BONNEVILLE POWER ADMINISTRATION

Non-Residential Lighting Northwest Market Model

JULY 2022

EXECUTIVE SUMMARY

Quantifying the Non-Residential Lighting Market

As efficient lighting technologies continue to drive significant energy savings in the Northwest, Bonneville Power Administration (BPA) has updated its non-residential lighting market model to represent the Northwest Power and Conservation Council's (the Council) Seventh Power Plan (Seventh Plan) action plan period (2016–2021). The model aims to improve the body of knowledge about this market in the Northwest region and build a more complete understanding of regional lighting energy consumption and savings patterns during the analysis period. This executive summary discusses the top-level findings and conclusions related to the market model, while more details on the mechanics of the model are found in the methodology memo.

QUICK HITS

150+ million lamp/fixture sales

43 electrical distributors reporting sales data

16 lighting technologies

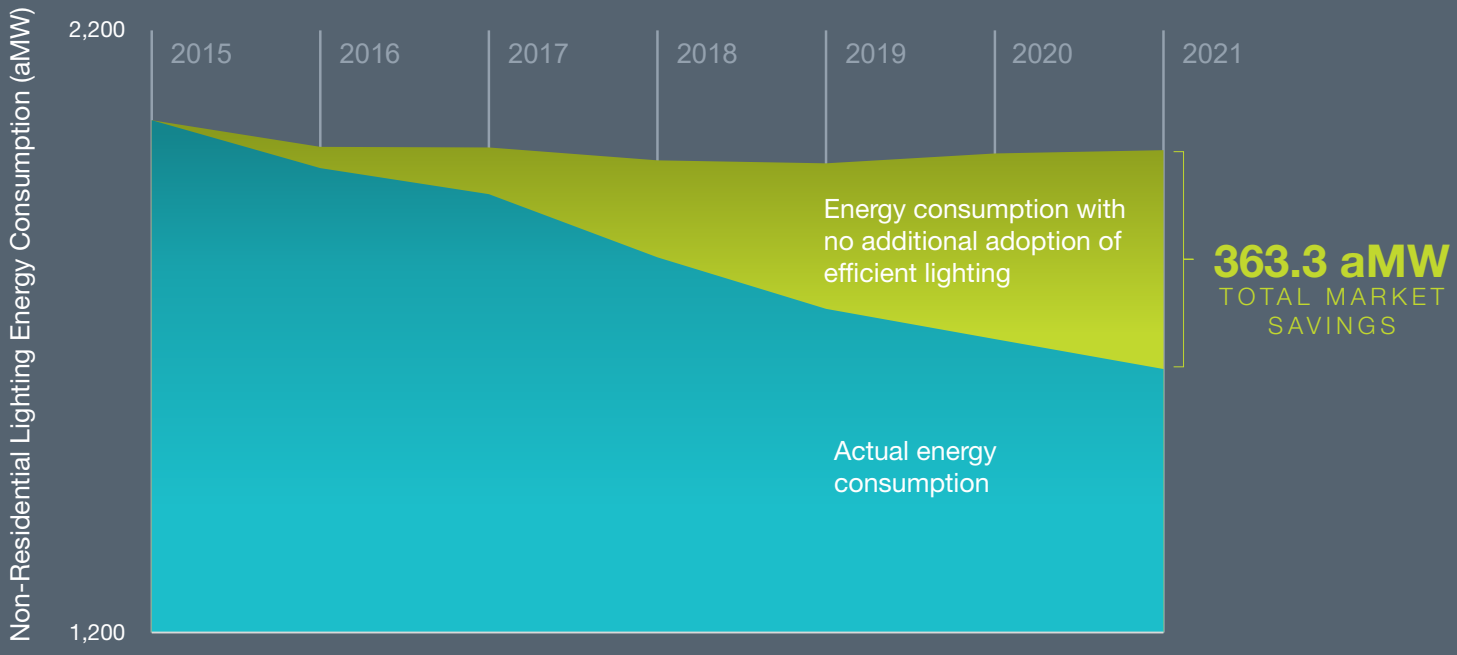
50% of the 2021 installed regional lighting stock is made up of LEDs

60.6 average megawatts (aMW) of Momentum Savings

The market model has three primary goals:

1. **Understand** changing energy consumption within the non-residential lighting market.
2. **Quantify** the adoption of LEDs within the market.
3. **Calculate** regional Momentum Savings.

