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2020 Residential Lighting Market Analysis

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Executive Summary

Background

The Northwest Energy Efficiency Alliance (NEEA) has tracked trends across the residential retail lighting[1] market since 2005. This study is a 2020-2021 update to NEEA's Northwest Residential Lighting Long-Term Monitoring and Tracking (LTMT) Study and combines this most recent year of data with findings from past studies dating back to 2012. These findings provide valuable insights into longitudinal trends in lighting technologies[2], lamp applications[3], and prices in the Northwest region to guide utilities and other stakeholders on lighting baselines, savings, and the rapidly transforming residential lighting market.

Methodology

This LTMT study utilized two primary data sources to assess lamp sales mix (market share), price, wattage, efficacy (lumens/watt), and lifetime rated operating hours within the Northwest for the 2020-2021 update: a shelf stocking study and point of sale (POS) data analysis. Each source provided a unique set of lighting data:

- ***Shelf Stocking Study:*** The research team collected detailed information from lamps on the shelves of 34 small hardware, membership club, and do-it-yourself (DIY) stores in NEEA's utility partners' territories within Idaho, Montana, Oregon, and Washington during site visits in the winter of 2021. These are the store types for which point-of-sale (POS) data are not available.

- ***CREED[4] LightTracker POS data:*** The research team purchased detailed POS lighting sales data from the Nielsen Company[5] ("Nielsen") for mass merchandise, grocery, and drug stores in Idaho, Oregon, and Washington. After 2018, Nielsen stopped offering Montana POS data, so as a proxy

[1] While the study is referred to as a residential retail lighting study, some retail sales go to the commercial market segment. NEEA does not include the commercial sector in its savings modeling.

[2] LED, CFL, halogen, and incandescent.

[3] General purpose, reflector, globe, decorative, and three-way.[4] The Consortium for Retail Energy Efficiency Data (CREED) is a consortium of program administrators, retailers, and manufacturers working together to collect the necessary data to better plan and evaluate energy efficiency programs. LightTracker is CREED's first initiative, focused on acquiring full-category lighting data, including incandescent, halogen, CFL, and LED bulb applications, for all distribution channels in the United States.

[4] The Consortium for Retail Energy Efficiency Data (CREED) is a consortium of program administrators, retailers, and manufacturers working together to collect the necessary data to better plan and evaluate energy efficiency programs. LightTracker is CREED's first initiative, focused on acquiring full-category lighting data, including incandescent, halogen, CFL, and LED bulb applications, for all distribution channels in the United States.

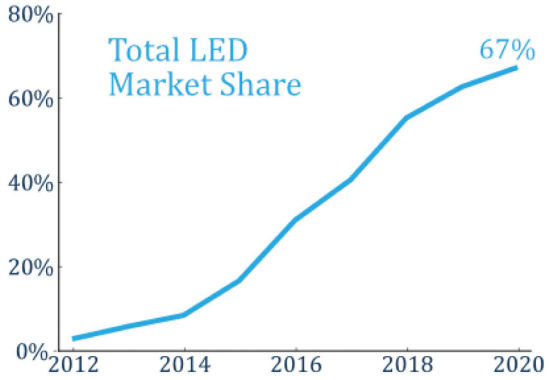
[5] The Nielsen Company is a global marketing research firm.

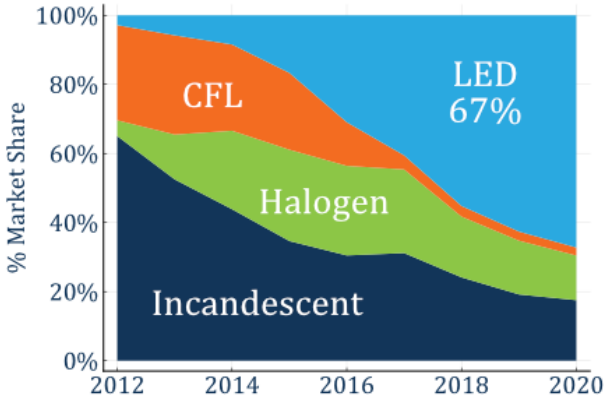
for 2019 and 2020 the team adjusted the 2018 Montana data using the changes in Wyoming's market shares in each of those years.[6] CREED team cleaned and corrected all the states' data.

Key Findings

The results of this analysis are presented in this report and are also available in a database here. The following key findings emerged from the research team's analysis.

The lighting market continued its shift toward LEDs across all applications in 2020. Overall, LEDs accounted for 67% of all Northwest lamp sales in 2020, up from 63% in 2019. LEDs made up a larger proportion of general purpose lamp sales (70%) and reflector lamp sales (76%) than specialty lamps[7] (63%).



