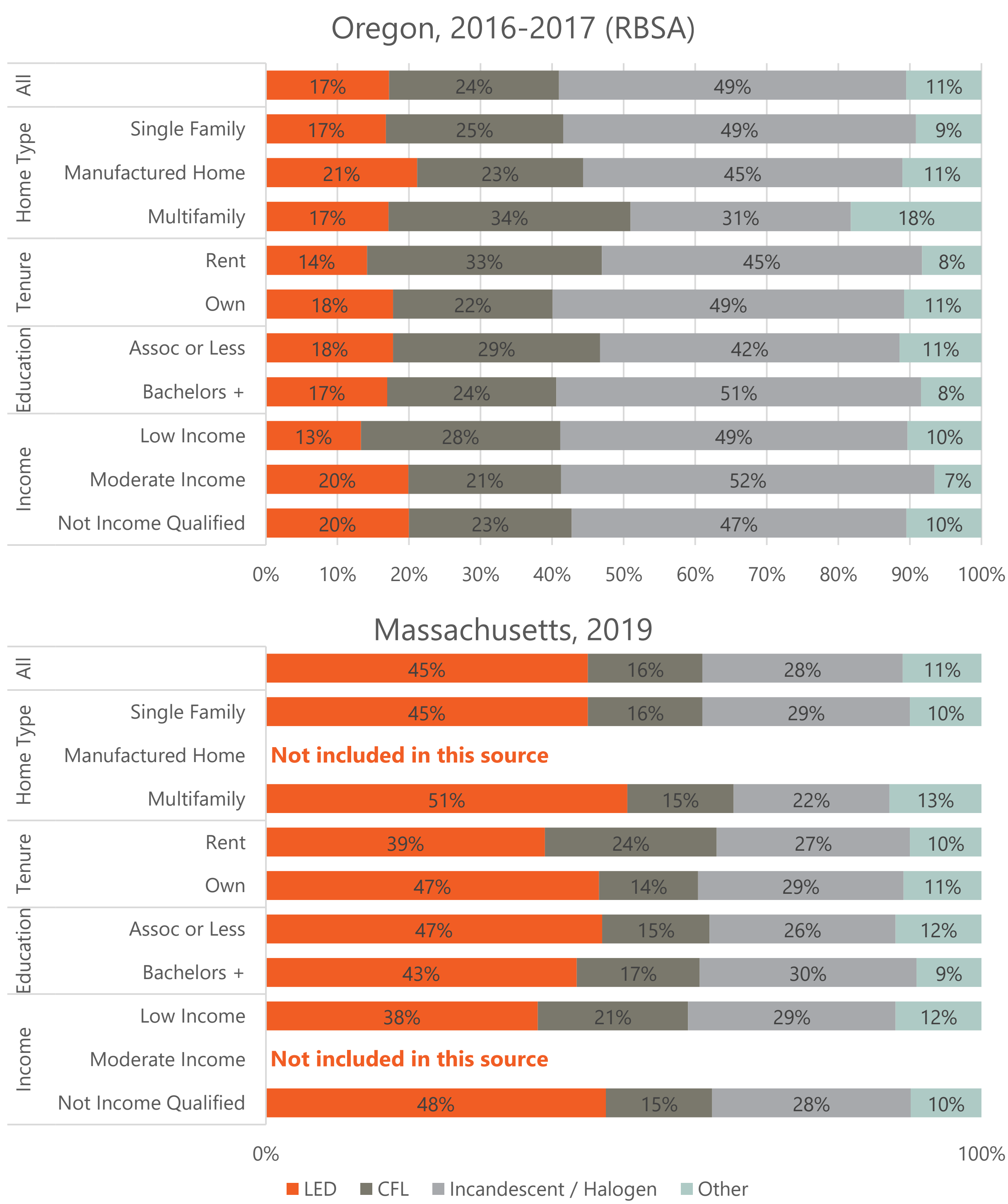
Table 2. 2025 Forecast of LED Saturation by Bulb Style, Stock Turnover Model and DOE Lighting Market Model

Bulb Style	Stock Turnover Model Forecast – 2025	DOE Lighting Market Model Forecast - 2025
Standard A Lamp	93%	62%
Reflector/Flood	94%	59%
Decorative	90%	42%
Globe	97%	Not Specified
Linear	40%	44%
Overall	**85%**	**58%**

1.2.1 Demographic Differences in Lighting Stock

Figure 3 shows differences in saturation of LEDs and other bulb technologies in Oregon homes by a variety of demographic variables. The most notable demographic difference in LED saturation in the RBSA data is related to income, with low income households having a notably smaller share of LEDs than other homes. Renters also had a lower share of LEDs than homeowners, although this difference could reflect the difference in saturation by income. It is notable that lower income households and renters had higher saturation of CFLs, likely reflecting past program efforts targeting these populations. The recent Massachusetts study referenced above shows similar trends relative to income and tenure, suggesting that these demographic differences likely persist as the overall saturation of LEDs has increased.

Figure 3. LED Saturation by Demographic Variables, 2016-17 RBSA and 2019 Massachusetts



Source: Oregon data reflect Cadeo team analysis of RBSA data, Unpublished 2020 Massachusetts Residential Lighting On-sites.

1.2.2 Connected Lighting

Connected ("smart") lighting[19] provides one possible source of future lighting energy savings. Limited data are available about the stock of connected lighting in homes. The DOE's Lighting Market Model estimated a stock of approximately one million connected lamps in the U.S. in 2018 (0.09% of installed lighting products).

The DOE Lighting Market Model's forecasts predicted that LED connected lamps and luminaires will continue to comprise less than 1% of installed lighting in homes through 2025. The model predicts the share of connected lighting will gradually grow so that connected lamps comprise 5% of installed lighting in 2035 and connected luminaires an additional 4%.

1.3 Residential Lighting Sales

This section incorporates current and forecasted data on sales of new lamps within the Pacific Northwest and the nation as a whole. In this review, the team was specifically looking for potential remaining opportunities to increase LED market share, with the understanding that the retail market for LEDs is likely transformed (or soon to be) for some lamp types.

The team reviewed five sources of current and recent lighting sales data to assess market share of lighting technologies in the Northwest. This section first describes LED market share by lamp characteristics, followed by retail channel, connected lamps, and then by customer demographics.

1.3.1.1 LED Market Share by Style

The team reviewed six data sources to assess residential LED market shares by style. All data sources indicate reflectors make up the highest share of LED sales. All sources other than the Residential Lighting Market Model show standard (A-lamps) as the second highest LED market share; Globes and decorative lamps show the lowest share of LEDs sold in the market. Table 3 offers the details for each data source.

[19] The DOE Lighting Market Model defines connected lighting as LED-based lighting system with integrated sensors and controllers that are networked, enabling communication and data exchange with other devices.

Table 3. LED Market Share Estimates, by Lamp Style and Data Source

Bulb Style	CREED (2019, OR)	NEEA LTMT (2019, NW)	Residential Lighting Market Model (2020, NW)	BPA Distributors[2] (2019, NW)	NEMA[1] (2019, US)
Standard (A Lamp)	59%	67%	61%	83%	73%
Reflector	82%	70%	73%	84%	Not Included
Decorative	56%	52%	38%	65%	
Globe	48%	52%	63%	None Sold	
Linear	Not Included	Not Included	54%	65%	
Other	Not Included	Not Included	Not Included	95%	
Overall	**61%**	**63%**	**57%**	**80%**	

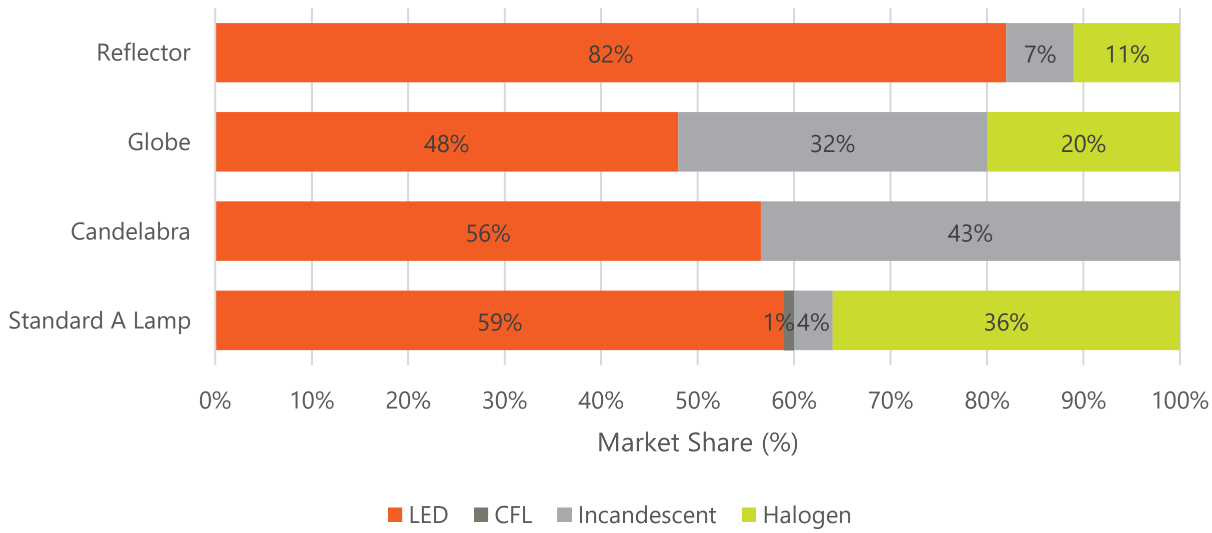
[1] NEMA shipment data excludes high and low lumen bins and only offers data on standard a-lamps
[2] BPA Distributor data represent sales to residential customers through contractors/distributers.

The CREED data offers additional information on market share of technologies by lamp style in Oregon. As depicted in Figure 4, candelabra (decorative) and globe style lamps show the highest proportion of incandescent market share remaining (43% and 32%, respectively), indicating potential opportunities for savings. Reflector lamps show the most transformed market, with 82% LED market share of that lamp style. CFLs have basically disappeared from sales.

Potential Opportunity

Target converting incandescent sales of candelabra and globe style lamps to LED alternatives.

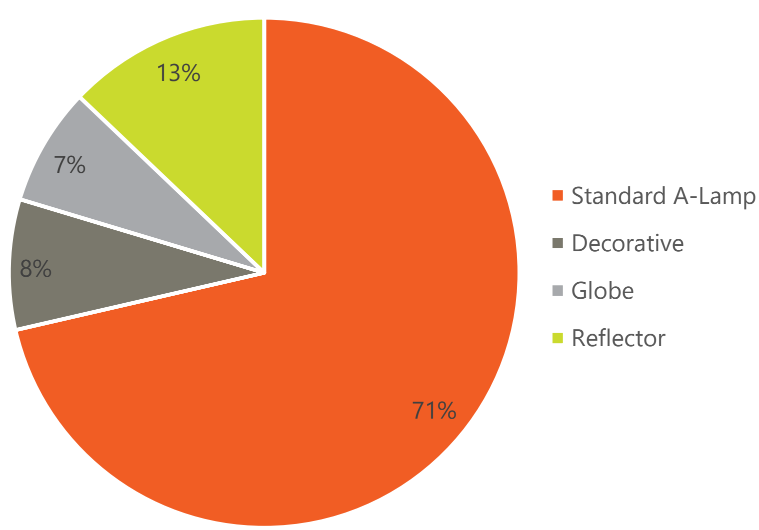
Figure 4. Lighting Market Share, by Technology and Lamp Style (2019 Sales)



Source: CREED 2019

When assessing remaining opportunities, the team also evaluated the percent of sales each bulb style represents. In this way, the team can assess how large an opportunity actually remains for these lamp styles. Figure 5 below indicates that standard a-lamps represent the highest percent of lamps sold in Oregon in 2019 (71%), while decorative and globe represent the lowest, at 7% and 8% of lamps sold, respectively.

Figure 5. Lighting Sales Distribution, by Lamp Style (2019 Sales)



Source: CREED 2019

1.3.1.2 LED Market Share by Lumen Bin

The CREED data also offers a breakdown of market share for standard a-lamps by lumen bin in Oregon. This breakout shows that the vast majority (nearly 100%) of the highest and lowest lumen a-lamps are incandescent technologies. Not surprisingly, these lumen bins were exempt from EISA legislation dictating the other lumen bin categories. However, those lamps only represent 4% of all a-lamps sold in Oregon (Table 4).

Potential Opportunity

Target converting incandescent lamp sales in the highest and lowest lumen bins to LED alternatives.

Table 4. A-Lamp Market Share Estimates, by Lumen Bin and Technology (2019 Sales)

Lumen Bin	Equivalent Incandescent Wattage[1]	% of Sales	% of Incandescent	% of LED	% of Halogen
0-309	15w	2%	98%	2%	0%
310-449	25w	7%	13%	4%	83%
450-749	40w	18%	4%	53%	43%
750-1049	60w	46%	3%	61%	36%
1050-1489	75w	14%	10%	39%	51%
1490-2600	100w-150w	12%	24%	43%	33%
2601+	200w+	2%	100%	0%	0%

Source: CREED 2019

[1] Approximate equivalent wattage.

1.3.1.3 LED Market Share by Retail Channel

The team also assessed LED market share by retail channel. The CREED data offers this detail in two channels, those retailers that sell POS data, and those that do not; the LTMT data offers the LED market share broken out in five channels, POS data, membership/club, online, small hardware, and do-it-yourself hardware. Both data sources indicate that the grocery/dollar/mass merchandise channel (referred to as the POS channel by CREED) sells the lowest percent of LEDs. Other channels, such as membership club stores, have moved to selling nearly all LED lamps. Similar to low and high lumen bin LED opportunities, the grocery/dollar/mass merchandise channel

Potential Opportunity

Focus program efforts on grocery, dollar, and mass-merchandise sales channels.

sells significantly fewer lamps than the others; only 30% of lamps sold go through the grocery/dollar/mass merchandise channel (Table 5).[20]

Table 5. LED Market Share Estimates, by Retail Channel and Data Source (2019 Sales)

Retail Channel	Share of Lighting Sales	LED Market Share	
		CREED 2019 (OR)	NEEA LTMT 2019 (NW)
Membership Club	70%[a]	67%	100%
Online Retailers			80%
Small Hardware			71%
Do-it-Yourself Hardware			67%
Grocery/Dollar/Mass Merchandise	30%[b]	45%	46%

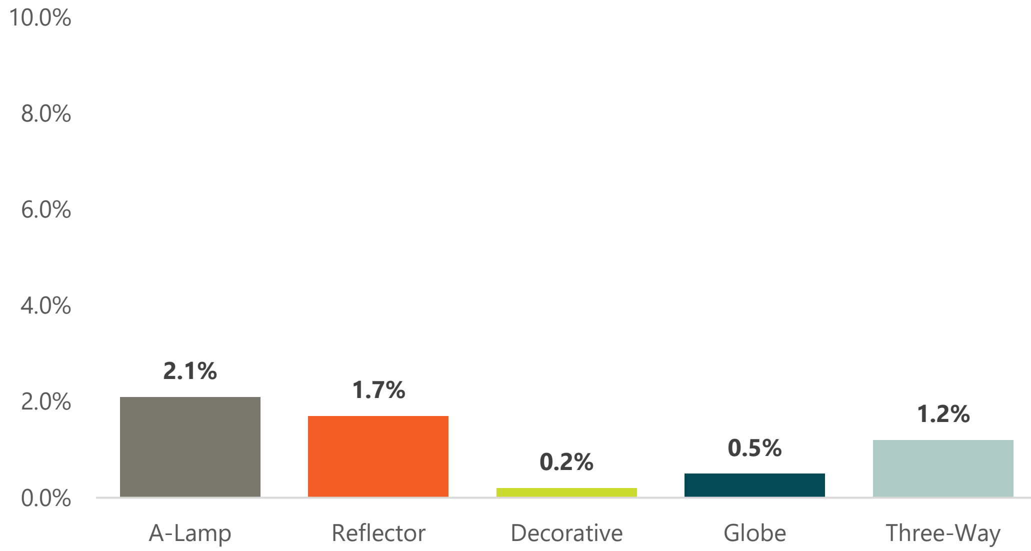
Source: CREED 2019
[a] Non-Point of Sale (POS) channels
[b] POS channels

1.3.1.4 LED Connected Lamps

There is limited information available on connected lamp market share. However, the NEEA LTMT intentionally collected data on this illusive lamp type during the 2019 data collection effort. The market share of connected LEDs remained small in 2019, at approximately 1% of all LED sales. Connected lamps were most often in standard, A-lamp shapes. The figure below shows the connected LED share of LED sales, by shape (Figure 6).

[20] Note that grocery, dollar, and mass-merchandise stores are a combined sales data category. There is evidence that grocery and dollar stores are lagging in efficient lamp sales more than mass-merchandise stores.

Figure 6. Connected Lamp Market Share, by Lamp Style (2019 Sales)



Source: LTMT 2020

1.3.1.5 Lighting Purchases by Customer Demographics

Energy Trust provided us with preliminary findings from its most recent Customer Insights study to inform our assessments of lighting purchases by demographic characteristics. This study offers self-reported purchases of lamps that are then disaggregated by race, ethnicity, income, home ownership, and region.

The study assessed types of purchased lamps by race of respondent. In this detail, a higher percentage of White respondents households purchased screw in LEDs than other groups, with Black respondents reporting lower purchase rates (Table 6). Black households also were the most likely to have purchased incandescent/halogen and CFL lamps.

Table 6. Percent of Households Purchasing, by Race

Type of Lighting	White (n=440)	Black (n=118)	Native American (n=138)	Asian American (n=348)	Other (n=53)
Screw-in LED	84%	59%	81%	82%	78%
Linear LED	13%	4%	15%	11%	2%
Incandescent/Halogen	16%	28%	18%	10%	27%
Linear Fluorescent	9%	5%	6%	12%	13%
CFL[1]	31%	44%	41%	35%	37%
Other[2]	2%	3%	3%	1%	0%

[1] CFLs reported through the Customer Insights study are reported at a significantly higher volume than through the CREED data, which reflects point of sale data and the team believes is accurate. This study is self-report, which could partially drive larger estimates. The team will investigate this discrepancy upon publication of the Customer Insights study.
[2] Typically, other LED types.

The numbers above represent the percent of households purchasing. Households often purchase >1 type of lamp, resulting in the percentages adding to >100%.

Source: ETO Market Insights Study, 2020

Similarly, the Customer Insights study assessed types of purchased lamps by ethnicity of respondent. In this detail, non-Hispanic respondents were more likely to purchase screw-in and linear LEDs than Hispanic counterparts (Table 7). However, non-Hispanic respondents were also slightly more likely to purchase incandescent/halogen lamps. Additionally, low income respondent households were less likely to purchase screw in and linear LEDs than their higher income counterparts (Table 8).

Table 7. Percent of Households Purchasing, by Ethnicity

Type of Lighting	Non-Hispanic White (n=4,296)	Hispanic/Latino (n=433)
Screw-in LED	84%	78%
Linear LED	13%	3%
Incandescent/Halogen	16%	13%
Linear Fluorescent	9%	5%
CFL	32%	37%
Other[1]	2%	3%

[1] Typically, other LED types.

The numbers above represent the percent of households purchasing. Households often purchase >1 type of lamp, resulting in the percentages adding to >100%

Source: ETO Market Insights Study, 2020

Table 8. Percent of Households Purchasing, by Income

Type of Lighting	High Income (n=2,522)	Moderate Income (n=1,705)	Low Income (n=962)
Screw-in LED	87%	79%	76%
Linear LED	14%	9%	8%
Incandescent/Halogen	14%	19%	17%
Linear Fluorescent	9%	9%	7%
CFL	31%	35%	35%
Other[1]	2%	2%	4%

[1] Typically, other LED types.

Source: ETO Market Insights Study, 2020

Homeowners were also more likely to purchase screw-in LEDs than renters or landlords (Table 9). Landlords purchased linear LEDs at a much higher rate than the other groups, which makes sense given their need to light hallways, lobbies, garages, and other shared spaces. Landlords purchased LED linear lamps at a higher rate than fluorescent linear lamps. Renters were the most likely to purchase incandescent/halogen lamps.

Table 9. Percent of Households Purchasing, by Tenure

Type of Lighting	Owner-Occupant (n=4,302)	Renter (n=1,438)	Landlord (n=37)
Screw-in LED	86%	74%	74%
Linear LED	14%	4%	26%
Incandescent/Halogen	14%	20%	5%
Linear Fluorescent	10%	6%	16%
CFL	32%	34%	19%
Other[1]	2%	2%	7%

[1] Typically, other LED types.

The numbers above represent the percent of households purchasing. Households often purchase >1 type of lamp, resulting in the percentages adding to >100%

Source: ETO Market Insights Study, 2020

Finally, the Customer Insights Study assessed lighting purchase by geographic location. This breakout showed very little difference in respondents' propensity to purchase different lamp types between geographic areas. For example, the Portland metro and Hood River area had a slightly higher percentage of respondents purchasing screw-in LEDs than Southern Oregon; however, Southern Oregon respondents were slightly less likely to purchase incandescent/halogen and more likely to purchase linear LED lamps (Table 10). Differences in lamp purchase decisions did not seem related to the geographic areas offered in this study.

Table 10. Percent of Households Purchasing, by Geographic Location

Type of Lighting	Portland Metro & Hood River (n=3,229)	Willamette Valley / North Coast (n=1,393)	Southern Oregon (n=915)	East of the Cascades (n=250)
Screw-in LED	84%	82%	80%	83%
Linear LED	12%	12%	15%	12%
Incandescent/Halogen	17%	14%	16%	16%
Linear Fluorescent	8%	10%	11%	11%
CFL	31%	35%	33%	30%
Other[1]	3%	2%	1%	1%

[1] Typically, other LED types.

The numbers above represent the percent of households purchasing. Households often purchase >1 type of lamp, resulting in the percentages adding to >100%.

Source: ETO Market Insights Study, 2020

1.3.2 Forecasted Market Share Estimates

The Residential Lighting Market Model estimates market share of lamps sold through 2025. This model expects LED market share of all lamp types to continue to increase sharply through 2025 (Table 11). Note that the current (2020) Residential Lighting Market Model over-estimated LED market share of globes, and underestimated LED market share of decorative lamps compared to both the CREED and LTMT primary data collection efforts. Therefore, the 2025 forecast of globes is likely to be ambitious at 91%, while the forecast of decorative lamps (53%) is likely to be conservative.

Table 11. LED Market Share Forecasts, by Lamp Style and Year

Bulb Style	Stock Turnover Model (forecast)	
	2020 (NW)	2025 (NW)
Standard (A Lamp)	61%	77%
Reflector	73%	91%
Decorative	38%	53%
Globe	63%	91%
Linear	54%	89%

During interviews, four key market informants weighed in on their expectations for the LED lighting market. One asserted that connected lighting market share will continue to increase, and that LEDs will eventually dominate in all shape categories. Additionally, that industry professional expects CFLs and incandescent lamps to basically go away, with only halogens and LEDs remaining in the market. In contrast, the other two industry professionals believe the overall market share for LEDs is leveling off and do not expect drastic increases in the coming years. However, they acknowledged that there are still small laggard segments of the market that will still see increases in LED saturation over the next few years.

1.4 Residential Codes and Standards

1.4.1 Codes

The State of Oregon is planning to adopt a new residential building code based on the 2018 International Residential Code (IRC). The new code is expected to take effect April 1, 2021. Both the existing code and the 2018 IRC require that most permanently installed fixtures in new homes contain high efficacy lamps, with allowances for a limited number of fixtures that do not need to meet this requirement. As Table 12 shows, the 2018 IRC expresses these requirements differently from the current residential building code.