Efficient lighting has created 363.3 aMW of total market savings since 2015



MODEL METHODOLOGY

Leveraging the Best Available Data

The model uses a stock-turnover mechanism to allow the installed stock of lamps each year to change over time. The stock-turnover mechanism has four main components:

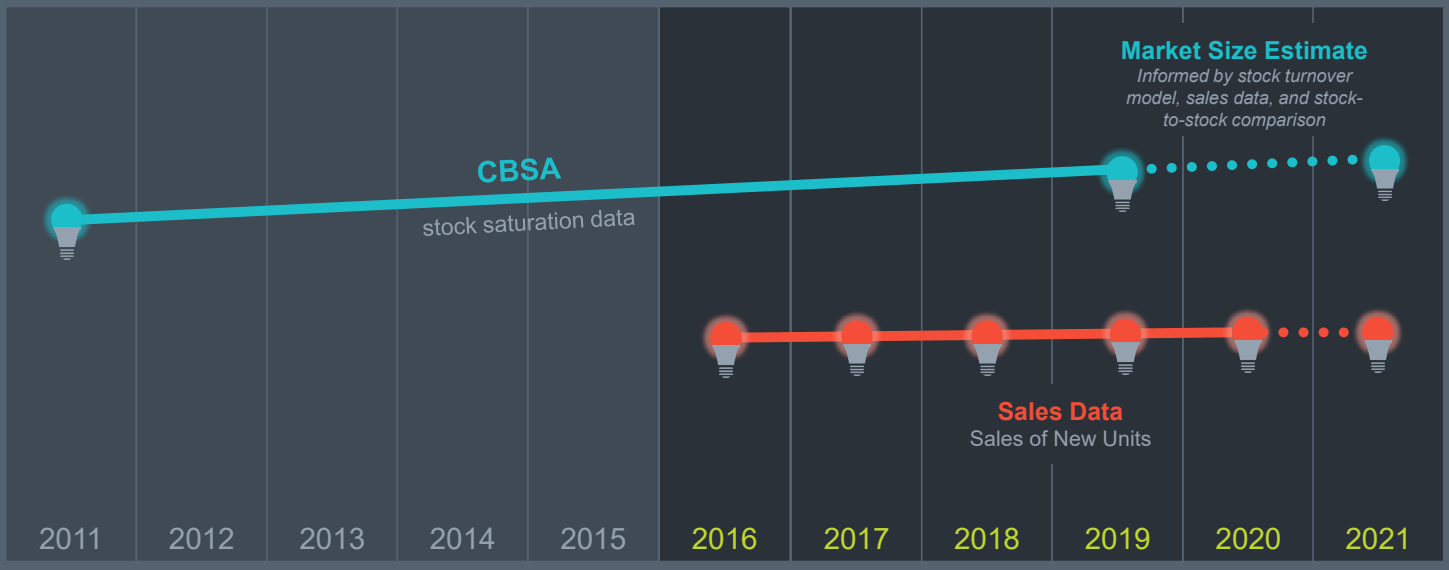
1. **Stock**
2. **Sales**
3. **Lifetime**
4. **Retrofit rate**

MODEL APPLICATIONS

- **Ambient Linear**
- **Building Exterior**
- **Decorative**
- **Downlight Large**[1]
- **General Purpose**
- **High/Low Bay**[2]
- **Parking Garage**
- **Parking Lot**
- **Street and Roadway**
- **Track**

[1] Directional lamps (pin and screw base) and downlight luminaires

[2] Bay lighting with ceiling height of at least 15 feet and/or lumen output of at least 5,000 lumens per fixture.



Note: Graph for illustrative purposes only

The model uses a diverse array of inputs to characterize the market. It simulates commercial, industrial, outdoor, and indoor-agricultural lighting in Oregon, Washington, Idaho, and Western Montana. Further, individual lighting applications within each sector are modeled separately to quantify a more granular understanding of application-specific trends. The most recent suite of updates to model inputs reflects the Seventh Plan action plan period, with 2015 as a baseline year. The research team modeled stock using the Northwest Energy Efficiency Alliance's (NEEA) Commercial Building Stock Assessment (CBSA). In this iteration of the model, the research team used the 2014 and 2019 CBSAs to align stock outcomes calculated by the model over time. The model leverages sales data collected from distributors and applies a calibration to that sales data to ensure the modeled stock mix is reflective of the CBSA over time. The research team estimates lifetimes and retrofit rates that are technology- and application-dependent.