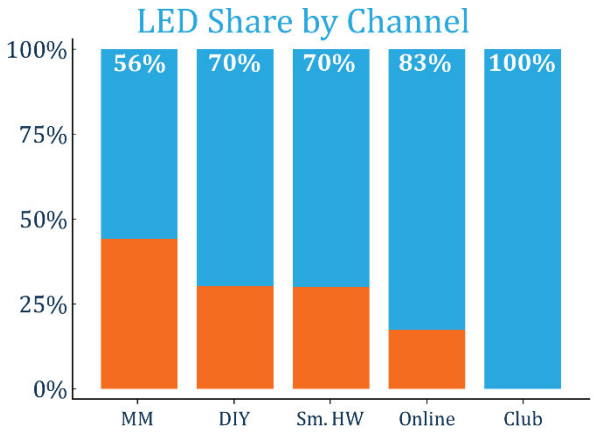


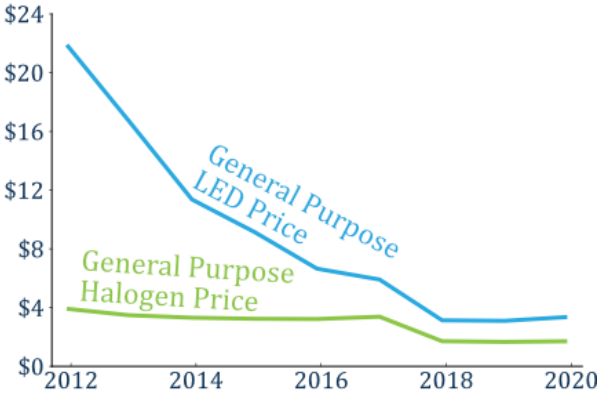
As in 2019, continued gains in LED share in 2020 came at the expense of incandescent and halogen lamps. LEDs rose to 67% of total Northwest lamp sales in 2020 from 63% in 2019 while incandescents fell to 18% and halogens to 13%.

[6] The methodology section in the body of the report and Appendix A describes the Montana approach in more detail.

[7] Specialty lamps are non-reflector specialty styles (i.e., globe, decorative, and three-way).

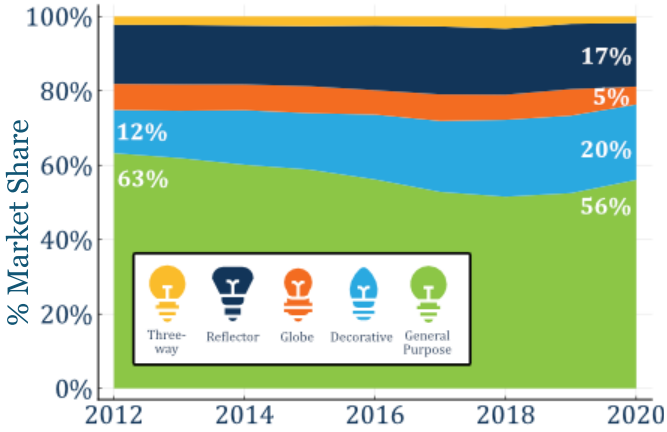
Grocery, dollar, and mass merchandise retailers ("MM" in figure) may present the greatest opportunity to further increase LED market share. LEDs grew rapidly from 46% in 2019 to 56% in 2020 of lamp sales on average across this combined channel. However, the MM LED market share was still lower than other channels and represents the second-largest volume of lamp sales at 29%. Although the Do-It-Yourself (DIY) channel comprises 50% of sales, its LED share has reached 70%. In the small hardware, club, and online channels, LEDs are 70% to 100% of sales.





Prices for general purpose LEDs (after any efficiency program, manufacturer, or retailer discounts[8]) increased slightly from 2019 to 2020[9]. General purpose LED lamps cost an average of $3.36 in 2020, an increase of 8% from 2019. This may be because fewer utilities are now offering general purpose LED rebates. General purpose LED prices decreased by 86% since 2012 and general purpose halogen prices dropped by 61% since 2012.[10]

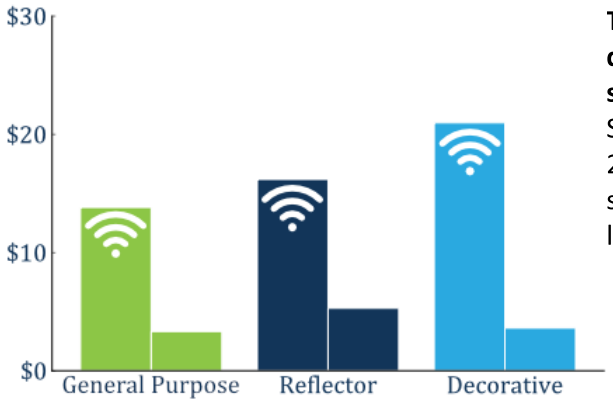
The sales share for general purpose lamps across all technologies fell from 63% in 2012 to 56% in 2020. This decline is likely because the share of longer-lived general purpose LEDs is increasing, resulting in less frequent replacement and thus fewer sales. That said, the share of general purpose lamps increased in 2020 (56%) relative to 2019 (52%). This may be due to the Covid-19 pandemic; people spent more time at home and so may have purchased more lamps.