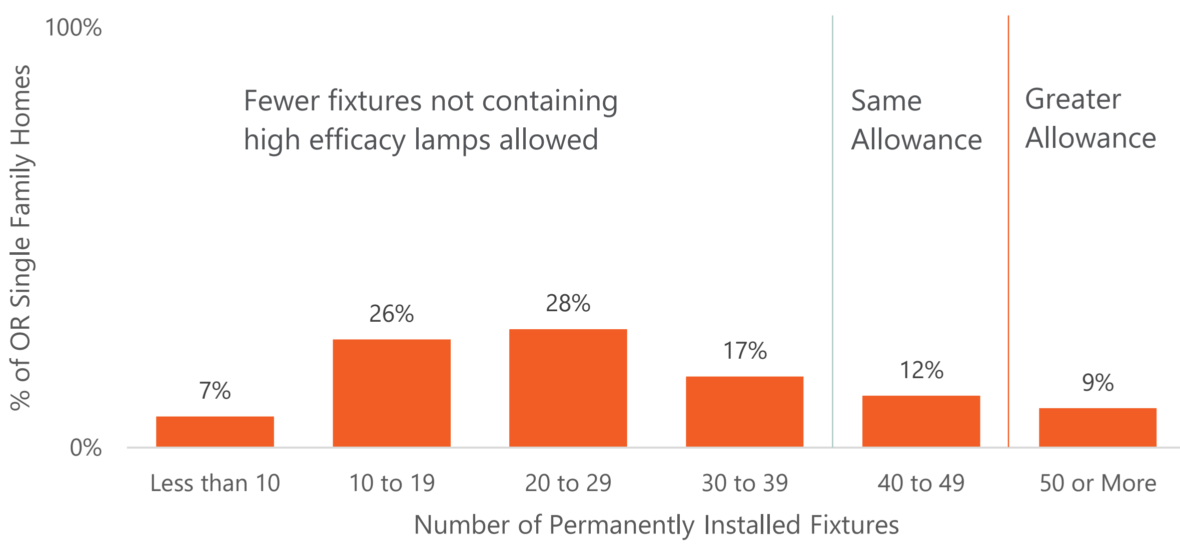
Table 12. Allowances for Fixtures Not Containing High Efficacy Lamps in Current and Planned Residential Building Code

Code	Allowance for Fixtures Not Containing High Efficacy Lamps
Current Oregon Code	2 interior fixtures + 2 exterior fixtures
2018 IRC	10% of all permanently installed fixtures

Source: Current Oregon code is the 2017 Oregon Residential Specialty Code, available at: https://codes.iccsafe.org/public/document/details/toc/1018; 2018 IRC available at: https://codes.iccsafe.org/content/IRC2018

RBSA suggests that, for approximately 80% of Oregon homes, the new code represents a shift from the patterns in existing stock. The new code changes the fixed allowance of four fixtures (two indoor and two outdoor) to a proportional allowance of 10% will reduce the number of permanently installed fixtures allowed to contain non-high efficacy lamps (Figure 7). For the 9% of homes with 50 or more permanently installed fixtures, the new code will result in a greater allowance for fixtures not containing high efficacy lamps, although new homes represent a very small share of overall lighting sales.

Figure 7. Comparison of Allowances for Fixtures Not Containing High Efficacy Lamps Between Current and New Residential Building Codes by Share of Housing Stock



Source: Cadeo team analysis of RBSA data

While the 2018 IRC would require more fixtures to contain high efficacy lamps in most new homes, the overall impact of the adoption of the new code on the lighting market is likely to be small. Based on the number of new home permits issued in Oregon and the average numbers of permanently installed fixtures and lamps within Oregon homes from the RBSA, the team estimates that 1.9% of Oregon lamp sales in 2019 were subject to code, meaning they went to permanently installed fixtures in new homes. Given that the current code already requires most lamps to be high efficacy, the share of lamps impacted by the code change is lower still, at 0.1% of 2019 lamp sales.[21] Even this may be an over-estimation since it assumes builders take advantage of every allowance to install non-high efficacy lamps.

1.4.2 Standards (EISA)

EISA, which passed in 2007, implemented minimum efficiency standards for general service lamps (GSLs) in two phases. The first phase of standards came into effect between 2012 and 2014 and required a reduction in the energy consumption of A-lamp bulbs of approximately 28% below common incandescent wattages. Lighting manufacturers met these requirements with halogen bulbs. EISA required DOE to conduct a rulemaking to consider energy conservation standards and exemptions for certain bulb types in the legislation's GSL definition leading up to a second, more stringent phase of regulations to take effect in 2020. EISA included a "backstop" provision, that an efficacy standard of 45 lumens/Watt would apply beginning January 1, 2020, if DOE failed to complete a rulemaking before January 1, 2017.

A congressional appropriations rider prevented DOE from completing the rulemaking process prior to 2017.[22] Nonetheless, DOE issued a ruling in January of 2017 that expanded the definition of GSLs to include several types of decorative and specialty lamps that had been exempt from the original definition.

In September of 2019, DOE published a final rule rescinding the expanded GSL definition from 2017. This rule greatly reduced the number of bulb types subject to EISA requirements. In December 2019 DOE published another final rule that effectively rescinded the backstop provision, arguing that energy conservation standards for GSLs do not need to be amended from the EISA phase one requirements. Two groups have filed lawsuits challenging DOE's recent rulings related to EISA.[23] Both groups and DOE filed briefs related to the lawsuits in June and July 2020, and the lawsuits are ongoing.

Lighting manufacturers and retailers generally supported DOE's actions, arguing that they would help to avoid a rapid increase in LED prices as program support was removed and a race to the bottom in terms of lamp quality as manufacturers seek to produce lower cost products. Manufacturers also argued that the market is transforming without regulation.

[21] Appendix I: Residential Market Research describes the methodology underlying these estimates.
[22] The rider, which passed in 2016, prohibited DOE from using funds to enforce standards, including maximum wattage and minimum rated life requirements, for general service incandescent lamps and minimum efficiency ratings for incandescent reflector lamps. The rider expired in May of 2017.
[23] The first group is led by the Natural Resources Defense Council (NRDC) and is made up of environmental organizations. The second group includes the attorneys general of 15 states, the District of Columbia, and the City of New York.

DOE's changing rulings on GSL standards, the subsequent legal challenges, and potential implications of a change in administration following the 2020 Presidential election have created uncertainty in the lighting market. If lawsuits or a political transition lead to the reinstatement of phase two EISA standards, it would likely be several years before those standards take effect.[24] As manufacturers point out, the lighting market will likely continue its transition toward LEDs in that time. Until the issue of national standards for lighting products is resolved, there will continue to be uncertainty in the lighting market, and true baseline lighting efficiency will be difficult to determine as they will depend on state regulations and customer preferences rather than federal standards.

1.5 Summary of Data Gaps

The team found gaps) in available residential lighting data in a few areas (Table 13). Most importantly, the RBSA last collected Oregon lighting saturation data in 2017. Because of the rapid transformation of the lighting market in the last three years (including significant increases in LED sales), these data are clearly outdated. The NEEA stock turnover model is regularly calibrated to LTMT data to create estimates of current saturation, however, these estimates become less and less precise until the model is updated with new RBSA primary research. This means that the granularity on urban/rural, demographics, and housing type lighting saturation is also antiquated.

In sales data category, there are no data available for integrated fixtures, nor the granularity to look at lighting trends in urban compared to rural retail locations.

[24] The EISA legislation included a three-year transition period between when phase two standards were to be established (2017) and when they would take effect (2020), which is typical of federal efficiency standards.

Table 13. Summary of Residential Lighting Data Gaps

Category	Gap	Addressability
Stock	There has not been primary data collected on Oregon residential lighting installed stock since the 2016-2017 RBSA; the installed lighting stock has likely changed since these data were collected.	The next RBSA results are expected to be released in 2022 or 2023. To the extent results need to be more current, the NEEA stock turnover model makes reasonable (although currently aggressive) estimates on stock changes and can be used as a proxy. Another opportunity to address this gap would be to conduct limited interim lighting stock assessments between RBSA studies.
Sales	There is no source of comprehensive full category sales data (point of sale) from large home improvement stores. Extensive efforts have been made, by NEEA and others, however, those data have not been released at the time of this report.	This is likely a persistent gap. However, both the LTMT and CREED have successful workarounds to address it. LTMT conducts shelf survey data from these channels and adjusts shelf findings to sales; CREED collects data on lighting purchases through a nationwide consumer panel that include purchases made through these retailers.
Sales	There are no specific sources of stock or sales data for integrated fixtures.	To date, there has not been widespread interest in this market. However, CREED and LTMT would be the best options for addressing these gaps if significant interest arises.
Sales	There is not sufficient granularity of sales data to assess differences in sales between rural and urban retailers.	The best opportunity for addressing this gap would be a large-scale shelf stocking effort. The current LTMT effort does not collect shelf data from all retail types and does not have the sample sizes required to make justifiable inferences about urban and rural retailers.

1.6 Summary of Potential Remaining Opportunities

As expected, there are a few niche markets with low saturation or market share of LEDs in Oregon that may offer opportunities for increased program interventions (Table 14). In retail markets, LED market share is lowest in grocery, dollar, and mass merchandise retail stores (2019

LED market share of 45% vs 67% in other channels); these retailers, however, only comprise about 1/3 of lighting sales in Oregon. Decorative and globe shaped lamps have a lower LED market share than standard (a-lamp) and reflector shapes, although these lamps comprise only 15% of lighting sales. Finally, standard (A-lamp) bulbs with very low lumens (<300) and very high lumens (>2600) are almost completely incandescent. Again, these lamps represent <4% of the standard a-lamp market sales. These lamps and retailers may offer the greatest opportunities to increase LED market share but are limited in terms of overall savings potential.

There is evidence that different groups are adopting LEDs at different rates.[25] Energy Trust is in the process of integrating findings from the Customer Insights study with its other efforts on diversity, equity, and inclusion, which could result in additional programmatic interventions designed to reach specific sub-markets.

Table 14. Summary of Potential Remaining Residential Lighting Opportunities

Category	Opportunity	Notes
Retail Channels	Grocery, dollar, and mass merchandise retail channels sell less LEDs than other channels (45% vs 67%).	These retailers combined only comprise about 1/3 of lighting sales in Oregon.
Lamp Styles	Decorative and globe shaped lamps have a lower LED market share than standard (a-lamp) and reflector shapes.	These lamps comprise only 15% of lighting sales.
Lumen Bins	Standard (A-lamp) bulb sales among lamps with very low lumens (<300) and very high lumens (>2600) are almost completely incandescent (98% and 100%, respectively).	These lamps represent <4% of the standard a-lamp market sales.
Demographic Variables	Use the Customer Insights study to inform program design likely to reach under-served populations.	Energy Trust is already committed to this this effort as it aligns with the organization's larger DEI initiatives.

[25] The Customer Insights study was still in draft form as of publication date. Please look for a final version of the report from Energy Trust in the first half of 2021.

Section 2 Nonresidential Market Research

2.1 Commercial Sector

2.1.1 Key Commercial Market Data Sources

The research team used four primary data sources to evaluate the commercial lighting market:

Commercial Building Stock Assessment (CBSA)[26]			
Data Collection Year:	**Geography:**	**Author:**	**Primary Use:**
2019 (published in 2020)	Regional	Cadmus on behalf of NEEA	Commercial Stock

The Commercial Building Stock Assessment (CBSA), published in 2020 by NEEA, is the most comprehensive and recent source of lighting installed stock data in the region. The CBSA includes findings by technology type as well as by building characteristics such as building type and size.

BPA Nonresidential Lighting Market Model (the BPA Model)[27]			
Data Collection Year:	**Geography:**	**Author:**	**Primary Use:**
2017	Regional	Cadeo on behalf of BPA	Nonresidential Stock, Sales, and Forecasting

For regional sales information as well as supplemental stock data, the team used the BPA Nonresidential Lighting Market Model (the BPA Model). The BPA Model is a comprehensive model of the full nonresidential lighting market in the Pacific Northwest. The BPA Model incorporates stock and sales market intelligence inputs like the CBSA to model current and forecasted stock and sales information. The BPA Model was last updated in 2017, and a model update is expected by late-2021.

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[26] Commercial Building Stock Assessment

[27] Please contact Kate Donaldson (kdonaldson@cadeogroup.com) for further information on the BPA Model.

Annual Distributor Nonresidential Lighting Sales Data Collection			
Data Collection Year:	**Geography:**	**Author:**	**Primary Use:**
2019 (published 2020)	Regional	Cadeo on behalf of NEEA/BPA	Nonresidential Sales

For 2019 sales data, the team used nonresidential lighting sales data collected from Northwest electrical distributors through an annual lighting survey conducted by NEEA and BPA. While this data only represents 23 distributors in the region, the data is estimated to represent about 45% of the Northwest nonresidential lighting market. This data is compared to the known distributor population mix of business model, size, and geographic coverage to assess representativeness.

DOE Lighting Market Model			
Data Collection Year:	**Geography:**	**Author:**	**Primary Use:**
2017 (published in 2019)	National	Navigant, on behalf of the U.S. Department of Energy (DOE)	Nonresidential Stock Forecast

Finally, the team looked at the DOE Lighting Market Model published in 2019 using 2017 stock data. The DOE Lighting Market Model forecasts the national lighting market through 2035 and includes an in-depth analysis of the lighting market by sector.

In addition to these key sources, the research team used several additional sources to fill gaps or gather further information on specific topics. Those sources included:[28]

- Massachusetts C&I Lighting Inventory and Market Model Updates (2020)
- Oregon C&I Lighting Controls Savings and Persistence Study (2015)
- Energy Savings Potential of Design Lights Consortium (DLC) Commercial Lighting and Networked Lighting Controls (2018)
- Interviews with four market informants, including staff from NEEA, Evergreen Consulting, and the Northwest Power & Conservation Council. These interviews focused on lighting trends and expectations for the nonresidential lighting market.

[28] For further bibliographical information about sources listed and a full list of all reviewed sources, consult the 2020 Oregon Lighting Market Research Workbook.

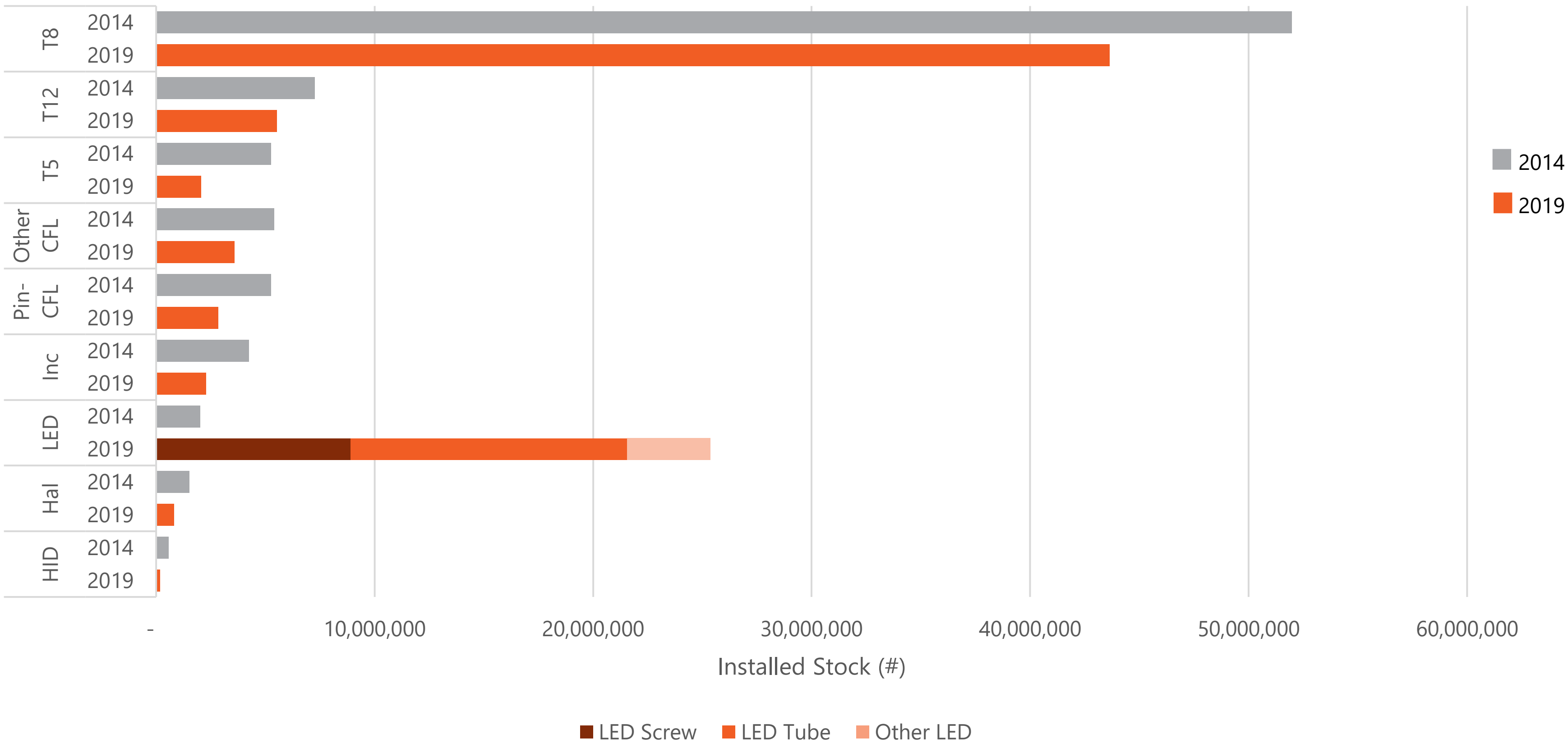
2.1.2 Commercial Lighting Stock

2.1.2.1 Technology Mix in Installed Stock

The CBSA data indicate that linear fluorescent (LFL) technologies still dominate the market at 60% of installed stock. LFL T8s alone comprised 50% of indoor lighting stock in 2019. T12s maintained a small share of the installed stock at 8% in 2019 while T5s saw a decline from 6% of stock in 2018 to 2% in 2019. LEDs saw a large increase in installed stock between the 2014 and 2020 stock assessments, accompanied by a decrease in stock across all other technology types.[29] In 2019, all LED technologies (screw based, tube, and other) comprised about 30% of indoor lighting stock, up from only 3% in 2014. All other technologies (incandescent, halogen, CFL, and HID) made up the other 10% of installed stock after showing decreases in stock between 2018 and 2019. The team expects they will continue to lose market share to LEDs alternatives. Figure 8 displays the distribution of linear T8s relative to other technologies.

[29] The team investigated if this increase in LEDs was driven by new buildings (built between 2014 and 2019) installing higher rates of LEDs. New construction only accounts for about 5% of the increase in LED volume in installed stock, seen in Appendix II: Nonresidential Market Research.

Figure 8. Commercial Indoor Lighting Installed Stock by Technology Type[30]



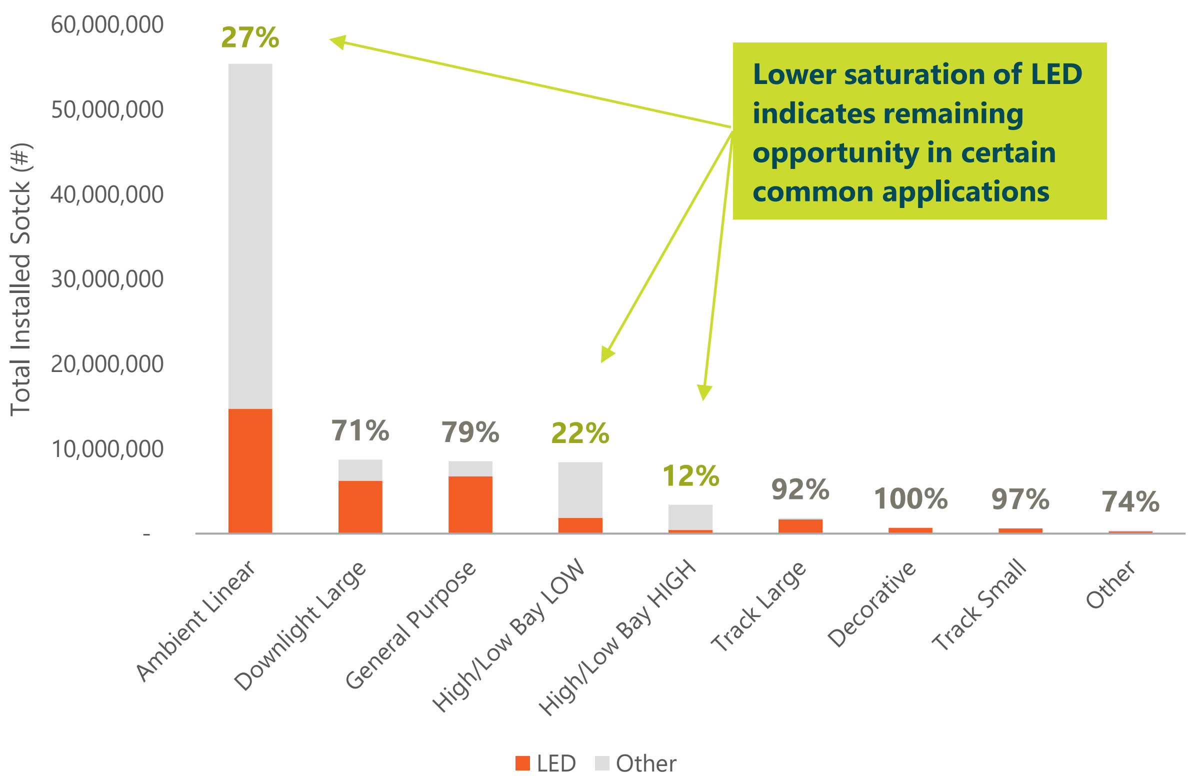
Source: 2020 CBSA and 2014 CBSA

[30] The research team only has LED types (screw-base, tubes, and other) from the 2020 CBSA, not the 2014 CBSA. The three types are aggregated in this graph to show total stock volume change from 2014 to 2019.

2.1.2.2 LED Saturation in Commercial Sector Applications

LED saturation across applications is uneven. As seen in Figure 9, the ambient linear application is by far the largest in the commercial market by volume. In this application, LED saturation is relatively low at only 27%, representing a potential energy savings opportunity in converting non-LEDs (mostly LFL) in installed stock to LEDs. There are also opportunities for energy savings in the high/low bay application at both high and low lumen levels. The high lumen output high/low bay application has the lowest LED saturation in the commercial market at 12% LEDs. High/low bay lighting is found in every major commercial building type represented in the CBSA, but this application is most often associated with warehouses, industrial facilities, and big box stores, which will be covered further in Section 2.2. All other applications have saturations at 70% LED or greater, indicating limited opportunity for substantial energy savings.

Figure 9. Commercial Indoor Lighting LED Stock Saturation by Application[31]



Source: BPA Nonresidential Lighting Market Model

[31] High/low bay high technologies have lumen outputs greater than 15,000, High/low bay low technologies have lumen outputs at or below 15,000.

2.1.2.3 Ambient Linear Application

As shown in Figure 9, the ambient linear application is by far the largest by stock volume in the region. This application is comprised of LFL lamps and LED lamps and luminaires (i.e. integrated LED fixtures), shown in Table 15. The largest energy savings potential in this application comes from the high percentage of T8s in the installed stock. While T8s have lower average wattages than other LFL technologies, like T12s, the large installed volume creates an opportunity for eventual replacement with lower-wattage LED technologies. For example, a 32W T8 is often replaced with an LED tube between 14-18W. However, this opportunity varies by building type and building size.