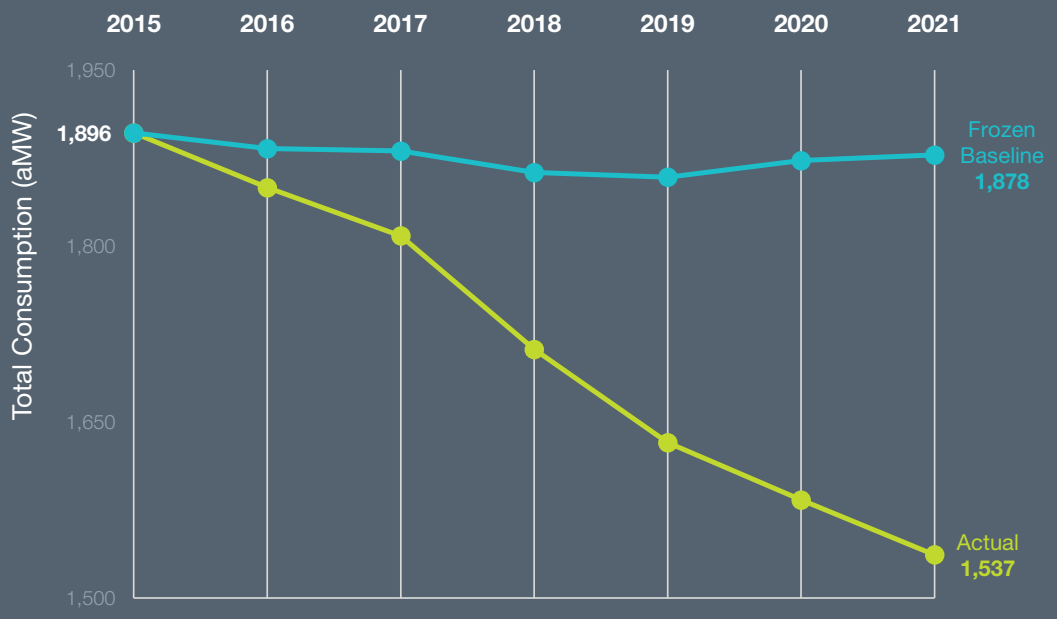
This stock-turnover logic allows the model to annually adjust the penetration of individual technologies in the market based on their expected lifetimes and changing sales patterns. The calibration of the sales data allows the research team to simultaneously rely on both the CBSA and the collected sales data where appropriate.

RESULTS

LED Adoption Continues to Save Energy

The model contains a variety of outputs relevant to market actors; however, the primary findings based on this model are consumption, total market savings, and Momentum Savings. Momentum Savings are cost-effective energy savings above the Northwest Power and Conservation Council's Power Plan baseline not directly paid for by regional utility programs or part of NEEA's net market effects. Other outputs of interest include application-level technology breakouts, burnouts and replacements, and changing product mixes.

Total lighting consumption 20% lower than baseline



Efficient Lighting Drives Decreasing Energy Consumption

Total lighting consumption in the market scenario decreased by nearly 20% over the analysis period because of efficient LEDs replacing less efficient technologies. The only application that showed growing lighting energy consumption was indoor agriculture.

WHAT ABOUT CONTROLS?

The model does not characterize the stock of lighting controls. BPA is pursuing further research into the controls market to determine whether characterizing controls stock may be possible in a future model (see below).

The figure above shows total market consumption (in average megawatts [aMW]) from non-residential lighting technologies for the baseline and actual scenarios. The research team froze the product mix entering the stock in 2015 to create the baseline scenario, causing the baseline consumption to remain relatively flat. In contrast, the research team allowed the actual scenario to continue adding more efficient technologies to the product mix, as represented in sales data collected from distributors around the region. This process led to a more efficient stock mix in the actual scenario and, therefore, decreased consumption.

The difference between the market and baseline scenarios is equivalent to the total market savings during the plan period. Total market savings continues to increase year over year because (1) the sales mix is gradually becoming more efficient, and (2) LEDs have long lifetimes, which means they do not require frequent replacement.

Innovating with New Data Approaches to Improve Stock Estimates

Stock assessments provide strong support to underpin the model calculations. During this round of model updates, three stock assessments were integrated into the model: the Commercial Building Stock Assessment (CBSA), the Outdoor Lighting Stock Assessment (OLSA), and an assessment of indoor agricultural lighting.