[8] As part of the 2017-2018 analysis, NEEA conducted an analysis of pre-incentive lamp prices. The resulting memorandum was not formally published but is available on request. This analysis was updated by NEEA internally in 2018-19, and was updated by staff of the Regional Technical Forum (RTF) in late 2019-20.

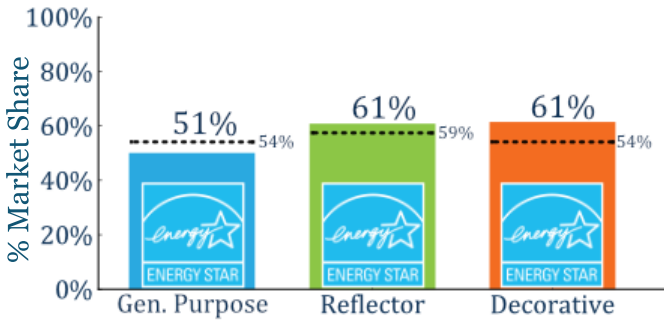
[9] Chart prices are in 2012 dollars to remove any inflation effects.

[10] Calculated in "real" terms with 2012 as the base.



The market share of Smart LEDs[11] more than doubled between 2019 and 2020, but their share is still relatively low at 2.3%. The market share of Smart LEDs increased from 1% in 2019 to 2.3% in 2020 across all applications. Prices of Smart LEDs are still at least four times more than standard LEDs, a likely factor in their still-modest market share.

Among general purpose LEDs, the share of ENERGY STAR-certified LEDs[12] fell between 2019[13] and 2020 but increased for other applications. The dotted lines in the figure indicate 2019 shares, while the bars indicate 2020 shares. As shown, for general purpose LEDs, the share of ENERGY STAR lamps fell from 54% in 2019 to 51% in 2020, the lowest share among applications. However, for reflector LEDs, the share increased from 59% to 61%, and for decorative increased substantially from 54% to 61%.



[11] Referred to more generically as "smart lamps", these are LED light bulbs that can be communicated with and controlled wirelessly.

[12] ENERGY STAR-certified bulbs have a 40% longer lifetime than non-ENERGY STAR bulbs.

[13] 2019 values are shown in dotted lines on the chart for comparison purposes.

1. Introduction and Objectives

This report presents findings from the 2020-2021 update to NEEA's Residential Lighting Long-Term Monitoring and Tracking (LTMT) Study, which assesses the current state and historical trends of the Northwest residential lighting market. NEEA has overseen this study since 2011 using a consistent methodology that enables NEEA and its regional partners to track trends in the lighting market. NEEA contracted with Apex Analytics, LLC and DNV ("the research team") to undertake the 2019-2020 study. This report details the methods and findings of this research. Results are also available in a database here.

2. Methodology

The research team relied on two primary data collection activities for the 2020-2021 LTMT effort: a shelf stocking study and point of sale (POS) data analysis.

Shelf Stocking Study

The research team collected detailed information from lamps on the shelves of 34 small hardware, membership club, and do-it-yourself (DIY) stores in NEEA's utility partners' territories within Idaho, Montana, Oregon, and Washington during site visits in February and March 2021. The team attempted to survey the same store locations that were visited during last year's analysis period.[14] These are the store types for which Nielsen POS data are not available.

Table 1 outlines the number of shelf surveys completed at each store type during the 2020-2021 analysis period. Appendix A (Shelf Survey Sample Design) provides more detail on the sample design.

Table 1: Shelf Survey Sample by Retail Channel

Retail Channel	Shelf Surveys Completed
DIY	11
Small Hardware	20
Membership Club	3
Total	34

[14] Field staff were able to complete shelf stocking surveys in all of the same stores that were surveyed in 2020 except one. Because of restrictions in place due to the Covid-19 pandemic, field staff were not allowed to enter one store in Salem, OR. The team selected a backup store in Salem in the same retail channel and completed a shelf survey there.