> ***Potential Opportunity***
>
> *Convert large stock volume of T8s to LEDs in the ambient linear application.*

Table 15. 2019 Commercial Sector Stock in the Ambient Linear Application[32, 33]

Technology	Percent of Installed Stock
T5	2%
25W T8	3%
28W T8	14%
32W T8	50%
T12	5%
LED Tube	20%
LED Luminaire	6%

Source: BPA Nonresidential Lighting Market Model

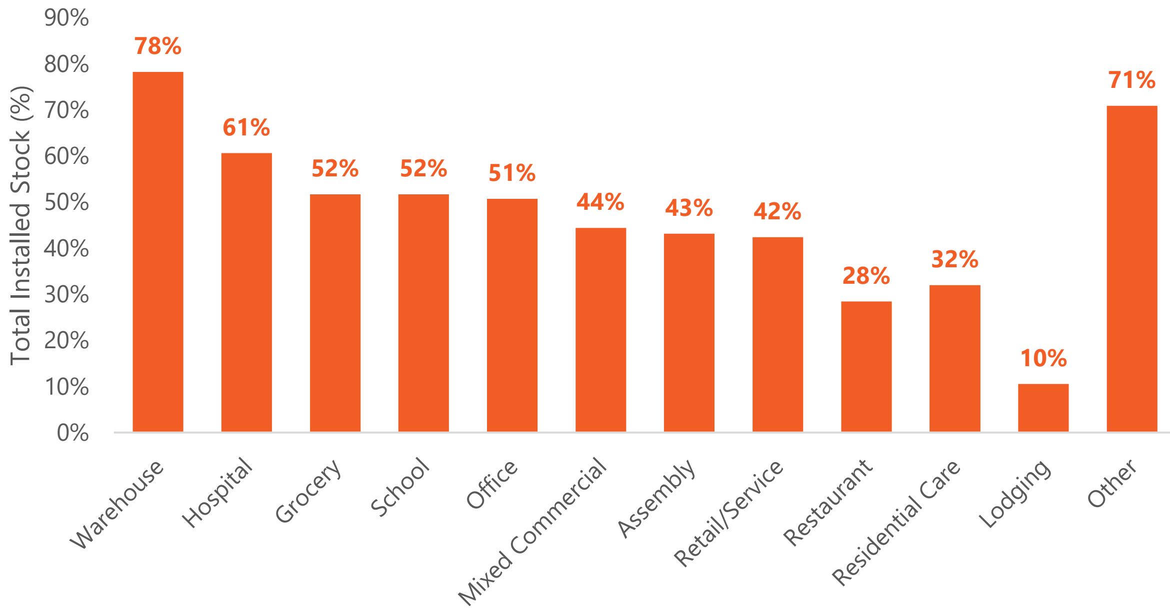
2.1.2.4 Opportunities by Building Type, Building Size, and Urban/Rural

The largest opportunities for energy savings come in building types where T8s have a high installed stock and the building type represents a large portion of commercial floorspace. Looking first at building type, Figure 10 shows that T8s have the largest presence in warehouses, hospitals, grocery stores, schools, and offices.

[32] Stock numbers in this table are from the BPA Model and may be different than what is reported by the CBSA.

[33] LED saturation per Table 15 may not match LED saturation per Figure 9 due to rounding.

Figure 10. Installed Stock of T8s by Commercial Building Type



Source: 2020 CBSA

Overlaying the building type's percent of commercial floor area in the Northwest with the prevalence of T8s in these building types (Table 16), the research team found that warehouses, offices, and schools represent the largest opportunities for converting T8s to LEDs. For specific estimates of commercial stock by technology type by building type and commercial floor area by building type, see Appendix II: Nonresidential Market Research.

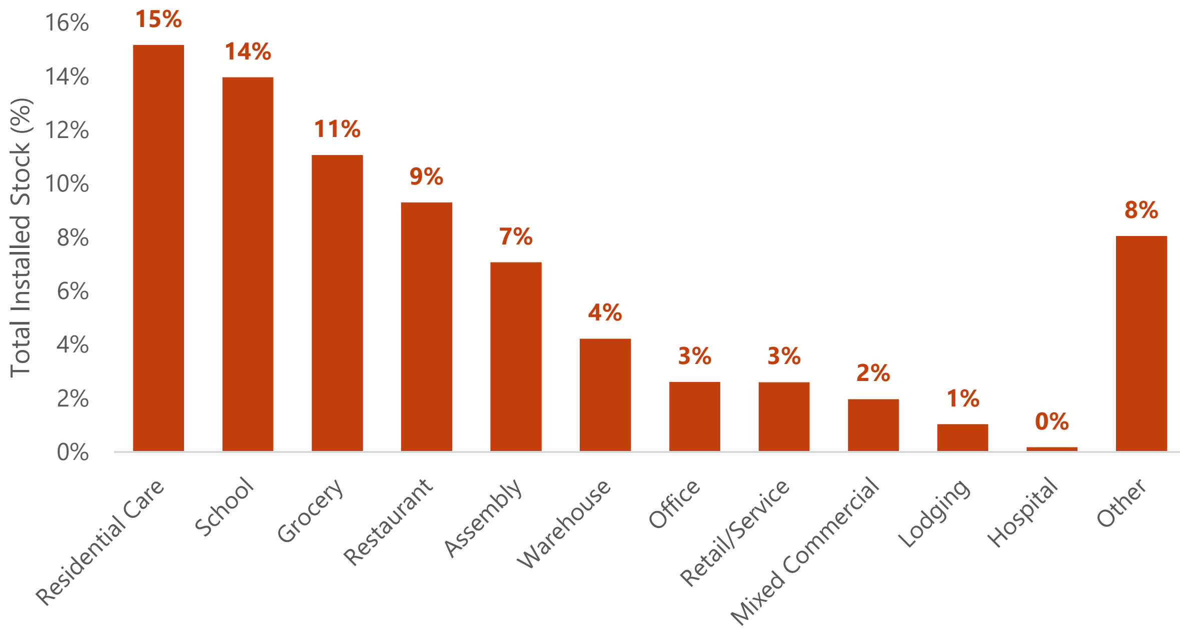
Table 16. Comparison of Prevalence of T8s and Percent of Commercial Floor Area by Building Type

Building Type	Percent of T8s in Building Installed Stock	Percent of Commercial Floor Area
Warehouse	78%	15%
Hospital	61%	1%
Grocery	52%	3%
School	52%	10%
Office	51%	13%

Source: 2020 CBSA

Another remaining opportunity in the commercial lighting stock stems from the small but sustained prevalence of T12s in the installed stock. Figure 11 shows the percentage of T12s in the installed stock is not evenly distributed across building types. T12s are most prevalent in residential care facilities, schools, grocery stores, restaurants, and assembly buildings.

Figure 11. Installed Stock of T12s by Commercial Building Type



Source: 2020 CBSA

Most of these building types, except for schools, make up a very small percentage of commercial floor space, shown in Table 17. However, taken together, the remaining building types make up a total 15% of commercial floor space. So, looking at T12s across building types presents more of an opportunity than one might expect if focused on one building type.

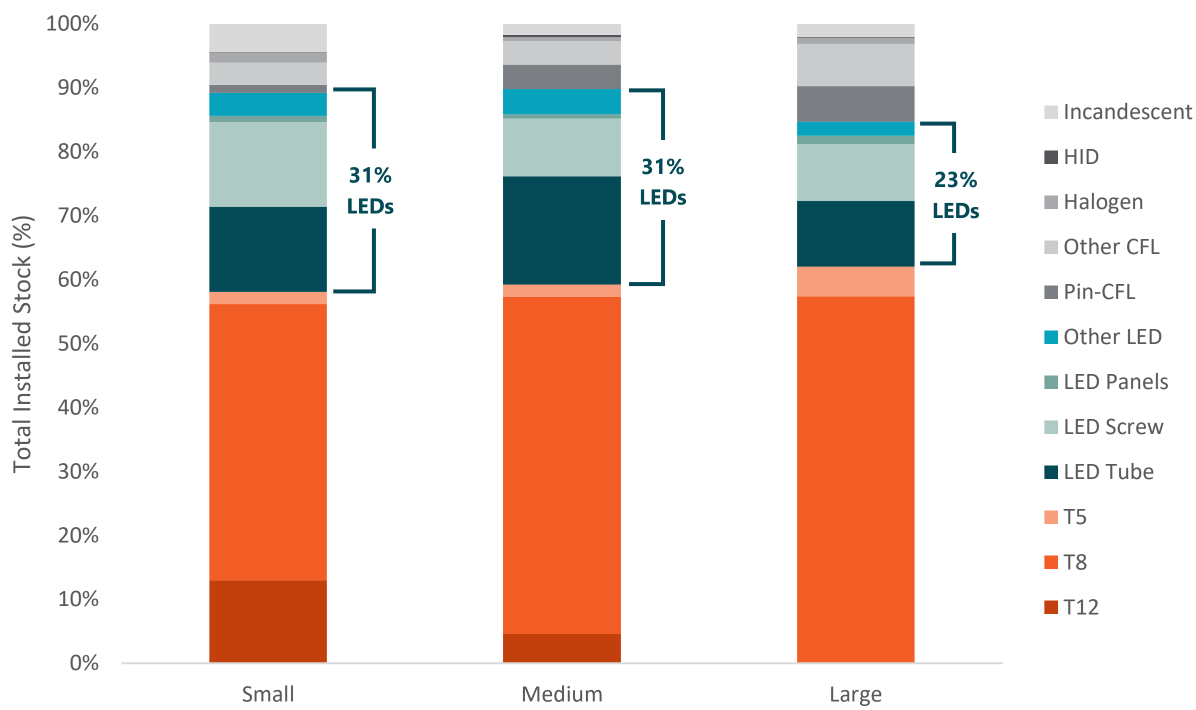
Table 17. Comparison of Prevalence of T12s and Percent of Commercial Floor Area by Building Type

Building Type	Percent of T12s in Building Installed Stock	Percent of Commercial Floor Area
Residential Care	15%	1%
School	14%	10%
Grocery	11%	3%
Restaurant	9%	4%
Assembly	7%	7%

Source: 2020 CBSA

Looking at technology mix by building size[34] in Figure 12, T8s installed stock is relatively evenly distributed across building sizes. The main difference in the technology mix by building type is in T12s. T12s see the largest share of installed stock in small buildings at 12%. Market share of T12s drops to 5% in medium sized buildings. Most commercial buildings (about 60%) fall into the medium building size with about 20% each falling into the small and large categories.

Figure 12. Commercial Stock Technology Mix by Building Size



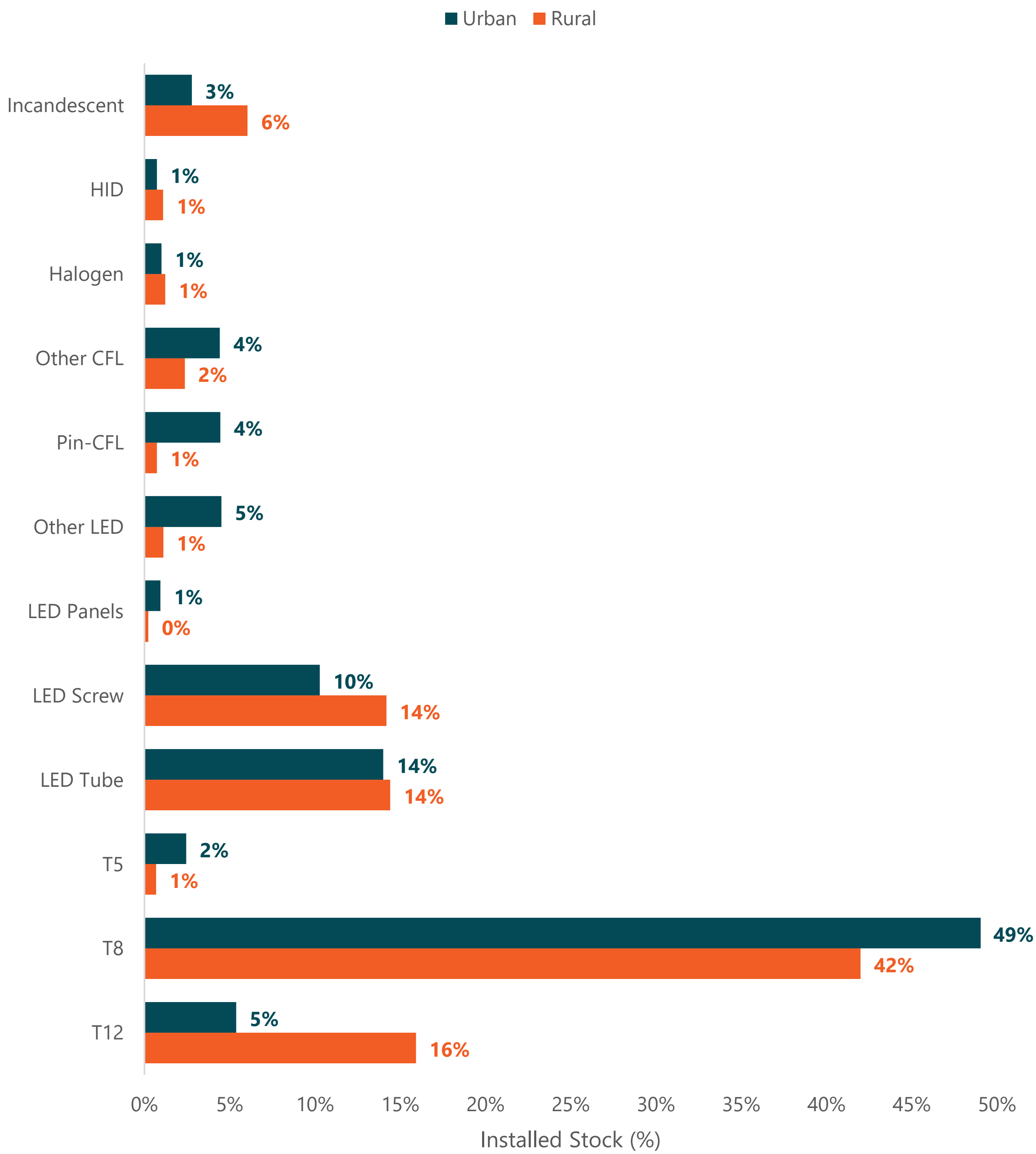
Source: 2020 CBSA

In addition to building type and size, the research team looked at technology mix across urban and rural settings[35] to assess potential opportunities for energy savings in each. Buildings in urban settings make up 89% of both commercial floor area and the number of buildings sampled in the CBSA. Based on volume, urban buildings comprise a larger portion of the installed stock and, therefore, a larger opportunity. Despite the substantial concentration in urban areas, the technology mix in these two settings appears relatively similar, seen in Figure 13. One of the largest differences between the two is that T12s are more prevalent in rural buildings (at 16% of installed stock) than in urban, where they are only 5% of stock. This is likely driven by the specific mix of buildings found in rural communities relative to urban

[34] The CBSA defines small buildings as buildings up to 10,000 square feet, medium buildings up to 100,000 square feet, and large buildings above 100,000 square feet.
[35] The CBSA defines urban and rural spaces by the census block the building site is in and applies a binary (1 or 0) for the urban and rural designation. For more information on the Oregon census blocks for urban and rural designations, visit the USDA Rural-Urban Commuting Area Codes website.

communities. For example, there are fewer office buildings and more grocery stores in rural communities. For further information on technology mix by building size and urban versus rural, see Appendix II: Nonresidential Market Research.

Figure 13. Commercial Indoor Lighting Stock Technology Mix in Urban vs. Rural

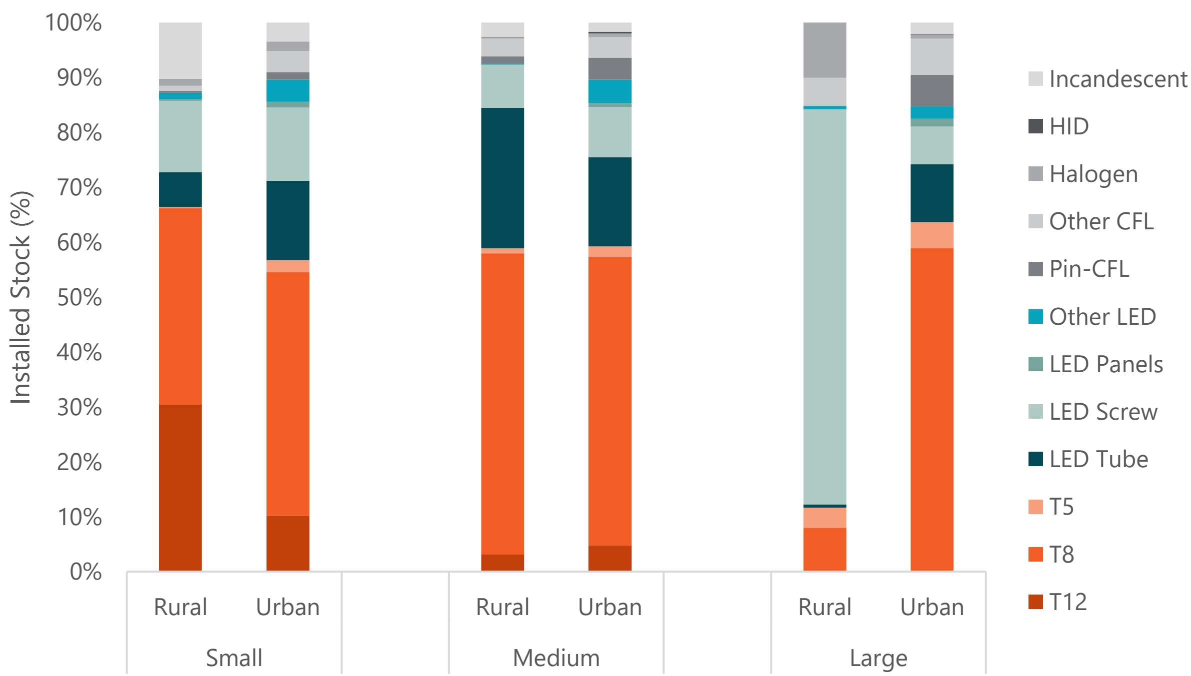


Source: 2020 CBSA

Overlaying building size with the technology mixes in urban and rural settings provides another view into the data, as shown in Figure 14. T8s hold a similar share of stock in small and medium buildings in urban and rural settings. The largest difference in T8 stock is between urban and rural large buildings where screw-based LEDs are the dominant technology. While T12s make up a significant percentage of large rural buildings, this specific building type is not a significant portion of commercial buildings in the Northwest. Small buildings have the highest remaining installed stock of T12s, particularly in rural areas where they are installed in approximately 30% of fixtures.

> ***Potential Opportunity***
>
> *Consider a direct install lighting program for T12s in small and medium sized commercial buildings, particularly in rural areas.*

Figure 14. Comparison of Urban and Rural Technology Mix by Building Size



Source: 2020 CBSA

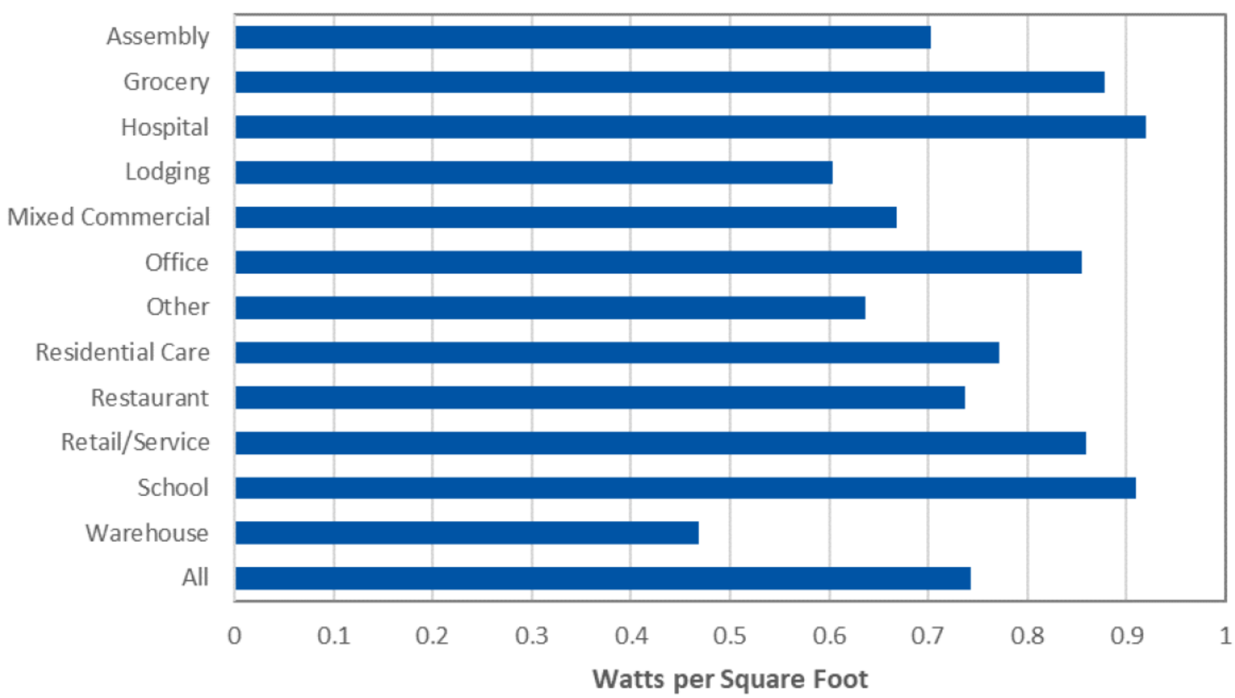
The technology mix is quite different for rural and urban buildings in the large category, athough this may be due to a small sample of rural, large buildings. Only 18% of buildings sampled in the CBSA were large buildings, and most of these buidlings were likely in urban communities given the distribution of urban and rural buidlings in the sample.

2.1.2.5 Commercial Indoor Lighting Power Density (LPD)

The CBSA reported the average commercial building indoor lighting power density (LPD)[36] was 0.74 watts per square foot (W/ft^2) in 2019. The average regional LPD decreased 0.25 W/ft^2 since the 2014 CBSA reflecting the transition in the stock to LEDs from less efficient non-LED technologies. Oregon and Washington also have stringent lighting power allowances required by code as of October 2020, which drive lower LPDs in new buildings and likely factoring into a regional reduction in LPD.

LPD varies by building type, with Figure 15 showing the highest average LPD in hospitals, schools, grocery stores, retail and service, and offices. This finding is consistent with the team's identification of hospitals, schools, and grocery stores as opportunities to convert high stock of T8s and T12s to low wattage LED-alternatives.

Figure 15. Commercial Building Indoor LPD by Building Type

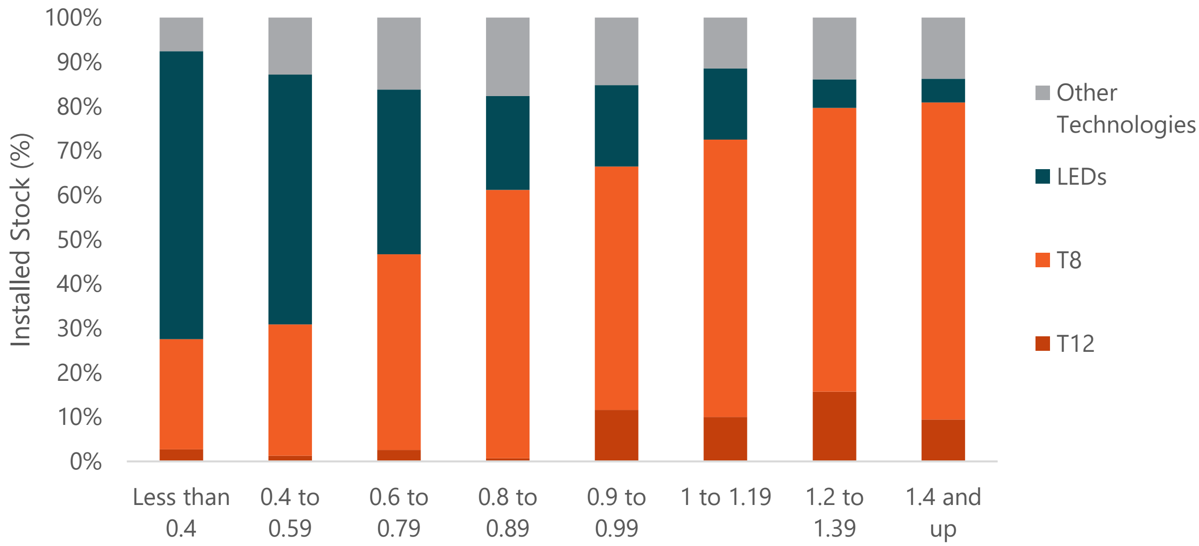


Source: 2020 CBSA

Figure 16 shows that average LPD decreases as the prevalence of LEDs in installed stock increases. This supports the CBSA's finding that the decrease in LPD in the last five years is directly related to the prevalence of LEDs increasing in installed stock from 2014 to 2019. If saturation of LEDs grow, average LPD will continue to decline.