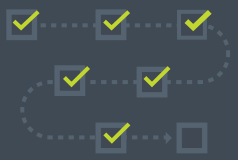
The CBSA, a survey implemented by NEEA, provides stock data that support assumptions about applications, technology breakouts, and a variety of building types. The most recent iteration of the CBSA collected data in 2019. This allowed the team to align the market model's characterization of lighting stock with the results of the 2019 CBSA. This alignment improves the reliability of the model results by ensuring an empirical basis for estimated changes in lighting stock over time.

The team also leveraged OLSA, the first regional assessment of outdoor lighting stock, for which BPA employed novel approaches. OLSA analyzed satellite nighttime imagery of streets across the Pacific Northwest as well as individually surveyed streets at different urban density intervals to estimate total stock size for outdoor lighting. The team leveraged the results of OLSA to validate the model's estimate of outdoor lighting stock size and mix of technologies.

Lastly, this round of model updates included an indoor agriculture module built with data and support from a variety of sources. Previous iterations of the model included indoor agriculture vis-à-vis the industrial sector, but detailed stock data sets were unavailable. In this model update, BPA obtained agricultural lighting stock data from Resource Innovation Institute to characterize the canopy area and technology distribution in the Pacific Northwest. This improved the model's quantification of changes in indoor agriculture such as LED conversions and canopy growth.

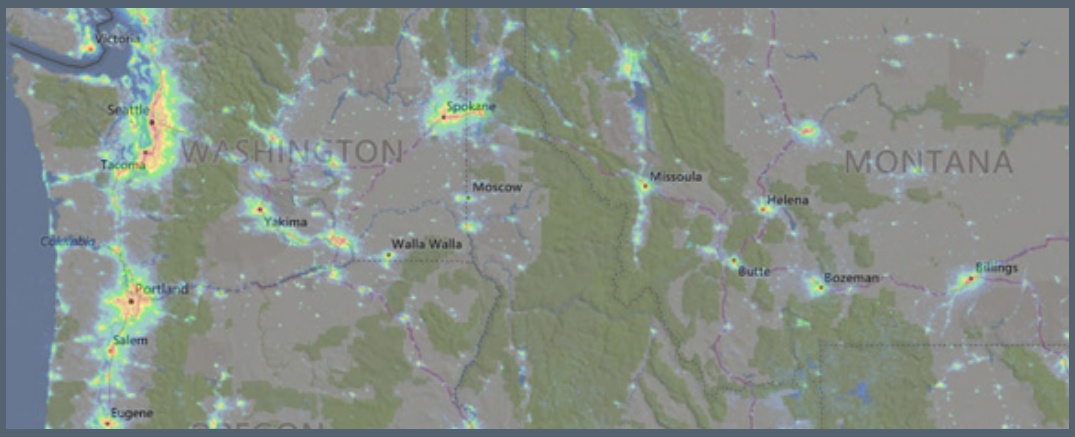
Data from Resource Innovation Institute characterizes indoor agriculture stock

OLSA characterizes outdoor street and roadway lighting application via satellite data



CBSA characterizes commercial sector as well as individual applications within the industrial sector via survey collection