CREED[15] LightTracker POS data

For the 2020-2021 study, the research team purchased detailed POS lighting sales data from Nielsen for mass merchandise, grocery, and drug stores in Idaho, Oregon, and Washington. After 2018, Nielsen stopped offering Montana POS data, so as a proxy for 2019 and 2020 the team adjusted the 2018 Montana data using changes in Wyoming's market shares in each of those years. (See Appendix B for additional detail.) As a result, the pricing and wattage in this report is based only on Idaho, Oregon, and Washington.

Sales-to-Stocking Ratio Assumptions

During the 2018-2019 analysis period, the research team had updated the sales-to-stocking ratio assumptions. Previous years' studies had used a ratio of one lamp sold for every lamp stocked on the shelf ("1:1") for all store and lamp types. However, findings from store manager interviews in 2018-2019 had indicated that small hardware stores understock LEDs and overstock incandescents and halogens; therefore, better estimates for the sales-to-stocking ratios are 2:1 for LEDs and 1:2 for incandescent and halogen lamps within this store type. Interview findings indicated that the 1:1 sales-to-stocking ratio was still appropriate for store types other than small hardware.

The store managers interviewed across all store types also indicated that stocking practices change frequently enough that a shelf survey conducted only once per year does not accurately represent a full year. Thus, the research team retained the methodology from previous years' studies of using an average of two years of shelf stocking data in calculations.

Chain Logic Model Methodology

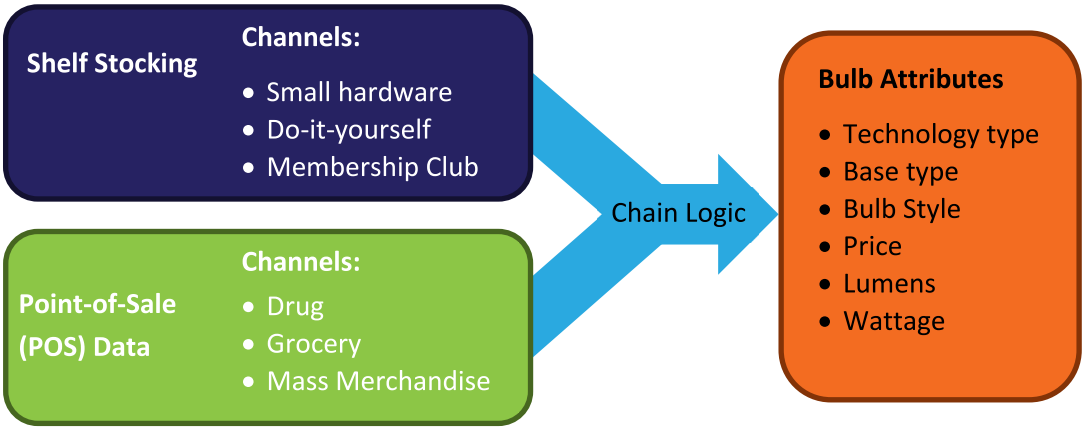
For 2020-21, the research team combined the weighted shelf stocking and POS data using the "Chain Logic Model Methodology" established in the 2016-2017 Northwest Residential Lighting LTMT study.[16] The Methodology estimates market shares based on shelf stocking data. It draws on assumptions about the ratio of products stocked to products sold and the market share of each retail channel to generate estimates of total sales volume. Figure 1 illustrates how the shelf stocking and POS data complement each other to provide data on a range of lamp attributes across retail channels.[17] See Appendix C for additional detail.

[15] The Consortium for Retail Energy Efficiency Data (CREED) is a consortium of program administrators, retailers, and manufacturers working together to collect the necessary data to better plan and evaluate energy efficiency programs. LightTracker is CREED's first initiative, focused on acquiring full-category lighting data, including incandescent, halogen, CFL, and LED bulb applications, for all distribution channels in the United States.

[16] See Appendix C: Chain Logic Model Methodology for further detail.

[17] See appendices for full list of attributes.

Figure 1: Data Sources



3. Findings

This section begins with a summary of lighting market characteristics, including sales and pricing trends, based on the shelf survey and POS data.

Lamp Sales Trends

LED Share of All Lamp Sales

The lighting market continued its shift toward LEDs. As shown in Figure 2, LEDs accounted for 67% of all Northwest lamp sales in 2020, up from 63% in 2019. As in 2019, the increase came at the expense of incandescents and halogens (Figure 3). The total market share of halogens and incandescents fell from 16% and 19% in 2019, to 13% and 18% in 2020, respectively.