[36] LPD is calculated as the ratio of total wattage to total floor space.

Figure 16. Technology Mix by LPD



Source: 2020 CBSA

2.1.3 Commercial Lighting Sales

2.1.3.1 Technology Mix in Sales

LEDs for the first time made up over half of all reported nonresidential[37] lighting sales (Table 18). LEDs passed LFLs to become the dominant technology in the sales mix in 2017. LFLs have seen a steady decline in sales share, and that decline continued between 2018 and 2019 dropping from 35% to 33%. CFL and incandescent technologies also saw declining sales share over the last four years while HIDs and halogens maintain small but steady sales shares.

[37] Collected distributor sales data represents the full nonresidential lighting market, not just the commercial sector. Because most of the sales represented end up in the commercial sector, the team used the nonresidential lighting sales data as a proxy for commercial lighting sales.

Table 18. Percent of Unit Sales by Technology Type, 2016-2019[38]

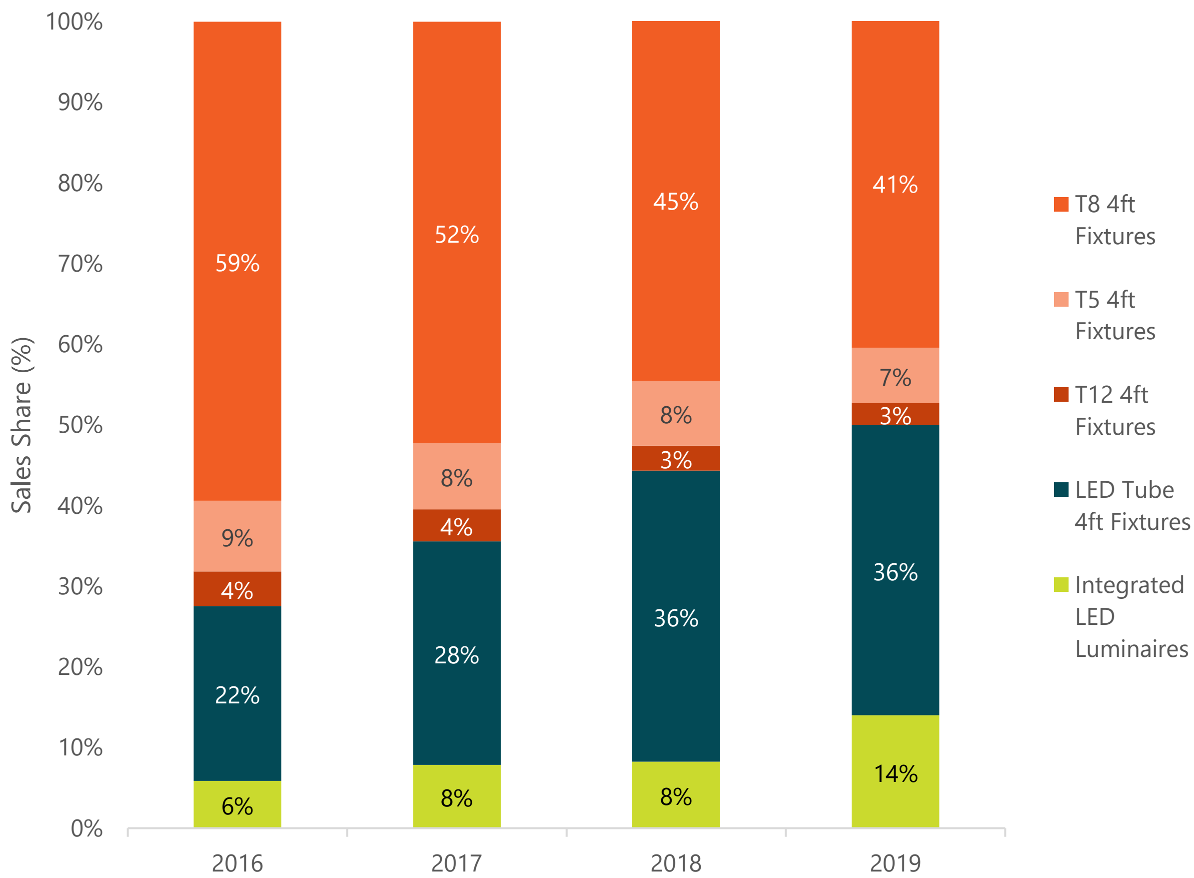
Technology	2016	2017	2018	2019
LED	**28%**	**38%**	**49%**	**53%**
Screw LED	7%	12%	16%	17%
Tube LED	14%	17%	22%	22%
Other LED	7%	10%	10%	14%
Linear Fluorescent	**48%**	**41%**	**35%**	**33%**
T5	6%	5%	5%	4%
T8	38%	32%	28%	26%
T12	4%	4%	3%	3%
CFL	**12%**	**9%**	**8%**	**8%**
Pin CFL	7%	7%	6%	6%
Other CFL	4%	2%	2%	1%
Incandescent	**6%**	**6%**	**4%**	**3%**
HID	**3%**	**3%**	**2%**	**2%**
Halogen	**3%**	**3%**	**2%**	**2%**

Source: 2019 Distributor Sales Data

In the ambient linear application, Figure 17 shows a steady replacement of LFL products with both LED tubes and integrated LED luminaires.[39] The sales mix shows LEDs at about 50% of sales in the ambient linear application, so the team expects the stock saturation to continue to increase in coming years. While T8s maintained about 40% of sales in ambient linear applications in 2019, this is down substantially from about 60% in 2016. The sales data also shows small but sustained sales of T12s at 3% of sales in 2019. An increase in LED tubes in the ambient application is the primary driver of the decrease in LFL technologies, but the growth of LED tubes in the sales mix slowed in the last year as growth in integrated LED luminaires began to increase.

[38] Sub-totals may not sum to totals due to rounding.
[39] An integrated LED luminaire is lighting fixture with an LED light source built into the fixture.

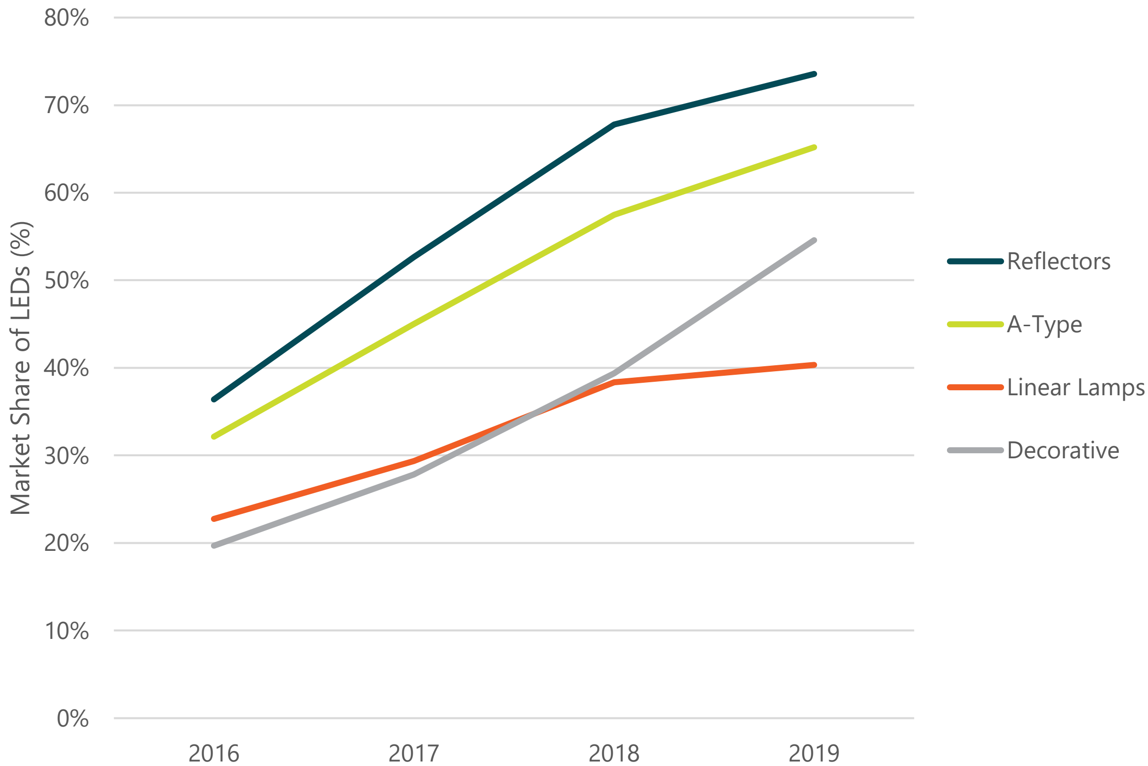
Figure 17. Technology Sales Mix in the Ambient Linear Application, 2016-2019



Source: 2019 Distributor Sales Data

This slowdown of LED tube sales is reflected in Figure 18, which shows the market share of LED sales in four key applications. LED saturation in linear lamps leveled off between 2018 and 2019. The research team is not confident of the cause of this leveling off, or if this represents a permanent or a one-year trend. Some possible causes for this leveling off could be an increase in integrated LED luminaires as an alternative to LED tubes linear fluorescent fixtures, shown in Figure 17, or the effect of declining availability of LED tube incentives across the region.

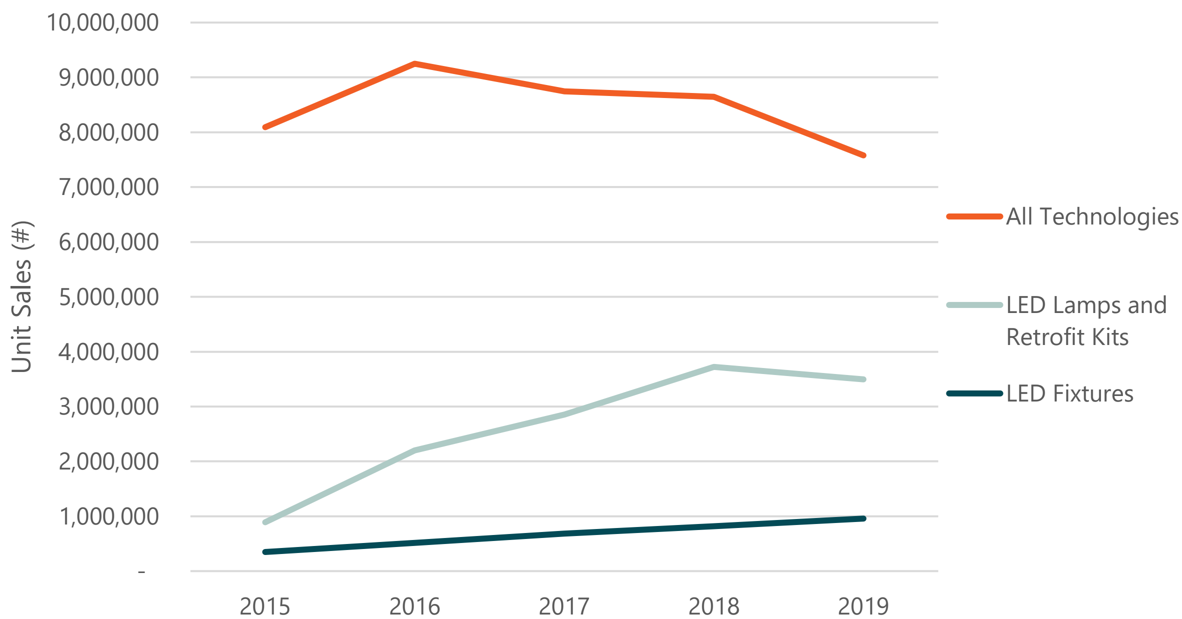
Figure 18. LED Market Share by Application, 2016-2019



Source: 2019 Distributor Sales Data

Examining the trend in LED lamps and fixtures more closely in Figure 19, a decline in LED tubes and retrofit kits mirrored the total unit sales decline between 2018 and 2019. LED tubes are competing for a smaller and smaller portion of the replacement market as LEDs gain stock saturation. Meanwhile, integrated LED luminaires saw slow but steady growth in the last five years of sales and are not experiencing the same downturn. Integrated LED luminaires, on the other hand, are being installed more consistently in new construction and retrofit markets. Market intelligence and sales data gathered by the research team indicates this growth in integrated LED luminaires will likely continue or even increase in the coming years.

Figure 19. Trends in Collected Sales Volume, 2015-2019



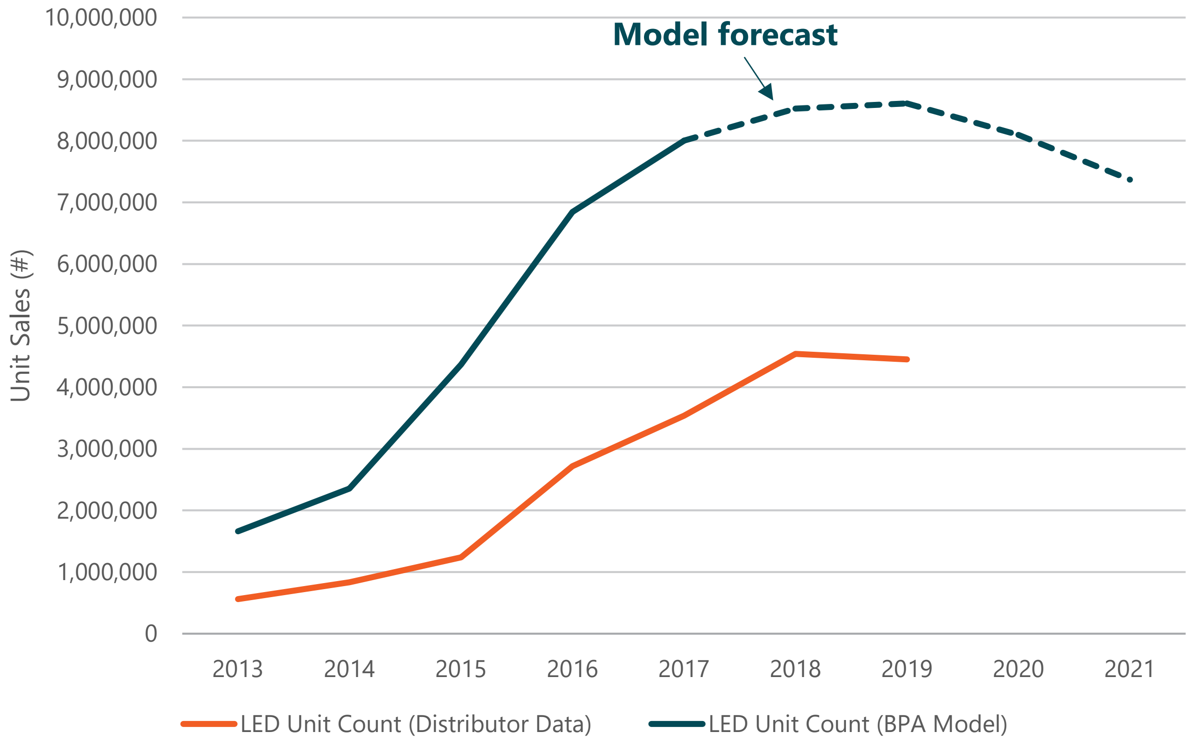
Source: 2019 Distributor Sales Data

2.1.4 Commercial Lighting Market Forecast

2.1.4.1 Short-Term Forecast of Nonresidential Lighting Sales in the Northwest

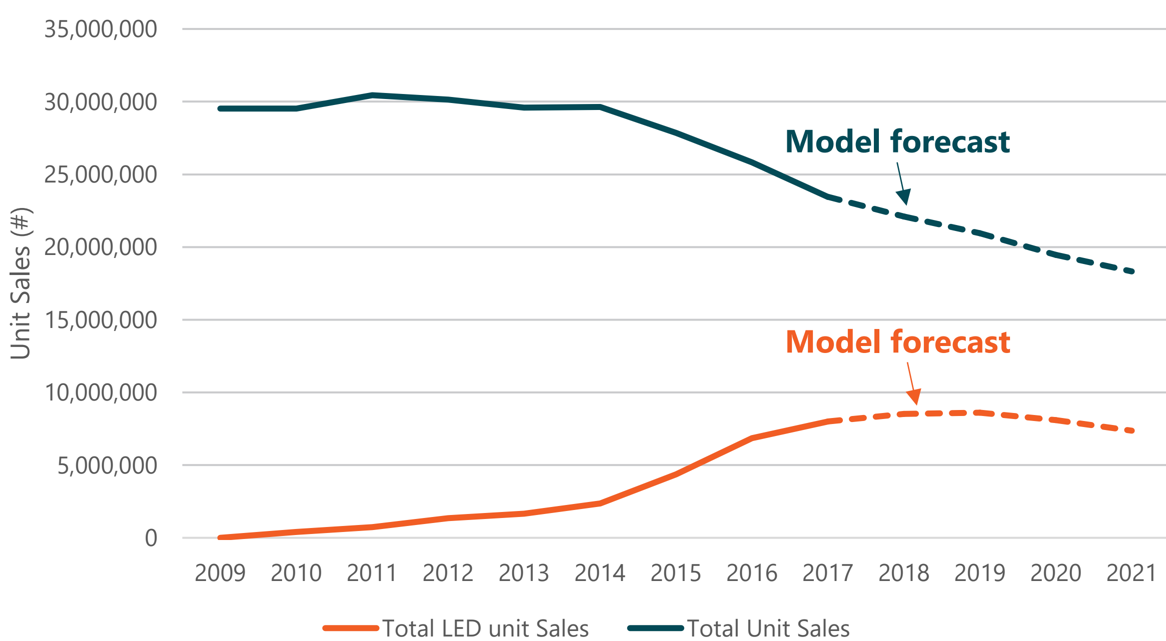
In the nonresidential market in the Northwest, unit sales of LEDs have been rapidly increasing since 2013. However, the BPA Model predicted a plateau and eventual decline in overall LED unit sales as the market becomes more saturated with long lasting LED products. This is particularly true for screw-in and reflector lamps, which were previously dominated by short-lived incandescent and halogen technologies with high turnover cycles. The BPA Model forecasted the plateau in LED unit sales occurring in 2018 before sales begin to decline after 2019, seen in Figure 20. The distributor data collected in 2019 confirmed the expected trend with unit sales declining for the first time between 2018 and 2019. The increase of LED saturation in the region resulted in a steady decrease in total unit sales across technologies over time, seen in Figure 21. The BPA Model anticipated the decline in total lighting unit sales beginning in 2012 with the increase of LED unit sales in the region. In the last few years, total unit sales have declined as growth in LEDs began to slow and plateau. The research team expects unit sales of LEDs and of all technologies to continue to decline in the coming years.

Figure 20. LED Unit Sales in BPA Model and Distributor Data, 2013-2019



Source: BPA Nonresidential Lighting Market Model; 2019 Distributor Sales Data

Figure 21. Total Unit Sales and LED Unit Sales in BPA Model, 2009-2019

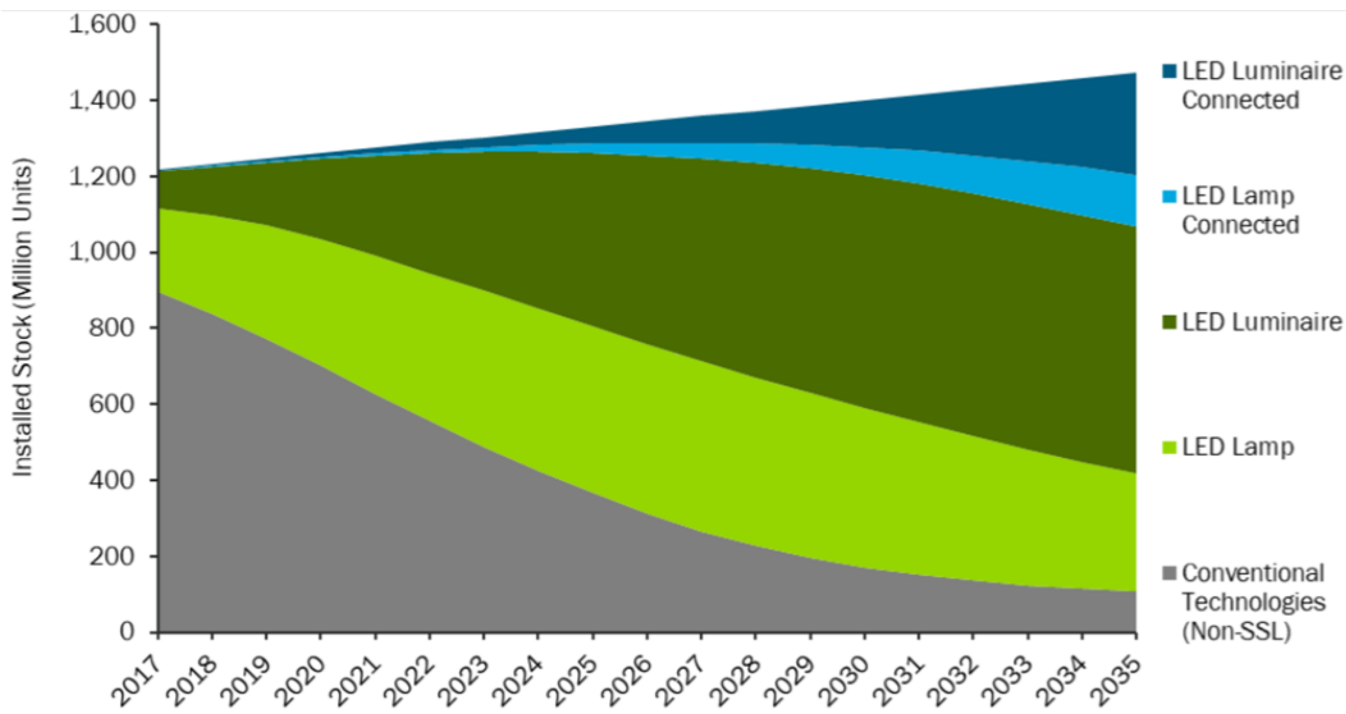


Source: BPA Nonresidential Lighting Market Model

2.1.4.2 National Sales Forecast

Looking at the DOE Lighting Market Model national forecast for the commercial market in Figure 22, LEDs are predicted to see steady growth in the lighting stock through 2025 in both lamps and luminaires. By 2035, this model predicts that 84% of commercial lighting stock will be LEDs with a larger portion of luminaires in the stock than lamps. Based on the current share of integrated LED luminaires in the Northwest-specific sales data, the team suspects that this forecast may overpredict the rapidity of the increase in LED luminaires in the region. Connected lighting currently comprises a small portion of the commercial lighting stock, but the forecast shows steady growth in connected lighting stock resulting in nearly 30% of stock in 2035.