Luminous flux at the census block level across the Pacific Northwest

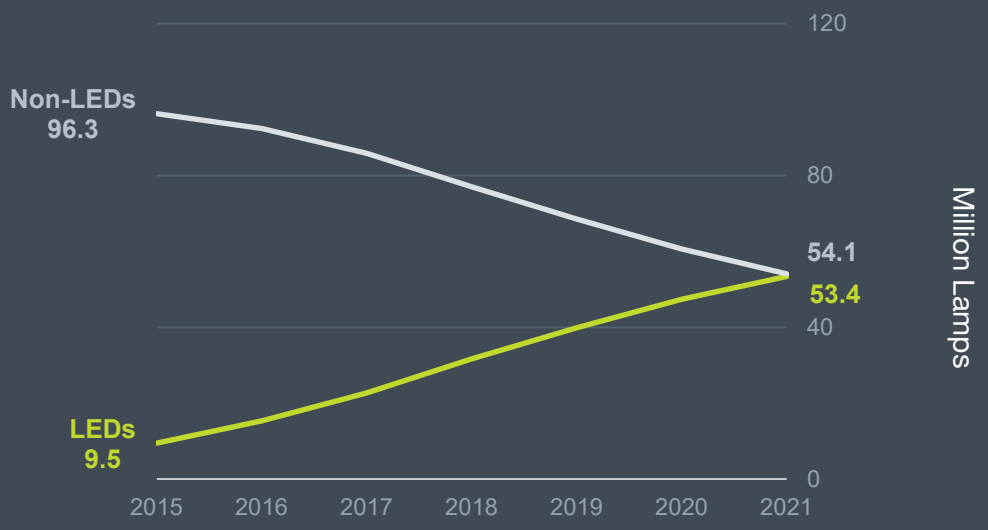


Note: Warmer colors denote higher luminous flux, an indication of greater density of outdoor lighting

LEDs are Now a Dominant Lighting Technology

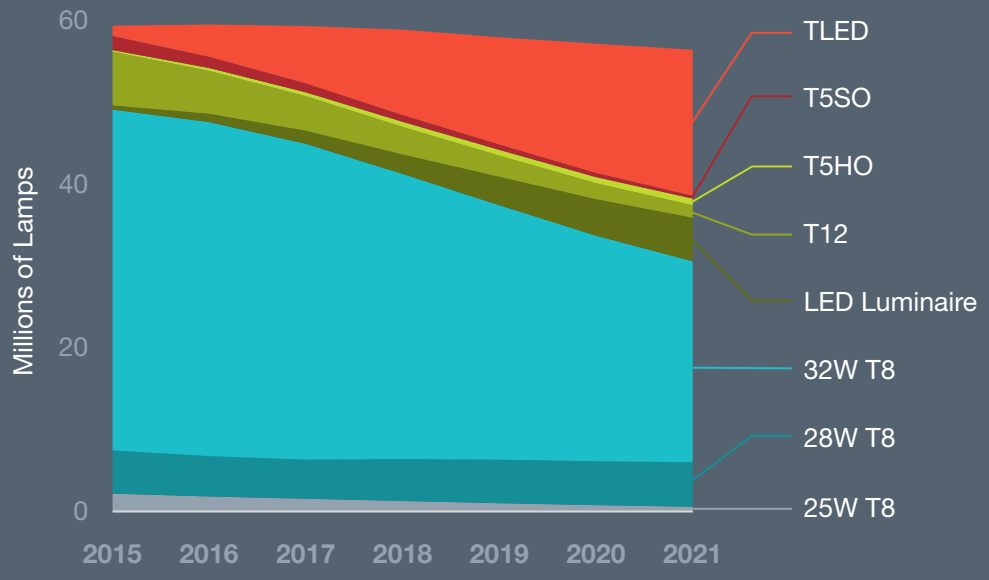
An additional result of this model is an understanding of the growth of LED penetration in the installed stock. The figure to the right shows LED growth over the plan period. Over the plan period, LED penetration rose from less than 10% of stock to 50% of stock—representing approximately 46 million additional LED lamps and fixtures entering the stock.

LEDs are close to outnumbering all other lighting technologies in the installed stock



More detailed findings from this model relate to application-specific market transformation trends. The largest individual application in the model (by consumption, lamp count, etc.) is ambient linear. This application represents overhead and ambient lighting, which linear fluorescent fixtures have traditionally dominated. The ambient linear application has experienced significant change over the plan period, including a marked increase in tubular LEDs (TLEDs). TLEDs have increased from 2% of the stock in this application in 2015 to 32% of the ambient linear stock in 2021, representing a growth of nearly 17 million lamps.

Ambient linear still dominated by fluorescent lamps, but TLEDs and LED Luminaires are gaining ground