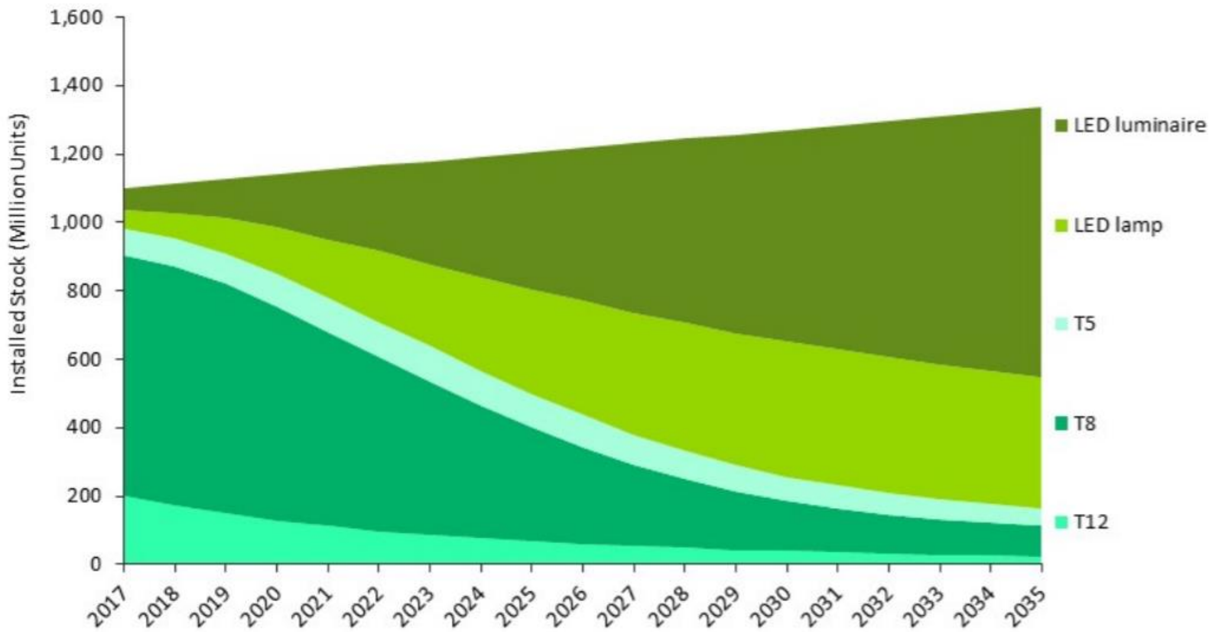
Figure 22. Commercial Building Sector Installed Stock Projections



Source: 2017 DOE Lighting Market Model

Looking specifically at ambient linear application in Figure 23, the DOE Lighting Market Model predicted that T12s will see a slow decline in market share but continue to hold a small percent of the market through 2035. The other LFL technologies, T5s and T8s, are expected to hold about 50% of installed stock through 2023. Their market share is predicted to taper over time. LED lamps and luminaries account for roughly half of all linear fixtures in the installed stock 2025, and their market share continues to increase through 2035. Note that T12s are forecast to retain a small share of the market well into the future. There is speculation that T12s are exploiting a loophole in the CRI requirement and this forecast likely assumes that loophole remains. According to our market informants, some states are passing state standards to close the loophole.

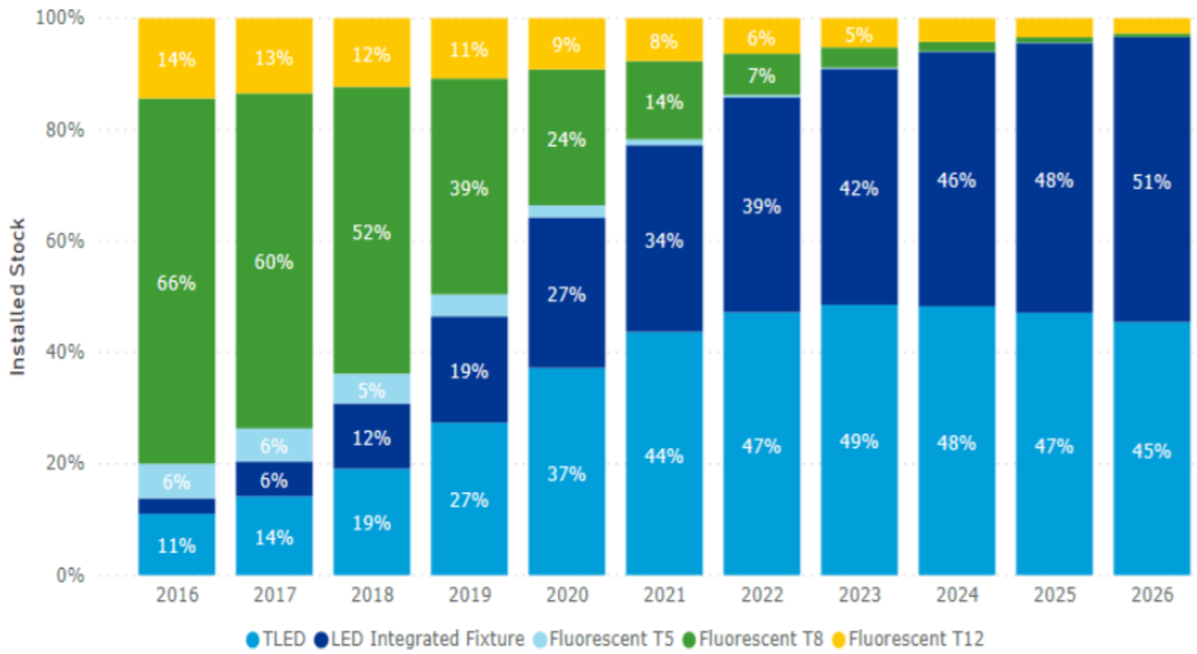
Figure 23. Linear Fixture Application Stock Forecast



Source: 2017 DOE Lighting Market Model

The most recent Massachusetts C&I Lighting Inventory also reported integrated LED luminaires growing at a faster rate in the installed stock than LED tubes. This study forecasts the ambient linear application in Figure 24, which shows LED Tubes top out at 49% of stock then begin to decline, as integrated LED luminaries grow and ultimately surpass LED tubes in 2025. Massachusetts 2019 stock market shares in the ambient linear application differ from the Northwest (Table 15). In 2019, a larger percentage of LED luminaries were in the installed stock in Massachusetts (19%) than the Northwest (6%), and the Northwest stock had far greater prevalence of LFL T8s (67%) than Massachusetts (39%). The Massachusetts forecast includes industrial lighting, which could drive some of these differences. Despite the differences, evaluating the Massachusetts and national stock forecasting trends and the Northwest sales trends indicates that Northwest lighting stock will likely experience similar transformation.

Figure 24. Massachusetts Forecast of LED Saturation by Technology in Ambient Linear Application[40]



Source: 2020 Massachusetts C&I Lighting Inventory

2.2 Industrial Sector

In the nonresidential lighting market, the commercial and industrial sectors are often discussed together (i.e. C&I). However, there are a few differences between the commercial and industrial sectors that led the team to examine them separately. For the purposes of this study, industrial buildings are places where things are made or stored at a large scale, and building types are generally but not exclusively factories and warehouses. The research team identified the following primary differences between the two sectors:

- The industrial sector is much smaller than commercial, with the DOE estimating the commercial sector is roughly 15 times the size of the industrial sector in terms of total lighting products installed.
  - Unlike the commercial sector, lighting is an overall small portion of industrial energy use and, therefore, the focus in energy efficiency opportunities is typically in larger load areas (e.g. pumps, fans, and motors).
- Lighting applications in industrial are characterized by long operating hours and high lumen output requirements, resulting in substantial energy savings potential.

[40] TLED and LED Integrated Fixture are the Massachusetts report's terms for LED tubes and integrated LED luminaires.

- Lighting projects in the industrial sector are often driven by large capital funded projects.
  - This is particularly important given the emerging effect of COVID-19 on the economy. Because of the uncertainty created by the economic effects of COVID-19, there has been a lull in capital expenditures.
- There are fewer common applications in the industrial sector versus the commercial sector, but ambient linear and high and low bay are prominent applications in both.
- Building codes are not applied the same way they are to commercial buildings with many exempted building types present in industrial designations.

2.2.1 Key Industrial Data Sources

For the industrial sector, the research team consulted three primary sources.

BPA Nonresidential Lighting Market Model			
Data Collection Year:	**Geography:**	**Author:**	**Primary Use:**
2017	Regional	Cadeo on behalf of BPA	Industrial Stock, Sales, and Forecasting

The BPA Model uses market intelligence to break nonresidential lighting stock and sales into commercial and industrial. The research team was unable to find designated regional sources for industrial lighting stock or sales data. Therefore, the team used the BPA Model as the best available estimate of the installed stock and sales in the industrial sector.

DOE Lighting Market Model			
Data Collection Year:	**Geography:**	**Author:**	**Primary Use:**
2017 (published in 2019)	National	Navigant, on behalf of the U.S. Department of Energy (DOE)	Industrial Stock Forecasting

The DOE Lighting Market Model provided a regional installed stock estimate for the industrial market in 2017 and forecasted the industrial sector lighting stock through 2035.

Industrial Facilities Site Assessment (IFSA)[41]			
Data Collection Year:	**Geography:**	**Author:**	**Primary Use:**
2013	Regional	Cadmus on behalf of NEEA	Industrial Stock and Market Intelligence

The Industrial Facilities Assessment (IFSA), published in 2013, is out of date and therefore not directly referenced. However, this report provided important background context on the industrial sector and was used as an input into the BPA Model.

In addition to these key sources, the research team consulted several additional sources to fill gaps or gather information on specific topics. Those sources included:

- Massachusetts C&I Lighting Inventory and Market Model Updates (2020)
- Oregon C&I Lighting Controls Savings and Persistence Study (2015)

The industrial sector has fewer sector-specific sources than the commercial market. However, the DOE Lighting Market Model indicates that most trends seen in the commercial sector will be mirrored by the industrial sector. Therefore, commercial sector sources can be consulted to make generalized estimates about the industrial market when no industrial-specific source exists.

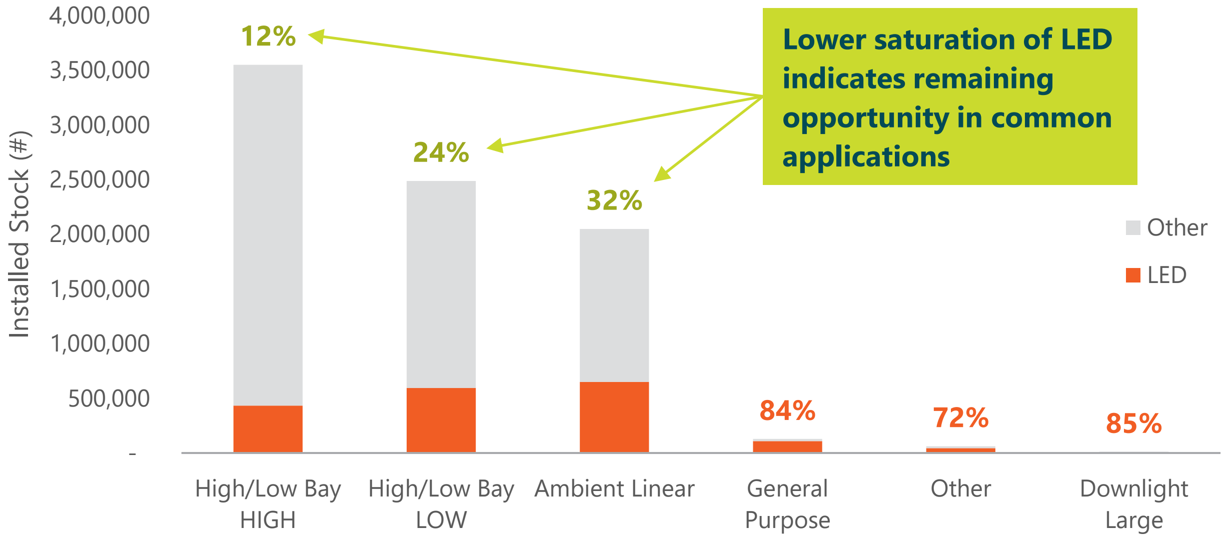
2.2.2 Industrial Lighting Stock

2.2.2.1 LED Saturation in Industrial Sector Applications

The key lighting applications in the industrial sector are high and low bay and ambient linear. Like the commercial sector, the industrial sector shows low saturation of LEDs in the applications that comprise the highest volumes of installed stock, as seen in Figure 25. While LED saturation is relatively low, the non-LED technology mix in industrial is often more efficient than the non-LED technology mix in commercial. Industrial buildings have strong use cases for long-lasting lighting technology because of the difficulty of changing out lighting systems. Because of the time and cost associated with maintenance or replacement and the long operating times of lights in these settings, industrial buildings skew towards long-lived, reliable, and efficient lighting.

[41] Industrial Facilities Site Assessment

Figure 25. Industrial Indoor LED Stock Saturation by Application



Source: BPA Nonresidential Lighting Market Model

Similar to trends observable in the commercial stock, the ambient linear application in industrial has low saturation of LED products. The forecasted 2019 technology mix in the ambient linear application in industrial is shown in Table 19 and looks similar to commercial. Because of this similarity, the research team recommends focusing on the energy efficiency opportunity in the high and low bay (high/low bay) application in the industrial sector.

Table 19. 2019 Industrial Sector Stock in the Ambient Linear Application

Technology	Percent of Installed Stock
T5	2%
25W T8	2%
28W T8	13%
32W T8	46%
T12	5%
LED Tube	19%
LED Luminaire	13%

Source: BPA Nonresidential Lighting Market Model

2.2.2.2 High/Low Bay Application

The high/low bay application in industrial is dominated by linear fluorescents, but LEDs are replacing these technologies. Based on 2019 stock forecasts in Table 20 and Table 21, LED saturation in the high/low bay high lumen output application is approximately 32% and 24% for the high/low bay low lumen output application. These stock numbers are based on the BPA Model forecast for 2019, so these numbers could be under forecasting the actual LED stock saturation. Looking at the Massachusetts C&I Lighting Inventory for comparison, Massachusetts sees a much higher LED saturation in the high/low bay application at 66% in 2019. The research team suspects this discrepancy stems from a different definition of industrial and a different mix of industrial buildings types and sizes in Oregon versus Massachusetts. However, the high saturation in Massachusetts could be an indication that the Northwest and Oregon can expect LED saturation to increase in the coming years.

> ***Potential Opportunity***
> *Convert legacy product stock to LEDs in the high and low bay application.*

Table 20. 2019 Industrial Sector Stock in the High/Low Bay Application (High Lumen Output)

Technology	Percent of Installed Stock
T5	51.8%
32W T8	30.4%
T12	3.4%
High Pressure Sodium	0.1%
Mercury Vapor	0.1%
Metal Halide	2.0%
LED Luminaire	12.2%

Source: BPA Nonresidential Lighting Market Model

Table 21. 2019 Industrial Sector Stock in the High/Low Bay Application (Low Lumen Output)

Technology	Percent of Installed Stock
T5	10.1%
32W T8	62.3%
T12	2.9%
High Pressure Sodium	0.1%
Metal Halide	0.6%
LED Lamp	13.2%
LED Luminaire	10.7%

Source: BPA Nonresidential Lighting Market Model

The technology mix in the high/low bay high and low lumen output applications have a few key differences:

- **T5s.** T5s comprise 51% of installed stock in high/low bay high lumen output applications versus only 11% of high/low bay low lumen output applications. This is very different than the commercial sector where T5s only constitute 2% of the installed stock.

- **T8s**. T8s comprise 30% of installed stock in high/low bay high lumen output applications, but high/low bay low lumen output application forecasts show T8s at 61% of installed stock.
- **LEDs.** 12% of installed stock in high/low bay high lumen output applications is LED luminaires. LED technologies, both lamps and luminaires, make up 23% of high/low bay low lumen output stock.

Despite these differences, 32W T8s are prevalent in both high/low bay applications, as well as the ambient linear application in industrial. Under the Reduced Wattage Lamp Replacement (RWLR) program, NEEA worked on replacing 32W T8s with reduced wattage T8s in the maintenance market, which could push the industrial market towards more efficient replacement lamps.[42]

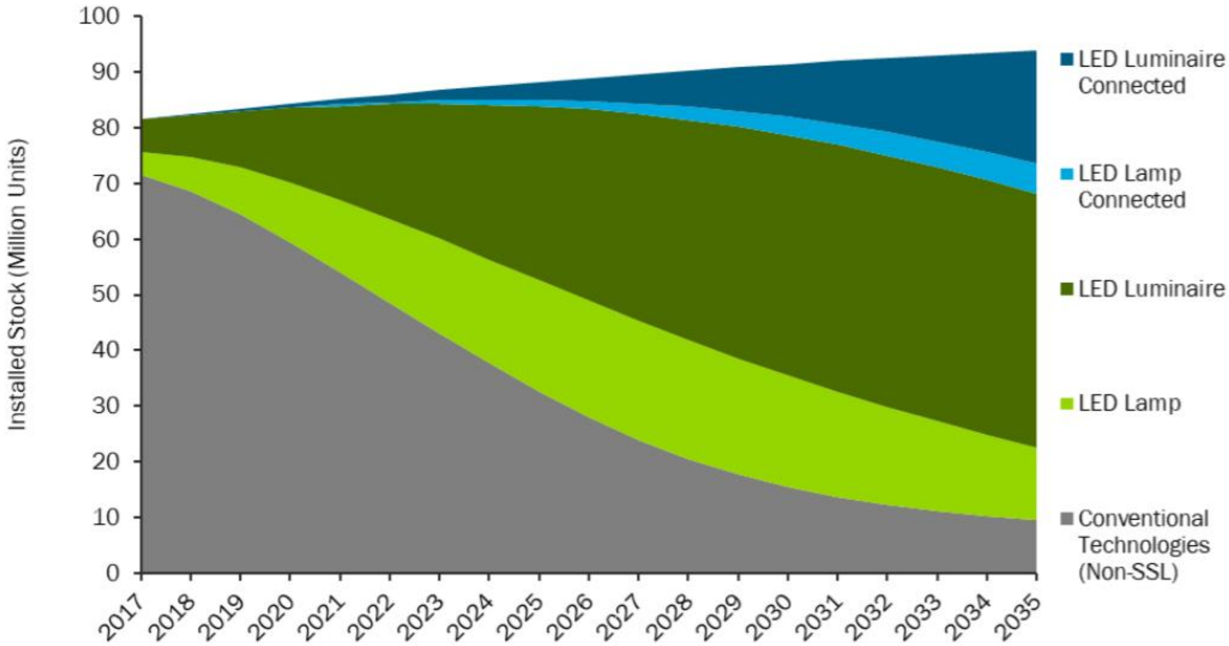
Because of the lack of an installed stock source like the CBSA for the industrial sector, it is more difficult to discern opportunities by building type and size. The CBSA defines applications differently than the BPA nonresidential lighting market model, but the research team examined the high/low bay application in the CBSA to see what could be gleaned. The CBSA shows high/low bay application lighting in every building type examined. Without a recent industrial stock data source and the prevalence of this application type in commercial building types, the research team is unable to recommend specific building type or size opportunities for the high/low bay application in the industrial sector.

2.2.3 Industrial Lighting Market Forecast

Looking at the DOE forecast for the industrial market in Figure 26, LEDs are predicted to see steady growth in the installed lighting stock through 2025 with the bulk of LED stock coming from LED luminaires. While we suspect this forecast could be optimistic, the research team hypothesizes the industrial sector will see higher adoption of LED luminaires due to the cost and difficulty of replacing or changing installed lighting in large industrial facilities. Similar to trends in the commercial sector, connected lighting currently comprises a small portion of the industrial lighting stock. Connected lighting growth is expected to be slower in industrial than in commercial, but by 2035 connected lighting could comprise nearly a quarter of the installed stock.

[42] For more information on the RWLR program, see the 2019 RWLR Transition Market Evaluation Report.

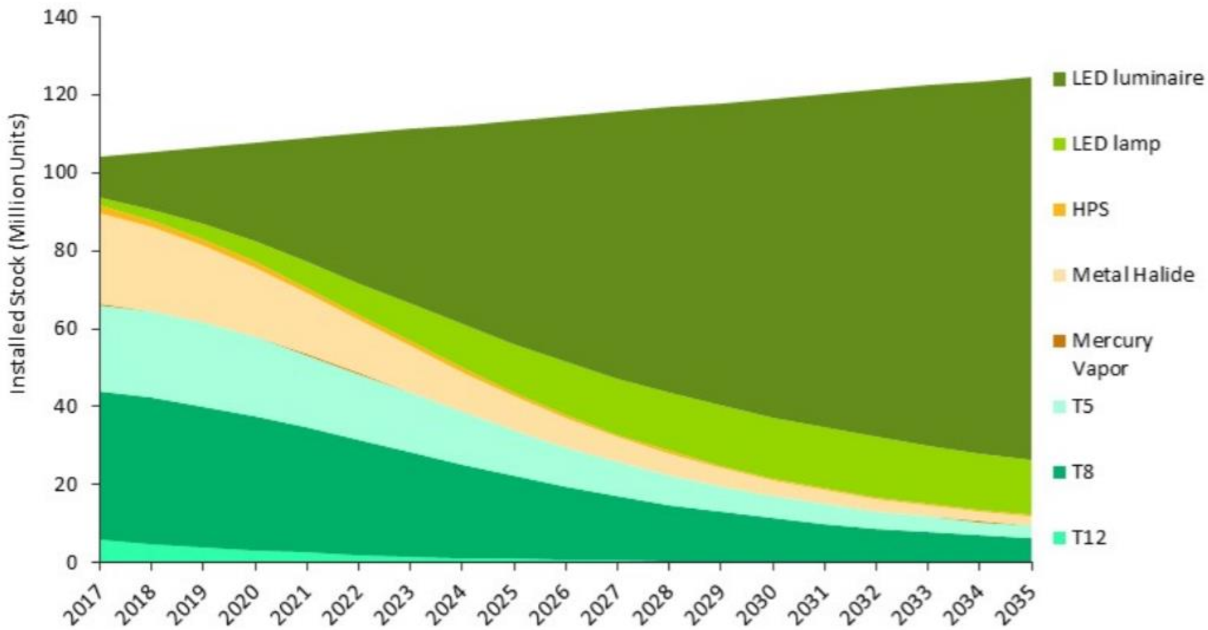
Figure 26. Industrial Building Sector Installed Stock Projections



Source: 2017 DOE Lighting Market Model

Looking ambient linear application specifically in Figure 27, DOE predicted that LEDs will hold the majority of the installed stock by 2025 at about 61%. Projecting out to 2035, LEDs become dominant with only a small portion of T5s and T8s holding market share. The DOE stock projections show metal halides at a larger percentage of the installed stock in 2019 than BPA nonresidential lighting market model. Because the BPA model is regional, the research team assumes the model is the more accurate picture of regional stock in 2019 and that metal halides will make up a negligible portion of the installed stock in the coming years.

Figure 27. High/Low Bay Application Stock Forecast



Source: 2017 DOE Lighting Market Model

2.3 Indoor Agriculture Market

The indoor agriculture market is a subsection of the industrial lighting sector. The research team evaluated indoor agriculture separately from the rest of industrial because this market has its own unique characteristics and data sources.

2.3.1 Key Indoor Agriculture Data Sources

The research team only relied on two key data sources for the indoor agriculture market:

DOE's Energy Savings Potential of SSL in Agricultural Applications			
Data Collection Year:	**Geography:**	**Author:**	**Primary Use:**
2019	National	Navigant on behalf of DOE	Indoor Ag Stock and Forecasting

DOE's Energy Savings Potential of SSL in Agricultural Applications, published in 2019, examines the installed lighting stock in the agricultural sector and its key submarkets to determine energy savings potential.

SDG&E Cannabis Agriculture Energy Demand Study			
Data Collection Year:	**Geography:**	**Author:**	**Primary Use:**
2016	Regional (OR, WA, and CO)	SDG&E	General Market Intelligence

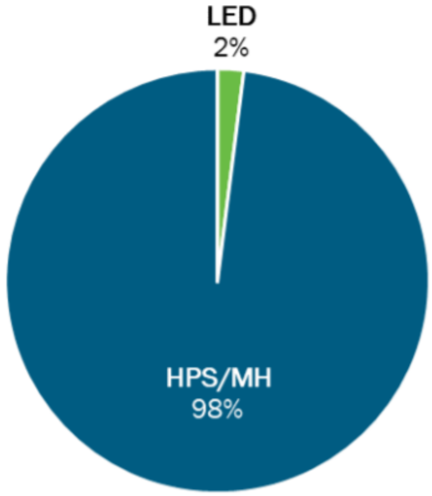
The SDG&E Cannabis Agriculture Energy Demand Study, published in 2016, primarily relied on in-depth interviews with market actors in Washington, Oregon, and Colorado to understand energy use and possible intervention strategies for energy efficiency in the cannabis industry.

2.3.2 Indoor Agriculture Lighting Stock

The DOE SSL Report for Agricultural Applications separated national installed stock in indoor agriculture into three core submarkets: supplemented greenhouses, high intensity sole-source farms, and sole-source vertical farms. Looking at the national installed lighting stock, the primary incumbent technology in the indoor agriculture market is HID, both high pressure sodium and ceramic metal halide technologies, but there are varying levels of LEDs in each submarket. A summary of DOE's findings for this market is in Appendix II: Nonresidential Market Research.

Supplemented greenhouses are greenhouse structures that primarily employ sunlight to grow plants. Supplemented greenhouses use electric lighting to extend the hours of light for plant growth or to supplement low levels of sunlight on inclement weather days. DOE estimates that 63% of national indoor agriculture grow area is comprised of supplemented greenhouses, but these greenhouses only consumed 13% of annual energy in 2019 because of the low LPD and low usage time of lighting systems. The low LPD and low usage time of a lighting system means a greenhouse will not see enough energy savings to offset the high up-front cost of LEDs relative to incumbent technologies. Because of these factors, supplemented greenhouses see a very low saturation of LEDs at only 2% of national stock, seen in Figure 28.

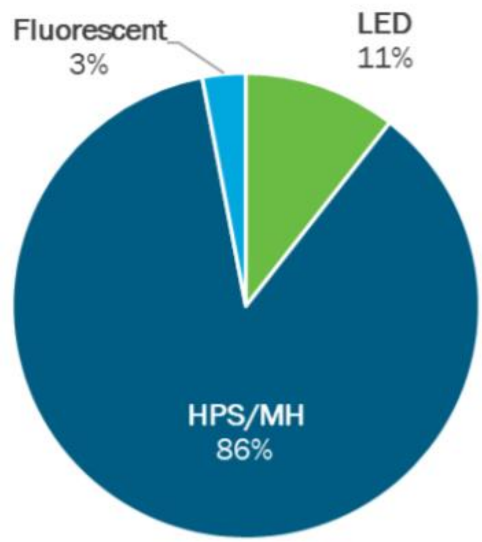
Figure 28. Technology Mix of Supplemental Greenhouse Lighting in 2019



Source: 2019 DOE SSL in Agricultural Applications Report

High intensity sole-source farms are structures that rely on electric lighting as their only source of light. Therefore, facility operators have complete control over all lighting system parameters that affect plant growth. High intensity sole-source farms comprise 36% of indoor agriculture grow area nationally. In high intensity sole-source farms, the saturation of LEDs is higher than in supplemental greenhouses but still relatively low at 11%, as shown in Figure 29. The LPD in these structures is significantly higher than in supplemented greenhouses, but high first cost is still a significant barrier to the adoption of LEDs in these operations. There is concern in this submarket about whether changing lighting types or systems will alter the attributes of the product, which can adversely affect sales, which makes farmers in this submarket averse to switching from legacy lighting products currently installed. High first cost is also a barrier in this submarket.

Figure 29. Technology Mix of High Intensity Sole-Source Farms Lighting in 2019



Source: 2019 DOE SSL in Agricultural Applications Report

Finally, vertical farms differ from high intensity sole-source farms because plants are stacked vertically to increase grow area. Vertical farms make up less than 1% of national indoor agriculture grow area. Due to the architecture required in these farms, LED and linear fluorescent fixtures are the only viable technology options as HIDs and other traditional light sources produce too much heat in close proximity to vertical grow stacks. Increases in LED product quality and decreases in LED costs, have encouraged widespread adoption of LEDs in this submarket. In 2019, adoption of LEDs in vertical farms was estimated at 100%.

These are national stock estimates which may not reflect the specific mix of technologies in Oregon's indoor agriculture market. While there is no Oregon or Northwest specific source of stock data to confirm stock numbers, Energy Trust staff report that about 25% of savings in the Production Efficiency (PE) Program in Oregon are coming from LEDs in grow facilities. Oregon has heavily invested in the indoor agriculture and cannabis growing markets, and the research team expects Oregon to have developed a stronger case for LEDs in these submarkets.

2.3.3 Indoor Agriculture Market Forecast

The research team was unable to find data-driven forecasting information for the indoor agriculture market. However, the team evaluated market intelligence to determine the factors driving, or preventing, adoption of high efficiency equipment, including:

Drivers

- Energy demand in indoor agriculture is large and growing, reaching an estimated 237 aMW by 2035 according to DOE forecasting. With increasing energy demand and low saturation of LEDs in the installed stock, there is a large opportunity for energy savings.

- In interviews with regional market observers, the team heard that COVID-19 is causing a large expansion in the indoor agriculture market. Therefore, the size of the market and the opportunity for energy savings, will continue to grow.

- Oregon specifically has invested heavily in energy efficiency in this market with a high percentage of savings reported from grow facilities. Success in the facilities that switched to LEDs can be leveraged to convert more facilities to LED technologies.

Barriers

- Operators are risk-averse to disrupting grow practices.
  - Installing new lighting products introduces a risk that the new lighting system may not work correctly. If the lighting system fails, especially in high intensity sole-source farms where electric lighting is the only source of lighting, the grower could lose crops.
  - Especially in cannabis growing, the grower has cultivated every aspect of the product using their current lighting system. Each product has distinct attributes that act as selling points, and customers are often loyal to a particular product for these attributes. Switching lighting systems could risk changing the attributes of the product and result in loss of a loyal customer base.
- Operators are cost-averse when changing lighting systems.
  - As long as proven inexpensive legacy technologies are available in the market, operators will continue to buy them.
  - The cost difference between the most inexpensive incumbent technology and an LED can be up to $1,000 per unit. If this cost differential remains high, upfront cost will be a significant barrier to converting incumbent technologies to LEDs, especially in supplemented greenhouses.

The opportunity for savings acquisition in indoor agriculture will likely require on-going marketing and incentives to offset upfront cost. Programs will need to highlight success stories where operators switched to LEDs without issue. Showing growers in the region that LED conversion can be successful can help assuage concerns from the more risk-averse growers.

Potential Opportunity

Continue to target high first cost and technology concerns through programs offering incentives and featuring success stories of LEDs in this sector.

2.4 Exterior and Outdoor Sector

For the purposes of this report, the research team defined exterior lighting as all outdoor lighting technologies associated with commercial and industrial buildings. These technologies are covered by the CBSA for commercial buildings, and the BPA nonresidential market model provides industrial stock. Outdoor is defined as outdoor lighting not associated buildings (such as streetlights or lighting for parks), and these technologies were partially addressed by the Outdoor Lighting Stock Assessment (OLSA) completed in early 2020.

2.4.1 Key Exterior and Outdoor Data Sources

Commercial Building Stock Assessment (CBSA)			
Data Collection Year:	**Geography:**	**Author:**	**Primary Use:**
2019 (published in 2020)	Regional	Cadmus on behalf of NEEA	Regional Stock

The CBSA examines the outdoor lighting associated with commercial buildings. The research team used the CBSA as most up to date stock data for the exterior lighting sector.

BPA Nonresidential Lighting Market Model			
Data Collection Year:	**Geography:**	**Author:**	**Primary Use:**
2017	Regional	Cadeo on behalf of BPA	Regional Stock, Sales, and Forecasting

The BPA Model has stock and sales estimates for exterior and outdoor lighting and was used to fill gaps or supplement stock information from the CBSA, like industrial stock information.

Outdoor Lighting Stock Assessment (OLSA)			
Data Collection Year:	**Geography:**	**Author:**	**Primary Use:**
2020	OR and Regional	Cadeo on behalf of BPA	Outdoor Lighting Stock

The Outdoor Lighting Stock Assessment (OLSA) estimated predominantly the street and roadway category of outdoor lighting and provides Oregon specific findings from 2020. Therefore, OLSA is the primary stock source for the outdoor sector.

DOE Lighting Market Model			
Data Collection Year:	**Geography:**	**Author:**	**Primary Use:**
2017 (published in 2019)	National	Navigant on behalf of DOE	National Stock Forecasting

The DOE Lighting Market Model forecasts the exterior and outdoor lighting sectors together and provides market intelligence to illuminate trends in this sector.

Additional sources consulted include:

- Massachusetts C&I Lighting Inventory and Market Model Updates (2020)
- Exterior Lighting Standard Practice Baseline and Work Paper Support Study (2018)

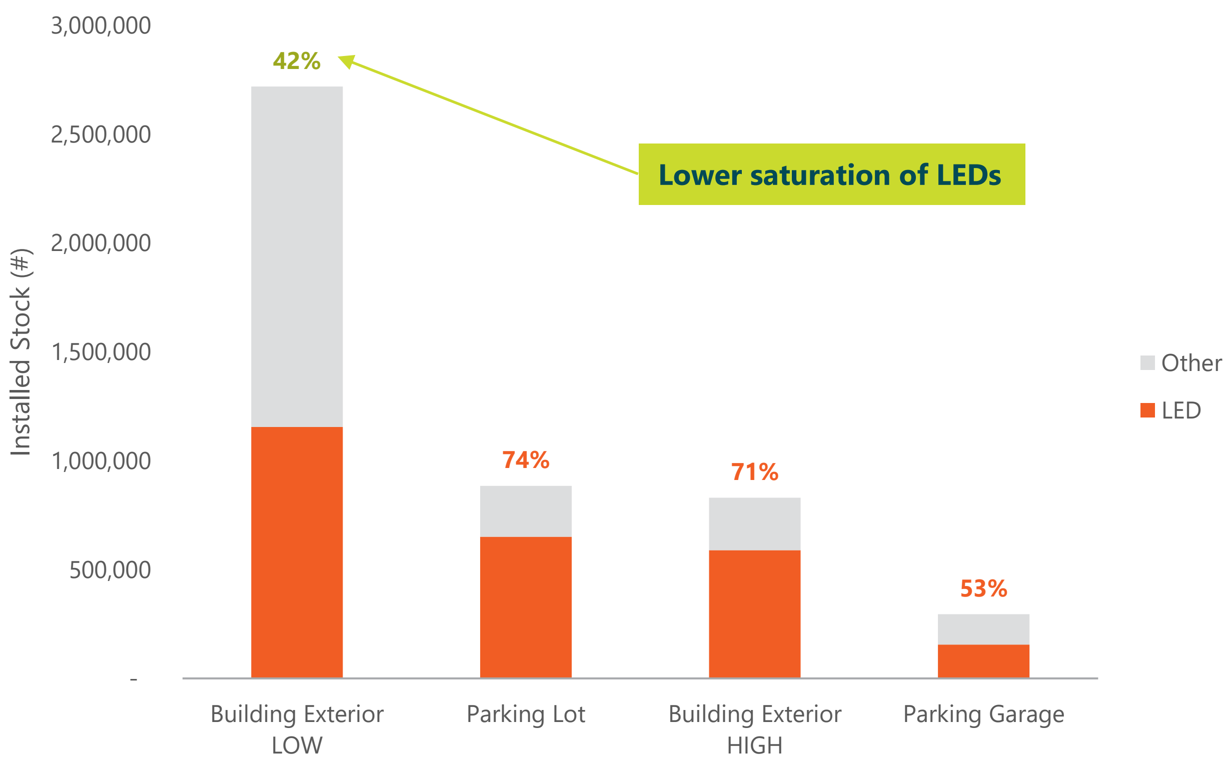
2.4.2 Exterior Lighting Stock

While LED saturation in exterior applications is generally high, as seen in Figure 30, saturation is lowest in the low lumen[43] building exterior application, which represents the largest volume of installed exterior lighting stock. While 42% saturation in this application indicates an opportunity, the team expects this application will see natural replacement of non-LED products with LED alternatives. There is a wide range of products installed on building exteriors, especially metal halides and high-pressure sodium lamps, but there are very few non-LED options currently in the market to replace them. Therefore, as lamps in the building exterior application burn out, it is assumed they will be replaced with LEDs.

Potential Opportunity

Support and seek to accelerate the natural replacement of legacy technologies in exterior lighting applications.

Figure 30. LED Stock Saturation in Exterior Stock (C&I)



Source: 2020 CBSA

[43] Building exterior high technologies have lumen outputs greater than 7,000, and building exterior low technologies have lumen outputs at or below 7,000.

2.4.3 Outdoor Lighting Stock

In outdoor lighting stock, street and roadway lighting (streetlights) is the dominant application. Saturation of LEDs in streetlamps, seen in Table 22, is high throughout the region and very high in Oregon, specifically. LEDs are advantageous in this application because of their lighting properties, durability, and long lifetimes, which makes LEDs attractive when considering the long operating hours and associated reduction of maintenance expenses. Finally, lighting system decision making in this application typically governed by municipalities that can incent in city-wide LED upgrades, so the path to adoption of LEDs is faster in the outdoor versus exterior sector, where building owners and operators make lighting system decisions for individual buildings. The OLSA team collected city level data for nearly every major city in the Northwest, and further examination of this data can illuminate any differences in LED saturation in major Northwest cities.

Table 22. Streetlight Technology Mix by State and Urban/Rural Designation[44]

State	Urban		Rural		Overall	
	HID	LED	HID	LED	HID	LED
ID/MT	73%	27%	84%	16%	73%	27%
OR	21%	79%	27%	73%	21%	79%
WA	32%	68%	45%	55%	33%	67%
Total	**32%**	**68%**	**54%**	**46%**	**33%**	**67%**

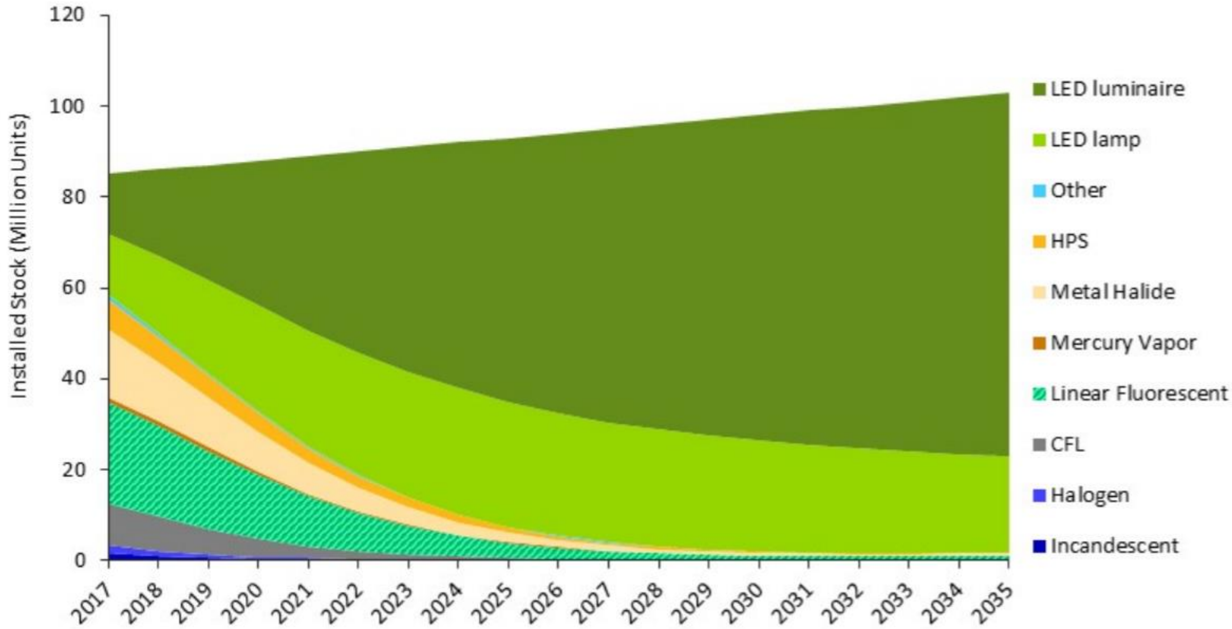
Source: 2020 OLSA

2.4.4 Exterior and Outdoor Sector Forecast

The national stock forecast for the exterior application in Figure 31 shows LED lamps and luminaires quickly gaining market share from non-LED technologies. DOE predicted the saturation of LEDs in the exterior application will reach 92% by 2025 and nearly 100% by 2030. The forecast for streetlights is similar with the projected stock of LED lamps and luminaires rapidly increasing to 90% of national installed stock by 2025 (Figure 32). In Oregon, the team knows the current saturation of LEDs in this application is closer to 80% versus the roughly 50% shown in the national projection. Based on current Oregon stock saturation, the team believes streetlights will reach full saturation of LEDs in Oregon sooner than the national forecast predicts.

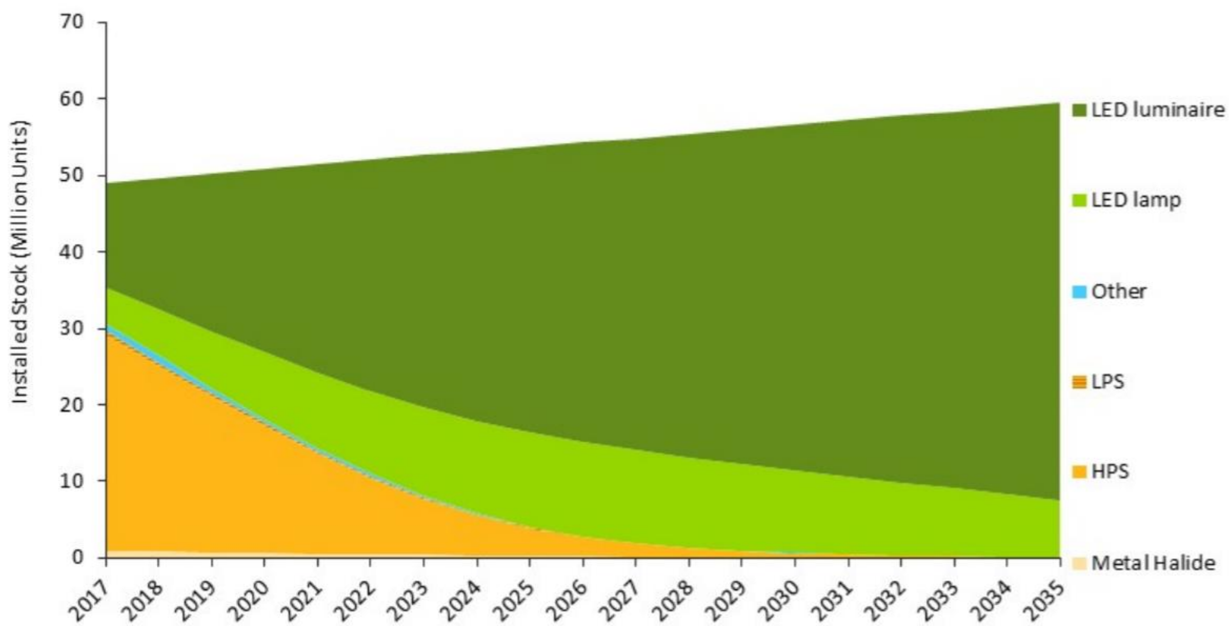
[44] OLSA uses the same census block designation for urban and rural used by the CBSA.

Figure 31. Exterior Lighting Application Stock Forecast



Source: 2017 DOE Lighting Market Model

Figure 32. Street and Roadway Lighting Application Stock Forecast



Source: 2017 DOE Lighting Market Model

2.5 Cross Sector Research

2.5.1 Key Cross Sector Data Sources

For cross sector research related to market trends, codes, controls, and the impact of COVID-19, the team relied on the following key sources:

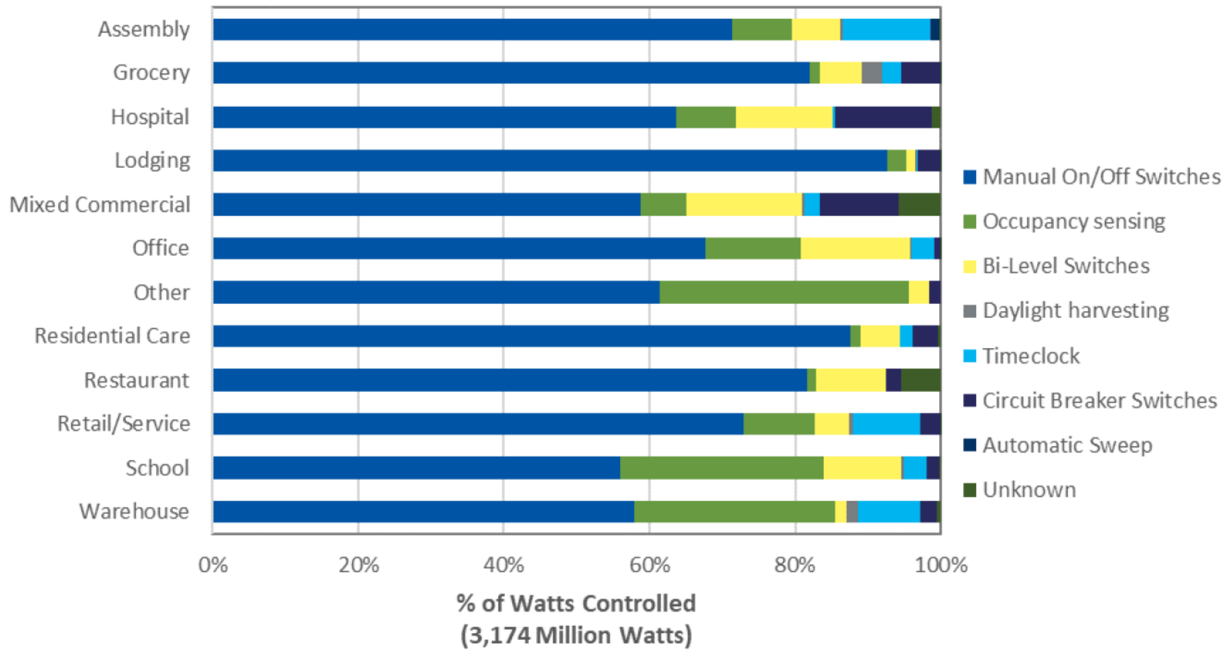
- Oregon C&I Lighting Controls Savings and Persistence Study (2015)
- Energy Savings Potential of DLC Commercial Lighting and Networked Lighting Controls (2018)
- Energy Savings from Networked Lighting Control Systems With and Without Luminaire Level Lighting Controls (2020)[45]
- 2019 Oregon Energy Efficiency Specialty Code (OEESC)
- NMR Market Assessment of Lighting Codes (2020)
- 2019 Oregon New Commercial Construction Code Evaluation Study
- Interviews with regional market informants

2.5.2 Controls

There remains a large opportunity for increasing the saturation of indoor lighting controls in commercial lighting stock, a majority of which (68%) continue to be controlled by manual on/off switches, shown in Figure 33. Occupancy sensing increased between the 2014 and 2020 CBSAs, but only 13% of commercial buildings have occupancy sensing installed. The team does not have a recent industrial-specific source on installed controls stock, but regional market informants indicated that industrial facilities tend to employ less advanced lighting controls. This could be due to facility use patterns, like 24-hour operating days, or safety concerns in processing areas.