RESULTS

LED Sales Have Skyrocketed, Eclipsing Less Efficient Technologies

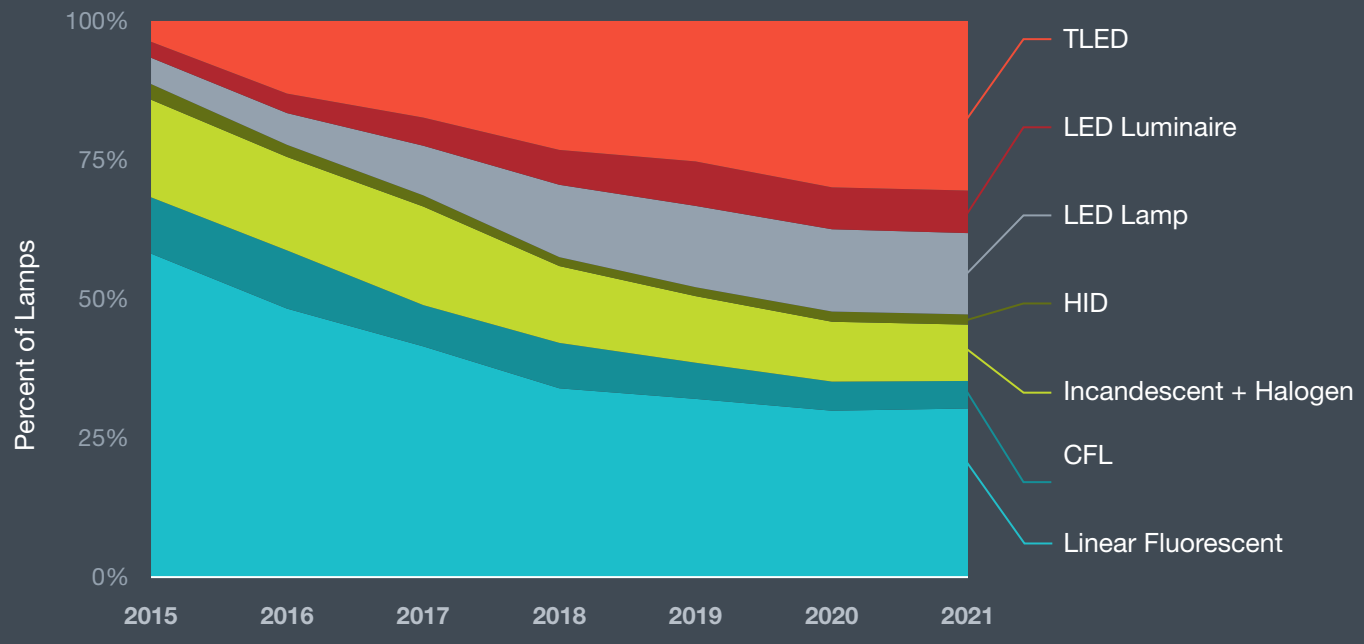
The model produced a detailed estimate of total market lighting sales by technology. The most dramatic trend over the analysis period has been the shift from 32-watt T8 linear fluorescent lamps toward TLEDs. Subtle but important trends include a decrease in the sales shares of incandescent, halogen, and CFL lamps, as well as high intensity discharge (HID) technologies. The model also shows slow but steady growth in sales of LED luminaires. This trend is particularly relevant in terms of energy savings because LED luminaires, with their long lifetimes and persistent savings, typically replace legacy technology lamp-bearing fixtures. An opportunity remains for energy efficiency programs to drive further adoption of LED luminaires, leading to lasting energy efficiency in buildings.

COVID IMPACTED THE LIGHTING MARKET

The COVID pandemic disrupted nonresidential construction activity and caused delays in the lighting supply chain. This model reflects the trends observed in sales data through 2020, including changes in sales caused by COVID. Future research will investigate the post-COVID recovery and the longterm impacts of COVID on lighting sales, turnover, and behavior.

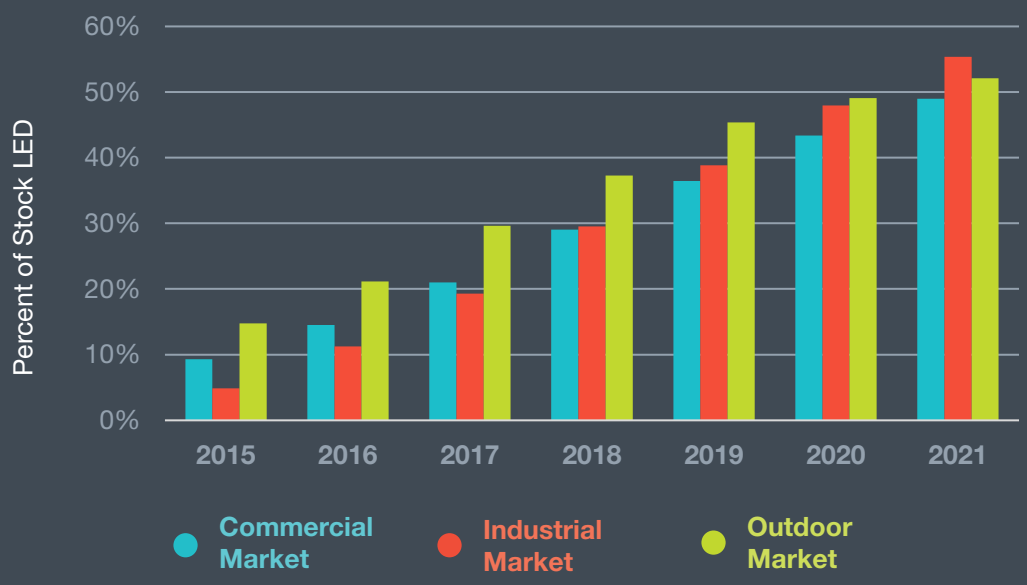
Sales Mix Shifting Dramatically Toward LEDs