[45] Energy Savings from Networked Lighting Control Systems With and Without Luminaire Level Lighting Controls

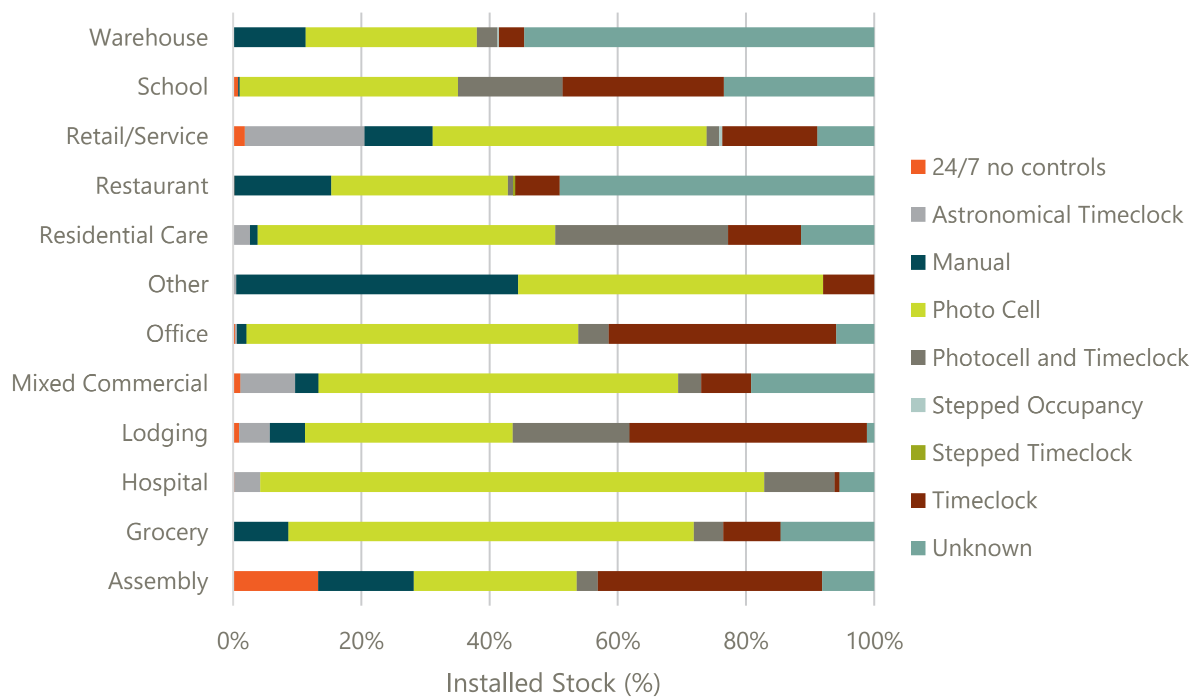
Figure 33. Commercial Indoor Lighting Control Type by Building Type



Source: 2020 CBSA

Most of the exterior lighting stock in commercial buildings is already controlled, as seen in Figure 34, with photocells being the most common type at 41% and timeclocks also common at 16%. There is a strong use case for these types of controls in the exterior and outdoor sector where long operating hours and safety concerns result in high energy usage. Limiting lighting operating hours by time or by reacting to ambient light is the simplest way to reduce energy costs in these applications.

Figure 34. Commercial Exterior Lighting Power by Control Type and Building Type



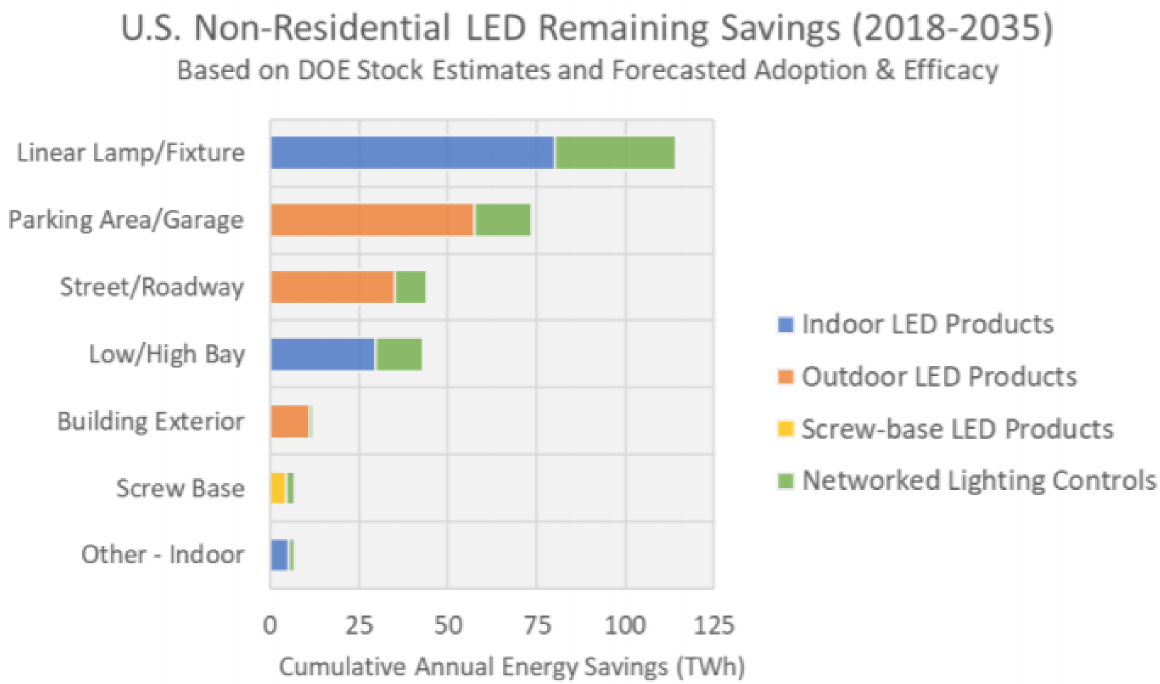
Source: 2020 CBSA

The research team did not extensively research controls opportunities in the nonresidential sector. However, we examined recent market intelligence from Design Lights Consortium (DLC) on which applications present the largest energy savings potential, show in Figure 35. Nationally, the most significant remaining C&I savings opportunity associated with controls is linear lamps and fixtures installed with networked lighting controls (NLCs). If LED linear lamps or fixtures are installed without controls, the additional savings potential is assumed to be “stranded” until that lamp is replaced because the expected additional energy savings will not justify the additional expense. The second largest opportunity is in parking area and garage lighting due to the size of the installed base and long operating hours, which create a strong case for controls. Importantly, projected savings from LEDs and LEDs with networked controls could be lower in the Northwest because of the prevalence of energy efficiency programs that have reduced overall energy savings potential and thus the savings expected from controls.

Potential Opportunity

Ensure every non-LED technology replacement is an LED, and, where possible, controls are installed at the time of replacement.

Figure 35. National Estimated Forecasted Energy Savings from LEDs and NLCs



Source: Energy Savings Potential of DLC Commercial Lighting and Networked Lighting Controls (2018)

The research team sought market intelligence to find a simple savings factor to quantify the controls opportunity. In 2012, LBNL estimated that a 25% reduction factor can be applied for most lighting controls measures, meaning hours of use (HOU) are reduced by 25%. A more recent study on C&I controls prepared for Energy Trust from 2015 found that 38% is a more accurate assumed reduction factor, but reduction rates vary from 24% up to 39%. Consistent with this research, the team recommends using a 38% HOU reduction factor for estimates of controls opportunities.

Looking specifically at NLCs, the 2020 NEEA report found that across building types, NLCs are likely to reduce lighting energy use[46] by 49% on average. This number increases to over 60% when looking at NLCs with luminaire level lighting controls (LLLCs). While reduced energy use potential varies across building types and management strategies, the team can recommend the simple estimate of 50% reduction from NLCs.

2.5.3 Codes

As of October 2020, Oregon has the most stringent codes in the region regarding energy efficiency and controls (Figure 36), Oregon has the most stringent codes in the region regarding energy efficiency and controls. Specifically, Oregon requires occupancy sensing in more space

[46] Reductions in energy use from controls include both reductions in HOUs and the lowering of lighting levels due to dimming.

types and requires daylight-responsive controls in larger areas. While not immediate, Oregon may see a quicker uptick in indoor lighting controls in the installed stock than other Northwest states as the code takes effect.

Figure 36. Building Codes in the Northwest

	Idaho	Montana	Oregon	Washington	Seattle
Based on	IECC 2018	IECC 2018	ASHRAE 90.1 2016	IECC 2018 (amended)	WA 2018 (amended)
Effective Date	1/1/2021	Adoption date uncertain*	10/1/2019	2/1/2021	Adoption date uncertain*
Expected Effective Term	At least 3 years	At least 3 years	At least 3 years	3 years	3 years
Occ Sensor Requirements Beyond IECC 2018			●	●	●
Secondary Sidelit Zone			●	●	●
Reference	ID Building Energy Code	MT Building Energy Code	OR Zero Energy Ready Code	WA State Energy Code	Seattle Energy Code

Source: NMR Market Assessment of Lighting Codes (2020)

Regional planners have sought to understand how the market is performing on LPD against the code baseline laid out in the 2019 Oregon code. NEEA sponsored an Oregon code evaluation study, which investigated the average LPD of four building types. Table 23 displays the average LPD in these four building types under the 2019 Oregon code baseline (based on ASHRAE 90.1 2016), the actual market performance, and the next code baseline in ASHRAE 90.1 2019. The market in the four sampled building types saw significantly lower LPDs than the code baseline in three out of four building types. A full list of LPD code requirements by building type under OEESC is in Appendix II: Nonresidential Market Research. The research team heard from regional market informants that new nonresidential buildings are able to meet code required LPD easily and will often strive for a more aggressive LPD to repurpose those efficiency points in other areas.

Table 23. Average LPD by Building Type - Code Baseline versus Market Performance

Effective Dates	1/1/2020-Present	Complete NEEA/ Ecotope Sample		ETO NB Participant Subset		For reference: next version of ASHRAE	
Building Type	2019 Oregon Energy Efficiency Specialty Code (OEESC) (W/ft²)	Ecotope Sample	% Difference from 2019	ETO New Building Participants	ETO Participants % Change from 2019 Code	ASHRAE 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings	% Change (Compared to 2019 OEESC)
School/ University	0.81	0.84	4%	0.71	-12%	0.72	-11%
Retail	1.06	0.81	-24%	0.82	-23%	0.84	-21%
Office	0.79	0.62	-22%	0.73	-8%	0.64	-19%
Multifamily	0.68	0.41	-40%	0.41	-40%	0.45	-34%

Source: Cadeo evaluation of OEESC, 2019 Oregon New Commercial Construction Code Evaluation Study, and ASHRAE 90.1

2.5.4 Impact of COVID-19

As of October 2020, the full impacts of COVID-19 on the nonresidential market remain uncertain. However, from qualitative research and conversations with regional market informants, the team anticipates there will be both challenges and opportunities resulting from this disruption.

- **Commercial.** With nonresidential building occupancy and use patterns disrupted due to COVID-19, it is possible that building owners will delay investing in building or system improvements, particularly if their buildings are fully or partially vacant. On the other hand, if occupancy and use patterns change more permanently, building owners may decide to redesign their spaces with new lighting and controls strategies to better align with new usage needs. Additionally, it is easier to make large or disruptive system improvements while buildings are operating at limited capacity.
- **Industrial.** The challenge facing industrial buildings is that capital expenditures, which fund a large portion of industrial lighting projects, are likely to be on hold until economic uncertainty is minimized. On the other hand, COVID-19 has the potential of drastically change national consumption patterns of consumer products as well as sector specific materials like healthcare. As consumption patterns change, there may be opportunities for facility owners to redesign industrial spaces to accommodate these changes.
- **Indoor agriculture**. Currently, COVID-19 does not appear to be negatively impacting the indoor agriculture sector. According to market informants, indoor agriculture, and especially cannabis growing, has thrived despite the economy uncertainty. Indoor

agriculture could continue to expand, creating additional opportunities for energy savings.

2.6 Summary of Gaps and Opportunities

The research team identified several important gaps in available nonresidential lighting data, summarized in Table 24:

Table 24. Summary of Nonresidential Market Data Gaps

Sector	Gap	Addressability
All	There is no source of sales data by building type, so it is difficult to predict in real time if any building types are not experiencing sales trends in the same way as the total market.	This is likely a permanent gap in market knowledge. It is difficult for market actors to provide sales data with enough granularity to track sell to destination and installation information. Therefore, market researchers will need to relay on up to date stock information to verify trends identified in generalized sales data.
All	Available data sources define stock metrics differently. While looking at all stock sources in aggregate shows a high level of insight into the commercial market, there are always assumptions when comparing between two stock sources.	This is likely a permanent gap. However, this gap is larger or smaller depending on timeline of published stock information. For this study, the research team had 2019 stock information due to the CBSA, but the BPA Model was last updated in 2017. If the team had conducted this research in 2019, the most recent stock information was from 2014. The assumptions needed to evaluate the 2014 CBSA and 2017 BPA Model would have been more numerous.
Industrial	There are no specific sources of stock or sales data for the industrial sector. In available sources, commercial and industrial sectors are often combined, making it challenging to call out specific industrial sector findings.	This is somewhat addressed by available market intelligence on what technologies and applications are most common in industrial. However, without targeted sources in this sector, the data lacks the granularity to make more targeted recommendations.
Indoor Agriculture	There is no Oregon-specific or Northwest specific stock data available in indoor agriculture.	It is possible to collect this information and would be highly valuable for defining the exact size of the opportunity in indoor agriculture.

The research team also identified several potential opportunities for further market transformation and energy efficiency intervention in the nonresidential lighting market, summarized in Table 25.

Table 25. Summary of Identified Opportunities in the Nonresidential Lighting Market

Sector	Opportunity	Considerations for Programs
Commercial/ Industrial	When legacy non-LED technologies are replaced, ensure LED replacement. LED replacements should be 1) fixtures and 2) controlled where possible.	Consider product bundles to justify programmatic investment and avoid lost opportunities, especially for controls.
Commercial/ Industrial	Continue to whittle away at stubborn stock of T12s.	T12s also represent an opportunity for energy savings, although they are distributed across a range of building types that each represent a relatively small share of commercial floor area. Therefore, a bounty program, particularly in small to medium rural buildings, that targets the technology instead of a specific building type could be successful.
Commercial/ Industrial	Continue to convert large installed T8 stock in ambient linear application to LEDs.	Programs should leverage policy changes (i.e. helping customers reach sustainability goals) to justify new lighting equipment.
Commercial/ Industrial	Convert legacy stock to LEDs in the high/low bay application.	Programs should anticipate the need to offer solutions for large-scale changes in occupancy and use patterns to industrial building customers.
Indoor Ag	There is a large energy efficiency opportunity in this sector, and the opportunity is growing with the impacts of COVID-19.	Programs should continue to work with farmers and growers through successful case studies and education about LED technologies in this sector. Incentives are crucial to addressing customers' high first cost concerns, and programs offering incentives will continue to be important to converting legacy stock to LEDs.
Exterior	Support and seek to accelerate natural replacement of non-LED technologies with LED alternatives on burn out.	While this market is already transforming, programs can accelerate adoption.

Section 3 Conclusions

3.1 Residential

LED market share and household saturation of LEDs have increased rapidly and are expected to continue to increase in the coming years. Overall, LEDs are estimated to comprise more than half the lamps in Northwest homes in 2020, with saturation expected to grow above 80% by 2025.

3.1.1 Opportunities

There are certain segments of the residential lighting market that continue to lag in LED market share, although these segments, individually, make up a relatively limited share of the market. Segments with lower LED market share, which may offer opportunities for program intervention, include:

- Grocery, dollar, and mass merchandise retail stores, which had an LED market share of 45% in 2019, relative to 67% in other channels. These channels comprise 30% of lighting sales.
- Decorative and globe shape lamps had lower LED market shares than standard (a-type) lamps and reflectors but comprise 15% of lighting sales.
- Standard (a-type) lamps with very high (>2,600) or very low (<300) lumen levels had very low LED market shares, although they represent less than 4% of a-type lamp sales.
- Black, low-income, and renter households were less likely to report purchasing LED bulbs and thus may represent an opportunity for program activity to encourage LED adoption.

Connected (smart) lighting may present opportunities for energy savings in the residential sector, but additional research is needed to assess the extent of the savings opportunity from connected lighting. Both the market share and installed stock of connected lighting are currently small, and, while they are expected to grow, connected lighting products will remain a small portion of installed lighting products, reaching 9% of installed lighting products by 2035.

3.2 Non-residential

In the nonresidential lighting market, the rapid proliferation of LEDs in the last several years has transformed the market, evidenced by the decrease in stock across all non-LED technologies between the 2014 and 2020 CBSAs. In many applications, LED saturation is approaching 100%, but some applications are transforming more slowly.

3.2.1 Opportunities

The largest remaining opportunity is in the ambient linear application, the highest commercial application by volume, with only 27% LED saturation. Program interventions to replace LFL technologies, particularly T8s but also small volumes of persistent T12s, will likely continue to have a role in the energy efficiency portfolio.

Another area of potential for the nonresidential lighting market is in controls, particularly in indoor lighting. The most recent CBSA data indicate that only about 30% of indoor commercial lighting is controlled by anything other than a manual on/off switch. Especially in the ambient linear application, replacing non-LED technologies with LED alternatives *with* controls offers the greatest savings opportunity due to mainly to the large installed volume of non-LED technologies in this application. Installing controls in tandem with luminaire replacement is crucial to avoid lost opportunities for savings from controls. It will be important to monitor studies confirming the incremental savings from installation of advanced or networked lighting controls over simpler controls strategies like occupancy sensing.

3.3 A Year of Disruption

2020 has proven to be a difficult year on which to base forecasts. The full effects of changes associated with political, economic, and public health disruptions remain unknown as the team prepares this report. It seems certain that the design and use of commercial spaces will likely be affected by the United States' experience with COVID-19, but precisely how these trends might affect efficiency program opportunities is not predictable. Will hotels, event spaces and restaurants return to pre-pandemic activity? What areas of the economy will continue to expand? Will residential contracting, shipping and warehousing, grocery, and indoor agriculture continue to flourish as stay-at-home orders subside? Will political shifts increase commitment to and investment in strategies to reduce the impacts of climate change? Maximizing success will require a suite of program interventions that can adapt to rapidly shifting economics and motivations. The team cannot say for certain that long standing trends in building investment and use cases will continue into the future.

Appendix I: Residential Market Research

This section describes the research team's approach to estimating the share of residential lighting sales likely to be impacted by the upcoming change in Oregon's residential building code. The team began by calculating the total number of fixtures impacted by the code change, as illustrated in Table 26.

Table 26: Calculation of Fixtures Impacted by Code Change

Number of Permanently Installed Fixtures	% of Single Family Homes[1]	Number of New Single Family Homes[2]	Non-High Efficacy Fixtures Allowance		Fixtures Impacted by Code Change	
			Current Code	New Code	Per Home	Total
Less than 10	7%	861	4	0	4	3,444
10 to 19	26%	2,985	4	1	3	8,954
20 to 29	28%	3,266	4	2	2	6,533
30 to 39	17%	1,959	4	3	1	1,959
40 to 49	12%	1,428	4	4	0	0
50 or more	9%	1,086	4	5	-1	-1,086
					Total	**19,804**

[1] From Cadeo team analysis of RBSA data
[2] Based on a total of 11,586 new single-family home permits issued in Oregon in 2019

Table 27 describes how the team built on this estimate of fixtures impacted by the code change to estimate the number and share of lamps subject to code and impacted by the code change.

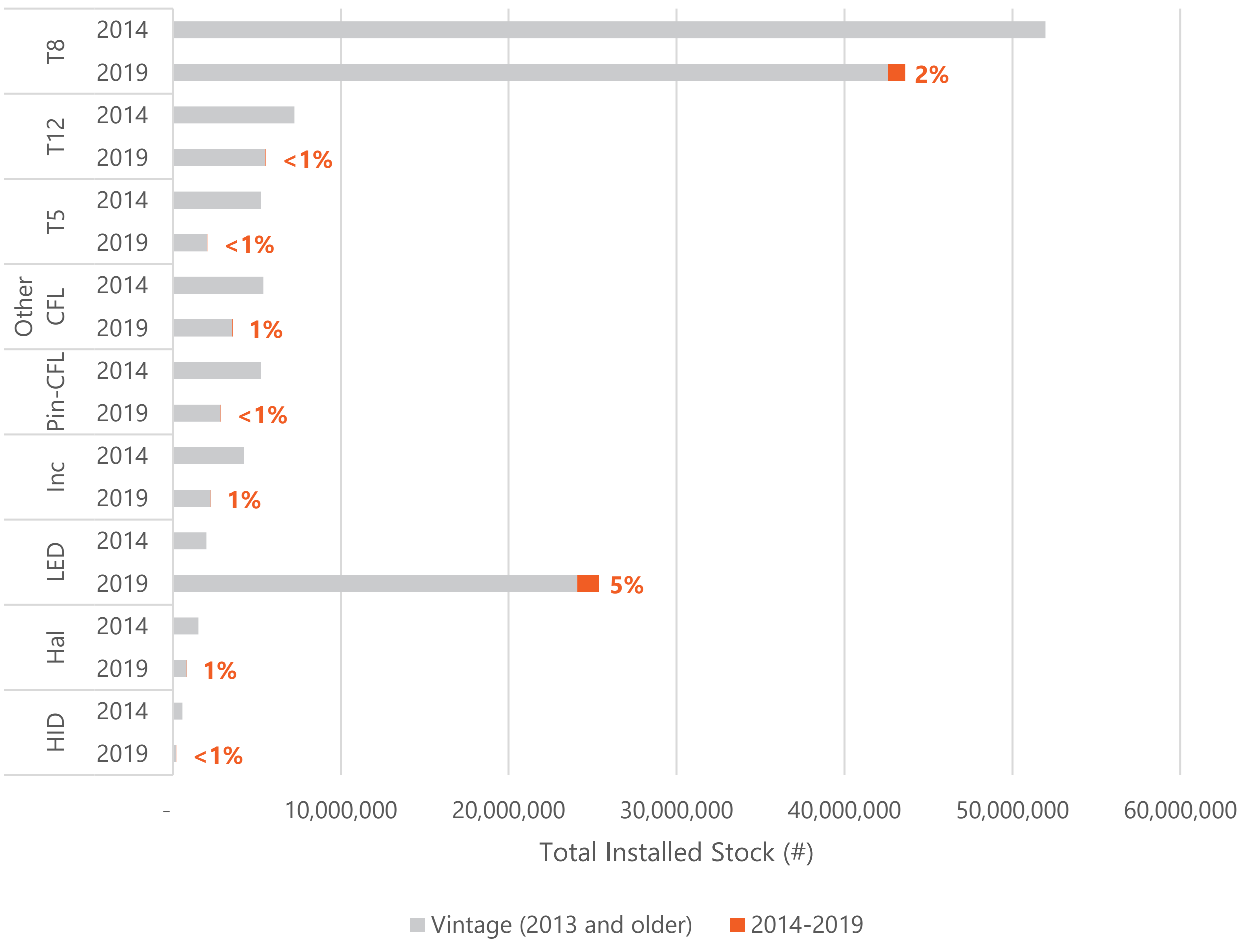
Table 27: Estimated Share of Lighting Sales Subject to Code and Impacted by Code Change

	Parameter	Estimate	Source
A	OR new single-family home permits Issued in 2019	11,586	U.S. Census Bureau, Building Permits Survey[1]
B	Average lamps in permanently installed fixtures per OR single-family home	50.6	RBSA
C	2019 lamps subject to code	586,831	Calculated (A x B)
D	2019 fixtures impacted by code change	19,804	Calculated
E	Average lamps per permanently installed fixture	1.8	RBSA
F	2019 lamps impacted by code change	35,749	Calculated (D x E)
G	2019 OR retail lighting sales volume	30,205,762	CREED
H	Share of sales volume subject to code	1.9%	Calculated (C/G)
H	Share of sales volume impacted by code change	0.1%	Calculated (F/G)

[1] https://www.census.gov/construction/bps/xls/stateannual_201999.xls

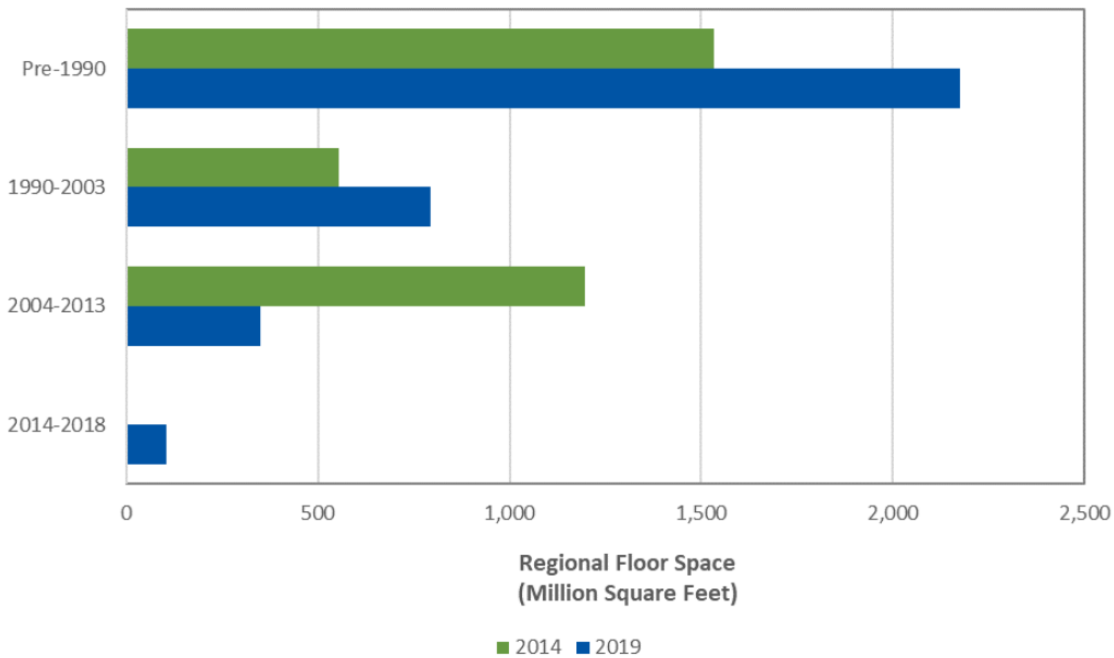
Appendix II: Nonresidential Market Research

Figure 37. Commercial Indoor Lighting Stock Technology Mix in New vs. Vintage Buildings, 2014-2019



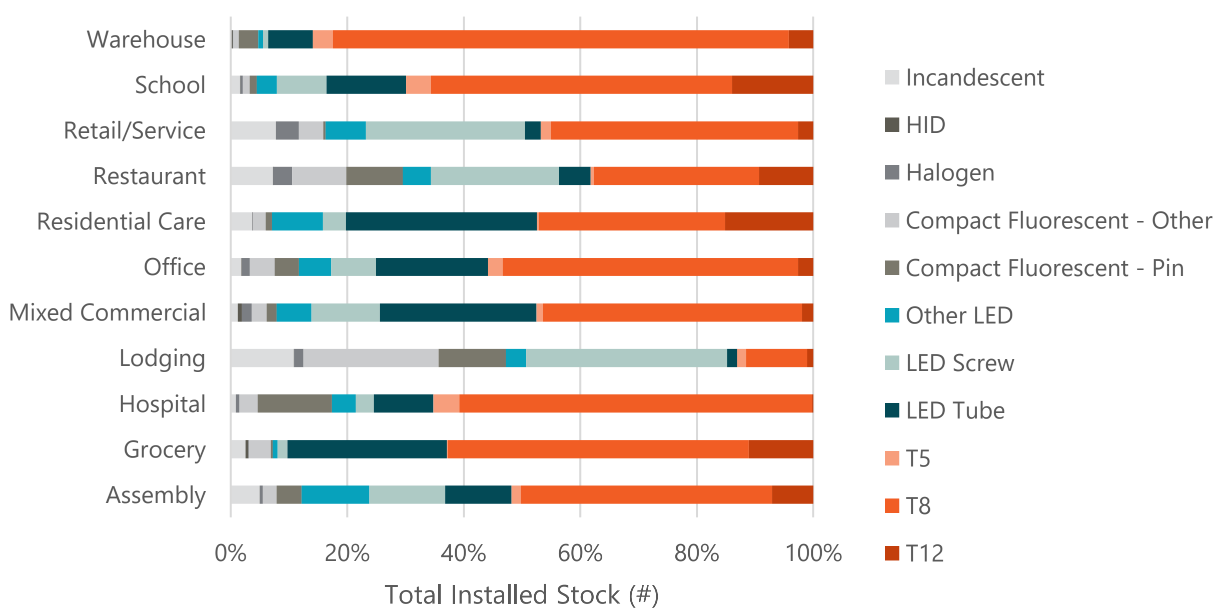
Source: 2020 CBSA

Figure 38. Distribution of 2014 and 2019 Floor Space by Building Year[47]



Source: 2020 CBSA

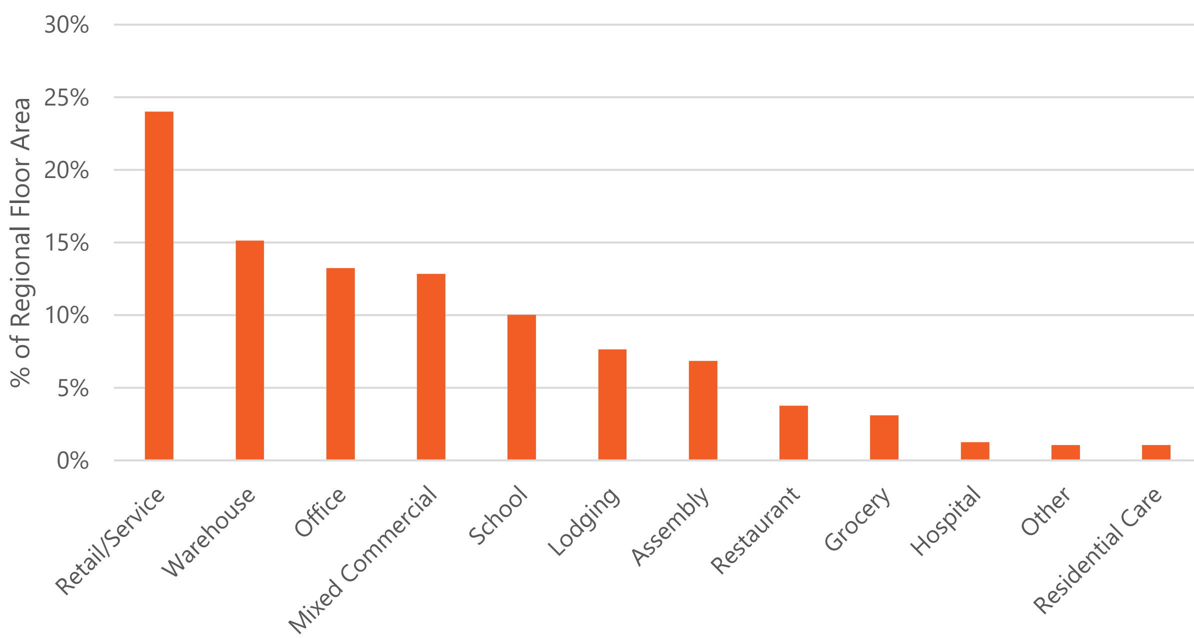
Figure 39. Commercial Indoor Lighting Technology Mix by Building Type



[47] NEEA used different sampling approaches for the CBSA in 2014 and 2019, resulting in uneven distributions of floorspace in the building samples between the two years.

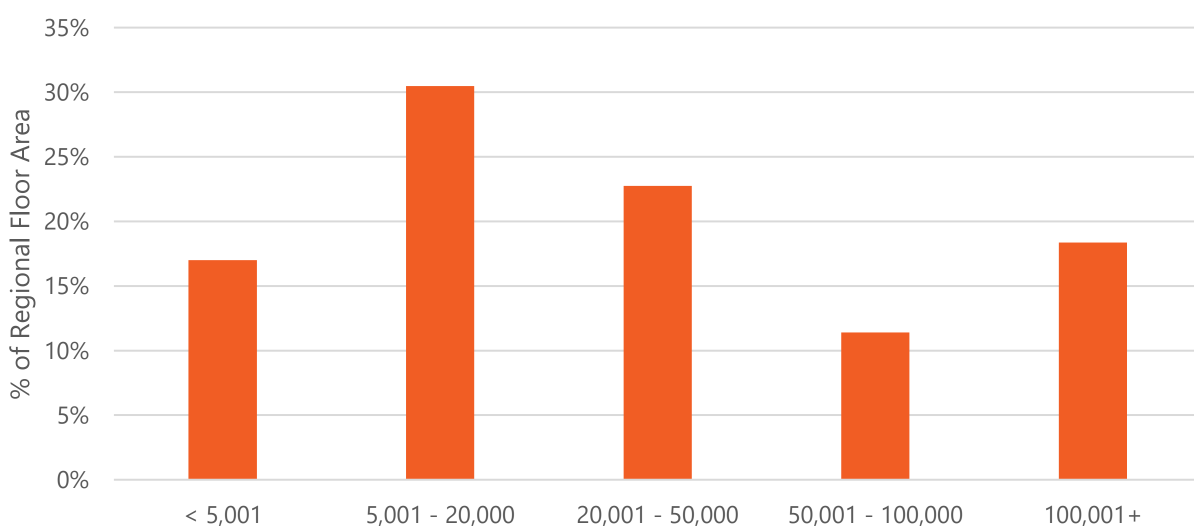
Source: 2020 CBSA

Figure 40. Regional Commercial Floor Area by Building Type



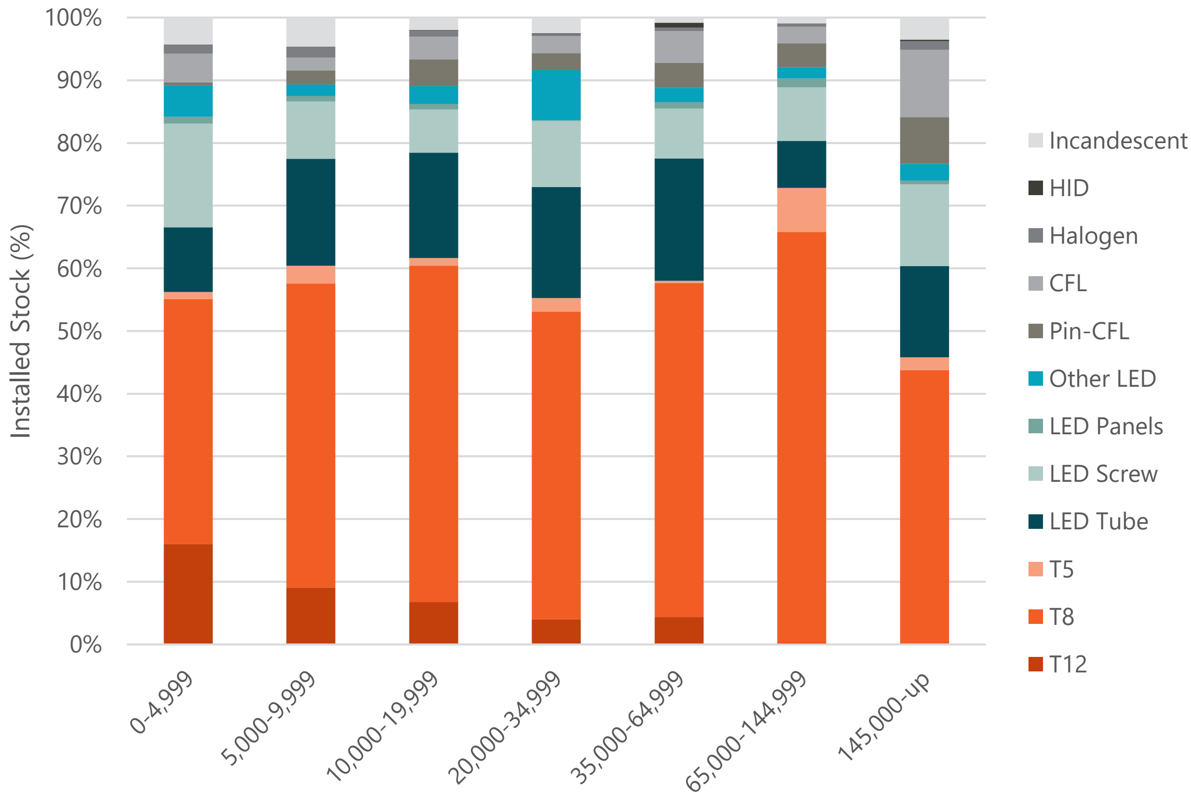
Source: 2020 CBSA

Figure 41. Regional Commercial Floor Area by Building Size



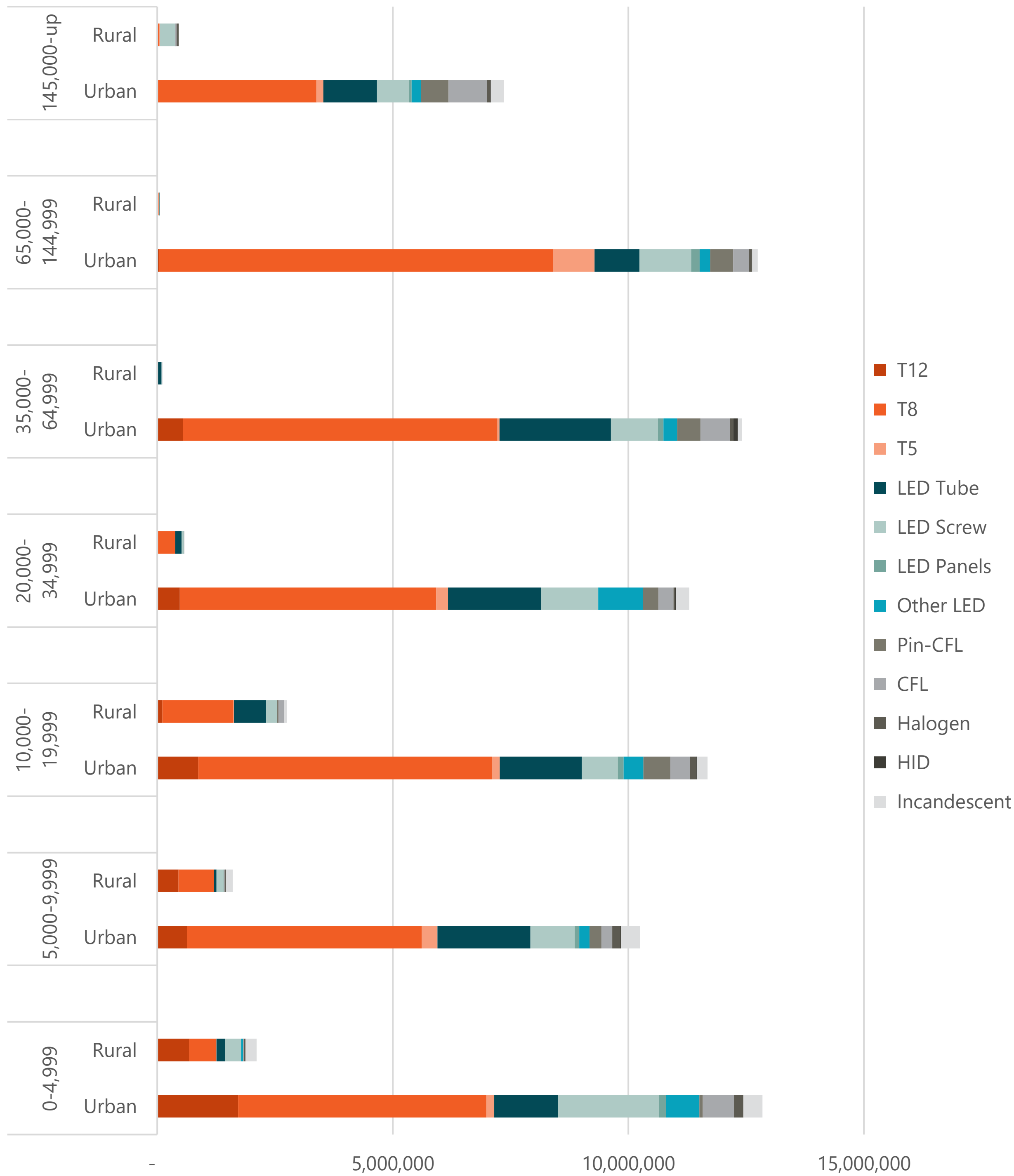
Source: 2020 CBSA

Figure 42. Commercial Lighting Technology Mix by Building Size



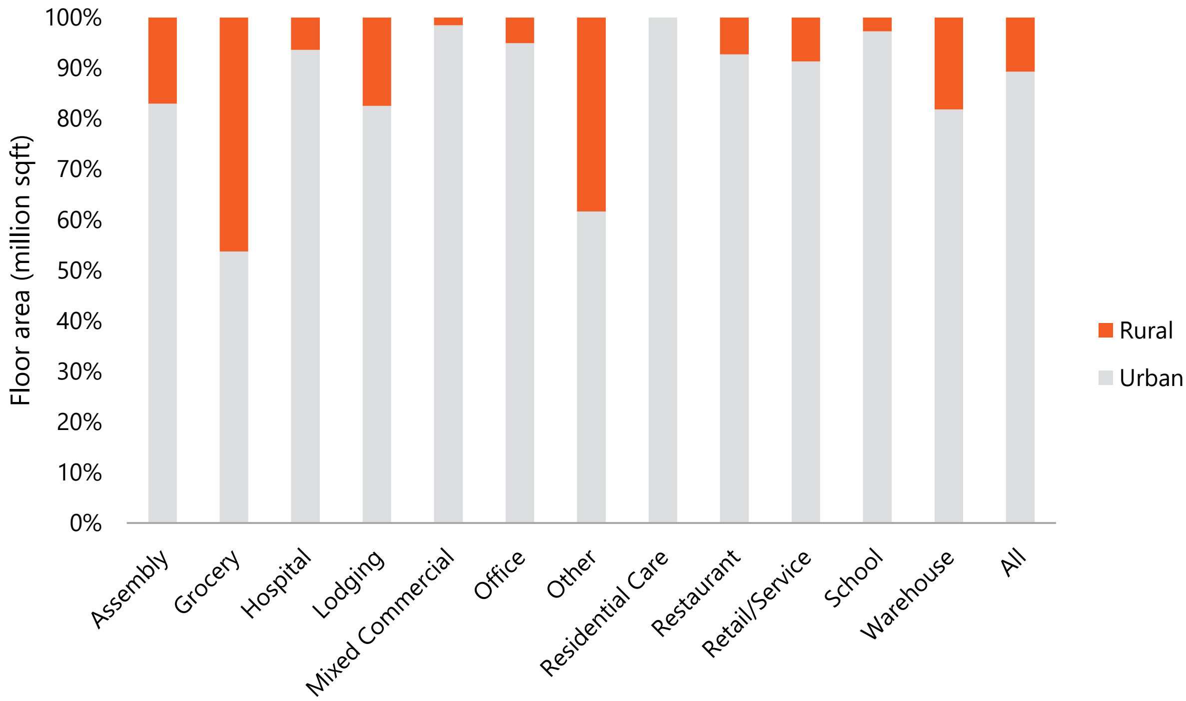
Source: 2020 CBSA

Figure 43. Commercial Lighting Technology Mix by Building Size in Urban vs Rural



Source: 2020 CBSA

Figure 44. Regional Floor Area by Building Type and Urban/Rural



Source: 2020 CBSA

Figure 45. Summary of DOE's Research and Findings in Agricultural Applications

Analysis Outputs	Units	Vertical Farming	Supplemented Greenhouse	High Intensity Sole-Source	Total[1]
Estimated Total Lit Grow Area	**Million ft^2**	0.8	56.6	31.9	89.3
Annual Operating Hours	**Hours/year**	6,570	2,000	5,200	--
Average Electricity Consumption					
LED	**W/ft^2**	15	7	35	--
HPS/MH		N/A	11	56	--
Fluorescent		23	N/A	5	--
2019 Technology Mix					
LED	**%**	100%	2%	11%	--
HPS/MH		0%	98%	86%	--
Fluorescent		0%	0%	3%	--
2019 Annual Energy Consumption					
Current	**GWh/year (tBtu/year)[3]**	81 (1)	1,202 (11)	8,307 (79)	9,591 (92)
Theoretical "All LED"		81 (1)	832 (8)	5,395 (52)	6,307 (60)
Theoretical % Lighting Energy Savings[2]	**%**	0%	31%	35%	34%

1. Values may not add due to rounding.
2. The theoretical percent energy savings given current technologies were all converted to LEDs, which is the percent difference in energy consumption of the Current and the Theoretical "All LED" scenarios. (Note percent energy savings are calculated from raw data, as opposed to rounded values presented in the table and, therefore, may not match.)
3. tBtu values given in this table are representative of source energy. Source energy consumption is calculated by multiplying site electricity consumption by a source-to-site conversion factor of 2.80 [34].

Source: 2019 DOE SSL in Agricultural Applications Report

Table 28. Streetlight Technology Mix by State

State	Urban				Rural				Overall			
	HID		LEDs		HID		LEDs		HID		LEDs	
	n	%	n	%	n	%	n	%	n	%	n	%
ID/MT	26,042	73%	9,835	27%	1,705	84%	334	16%	27,747	73%	10,169	27%
OR	28,428	21%	106,774	79%	362	27%	969	73%	28,791	21%	107,743	79%
WA	67,869	32%	141,024	68%	1,247	45%	1,537	55%	69,117	33%	142,560	67%
Total	**122,340**	**32%**	**257,633**	**68%**	**3,314**	**54%**	**2,840**	**46%**	**125,654**	**33%**	**260,473**	**67%**

Source: OLSA

Table 29. LPD Code Requirements by Building Type

Effective Dates	July 2014 - Dec 2019	1/1/2020-Present		The next version of ASHRAE	
Building Type	2014 Oregon Energy Efficiency Specialty Code (OEESC) (W/ft^2)	2019 Oregon Energy Efficiency Specialty Code (OEESC) (W/ft^2)	% Change (Compared to 2014 OEESC)	ASHRAE 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings	% Change (Compared to 2019 OEESC)
School/University	1.01	0.81	-20%	0.72	-11%
Retail	1.32	1.06	-20%	0.84	-21%
Office	0.91	0.79	-13%	0.64	-19%
Multifamily	0.58	0.68	17%	0.45	-34%
Automotive Facility	0.79	0.71	-10%	0.75	6%
Convention Center	1.08	0.76	-30%	0.64	-16%
Court House	1.05	0.90	-14%	0.79	-12%
Dining: Bar Lounge/Leisure	0.99	0.90	-9%	0.80	-11%
Dining: Cafeteria/Fast Food	0.90	0.79	-12%	0.76	-4%
Dining: Family	0.89	0.78	-12%	0.71	-9%
Dormitory	1.00	0.61	-39%	0.53	-13%
Exercise Center	0.88	0.65	-26%	0.72	11%
Gymnasium	1.00	0.68	-32%	0.76	12%
Healthcare - clinic	0.89	0.82	-8%	0.81	-1%
Hospital	1.08	1.05	-3%	0.96	-9%
Hotel/motel	1.00	0.75	-25%	0.56	-25%
Library	1.17	0.78	-33%	0.83	6%
Manufacturing Facility/Data Center	1.24	0.90	-27%	0.82	-9%
Motion Picture Theater	0.83	0.83	0%	0.44	-47%
Museum	1.04	1.06	2%	0.55	-48%

Parking Garage	0.25	0.15	-40%	0.18	20%
Penitentiary	1.00	0.75	-25%	0.69	-8%
Performing Arts Theater	1.39	1.18	-15%	0.84	-29%
Police Station	0.89	0.80	-10%	0.66	-18%
Fire Station	0.74	0.53	-28%	0.56	6%
Post Office	0.98	0.67	-32%	0.65	-3%
Religious Building	1.05	0.94	-10%	0.67	-29%
Sports Arena	0.78	0.87	12%	0.76	-13%
Town Hall	0.94	0.80	-15%	0.69	-14%
Transportation	0.77	0.61	-21%	0.50	-18%
Warehouse	0.66	0.48	-27%	0.45	-6%
Workshop	1.20	0.90	-25%	0.91	1%

Source: OEESC; ASHRAE 90.1 2019