LEDs have grown from marginal technology to the dominant technology in the sales mix



Some Applications Have Embraced LEDs More Rapidly

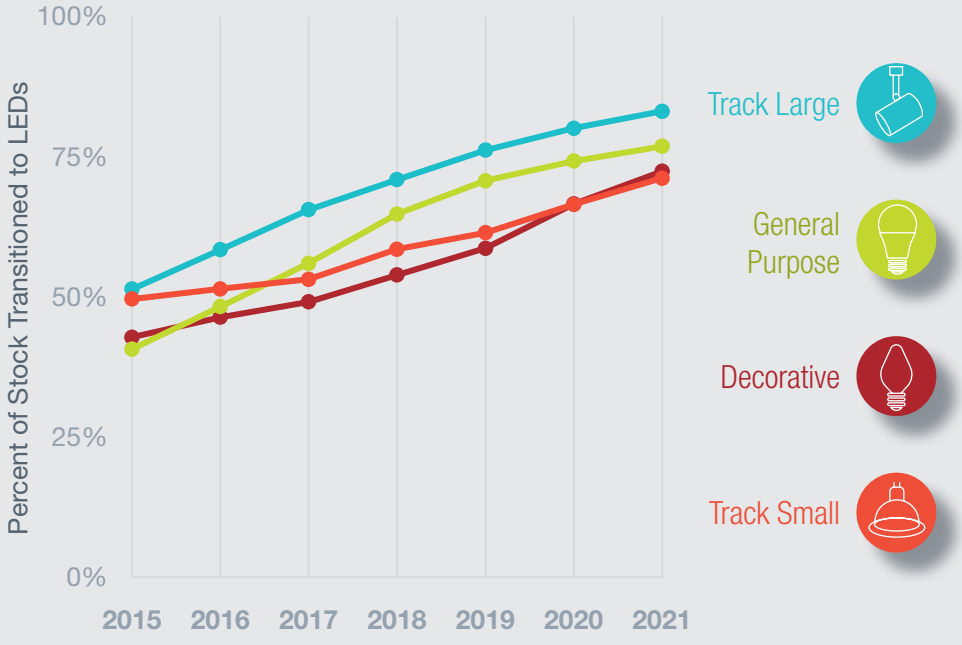
LEDs now dominant in all sectors



Earlier in the analysis period, the outdoor sector significantly outpaced commercial and industrial sectors in LED adoption. However, as LEDs have become more widely adopted, the penetration of LED by sector has evened out, with all sectors having an LED penetration of approximately 50% in 2021.

Certain applications have gained ground in LED adoption. The figure at right shows the applications with the highest share of LEDs: track (large and small), general purpose, and decorative. These four applications are all dominated by small lamps, and the legacy technologies that LEDs have displaced had short lifetimes. This indicates that as LED lamp quality increased and LED lamp pricing decreased, building operators took advantage of the easy upgrade to switch to LED lamps. Notably, these applications have also benefitted from the support of regional energy efficiency programs, which have offered discounted pricing on a variety of LED lamps for years.

Top performing applications by LED adoption



PROGRAMS DRIVE SAVINGS

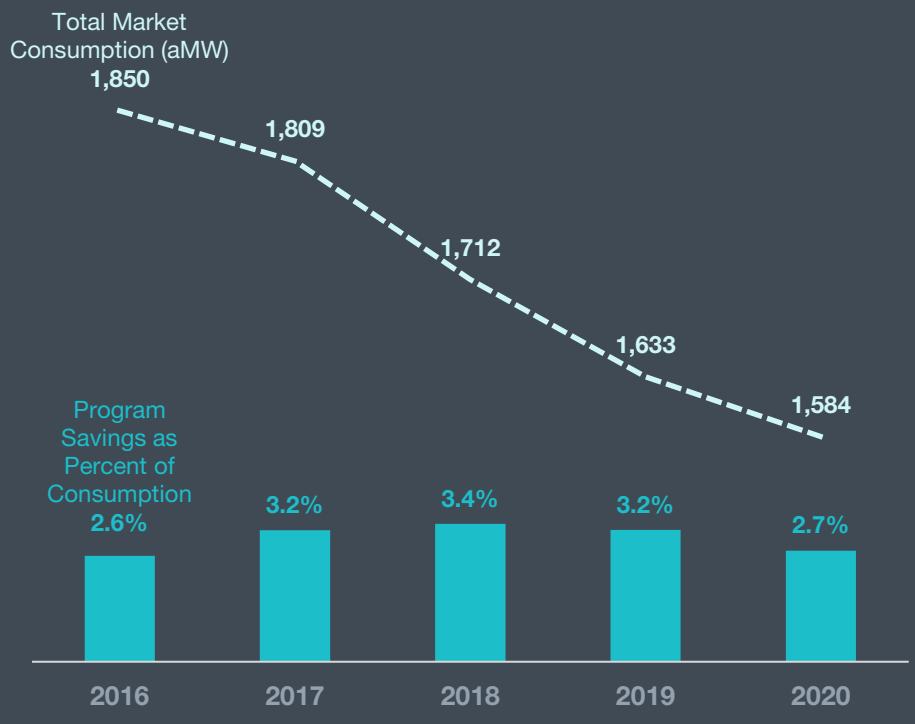
Regional energy efficiency programs drove the majority of the observed total market savings in non-residential lighting. As the baseline mix of efficiencies improves over time, programs have adapted to continue achieving deeper savings. As shown below, the model demonstrates the success that programs have achieved in this effort: year over year, programs continue to deliver savings that amount to approximately 3% of total market energy consumption. This shows that even as the "low-hanging fruit" opportunities to save energy have diminished, programs have continued to impact energy consumption in a meaningful way throughout the region.

LUMINAIRES STILL NEED A BOOST

An estimated 41% of lamps installed in ambient linear applications were LED in 2021, the majority being TLEDs. However, over 14 million linear fluorescent fixtures remain in this application's stock mix. Building operators can improve efficiency by upgrading these fluorescent fixtures to TLED lamps, but LED luminaires are an even better option for additional savings and better persistence.

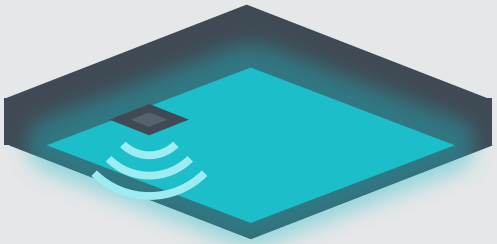
Programs Play an Ongoing Role in Lighting Market Transformation

Program impact is holding steady as consumption declines



LIGHTING CONTROLS

As the lighting industry has embraced LEDs, a new opportunity has developed: LEDs have enabled the proliferation of sophisticated controls systems. Controls technology has advanced rapidly as manufacturers look for ways to add functionality and value to high-performance LED lighting systems. Networked lighting controls, and especially luminaire-level lighting controls, can fine-tune lighting control according to daylight conditions, occupancy, and time schedules. As the Northwest continues to embrace LEDs as the best way to light buildings, programs can help building operators simultaneously adopt the best controls systems on the market, ensuring that not a single kilowatt-hour is wasted on lighting spaces.



Lighting an Intelligent Way Forward

Lighting continues to offer cost-effective energy saving opportunities as the region enters the 2021 Power Plan period. The model shows that the combined efforts of efficiency programs, federal standards, and industry innovation have resulted in massive market transformation. In particular, the model indicates that LED luminaires are a bright opportunity for highly persistent savings. This progress can continue, with remaining legacy lighting technologies waiting for upgrades to LEDs. As LEDs begin to become a standard practice in non-residential lighting, regional programs and research will also continue to promote and understand the opportunity to add controls.

WANT TO LEARN MORE?

Read the full reports:

- **Model Methodology**
- **Sales Data Summary**

Additional detail is available in the following data workbooks:

- **Model Input Documentation**
- **Model Export Tables**

Developed for the Bonneville Power Administration
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