Figure 2: LED Market Shares

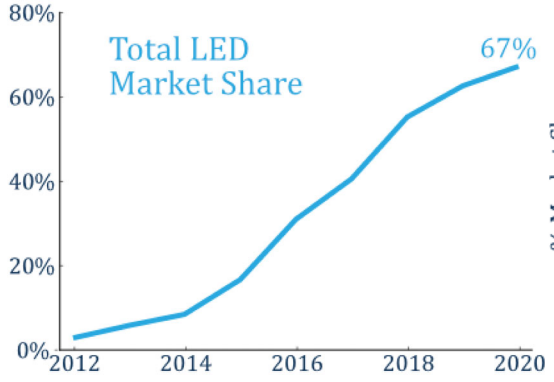
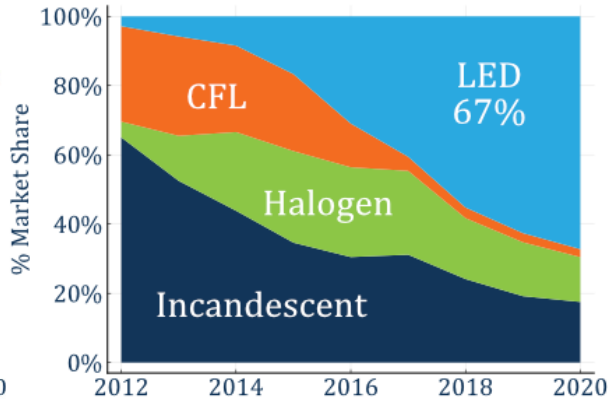


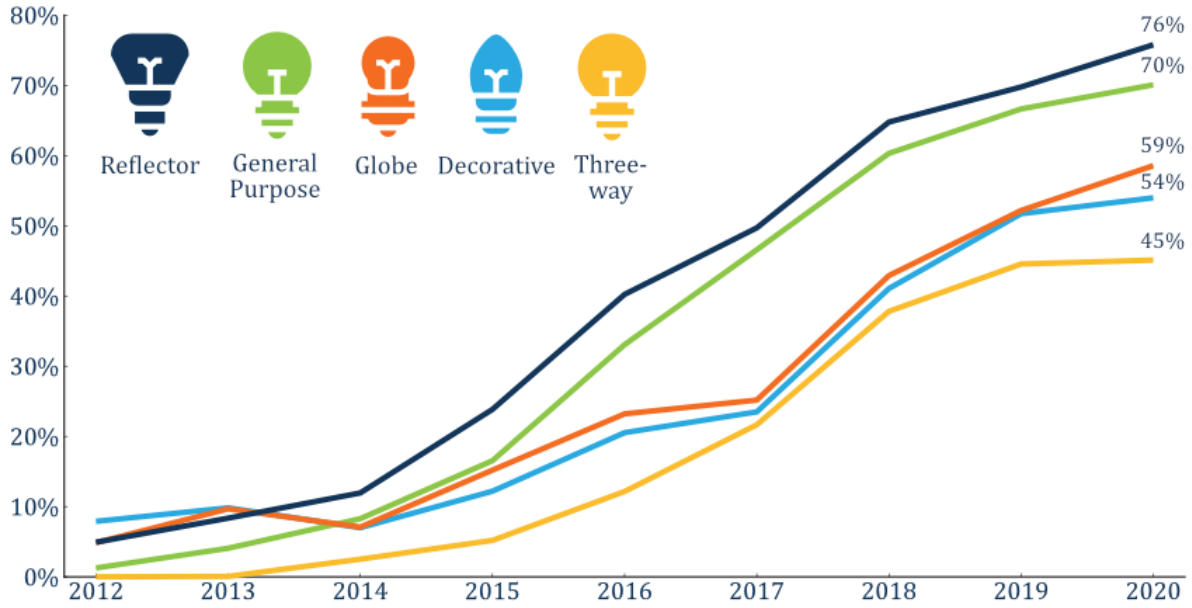
Figure 3: Market Shares by Technology



LED Technology Share by Lamp Application

Figure 4 shows the growth in LED technology share within each lamp application.[18] Reflector lamps continue to have the highest LED technology share, reaching 76% in 2020, up substantially from 70% in 2019. They again outpaced the LED share of general purpose lamps which reached 70%, up from 67%. The LED shares of specialty lamps (decorative/mini-base, globe, and three-way) continued to lag behind reflectors and general purpose lamps. However, the LED shares of both decorative/mini-base and globe lamps grew from 52% in 2019 to 59% and 54% in 2020, respectively. The LED share of three-way lamps remained at 45%.

Figure 4. LED Technology Shares by Application, 2012-2020



Data source: Weighted combination of sales data and NEEA shelf data

Technology Share by Lamp Application

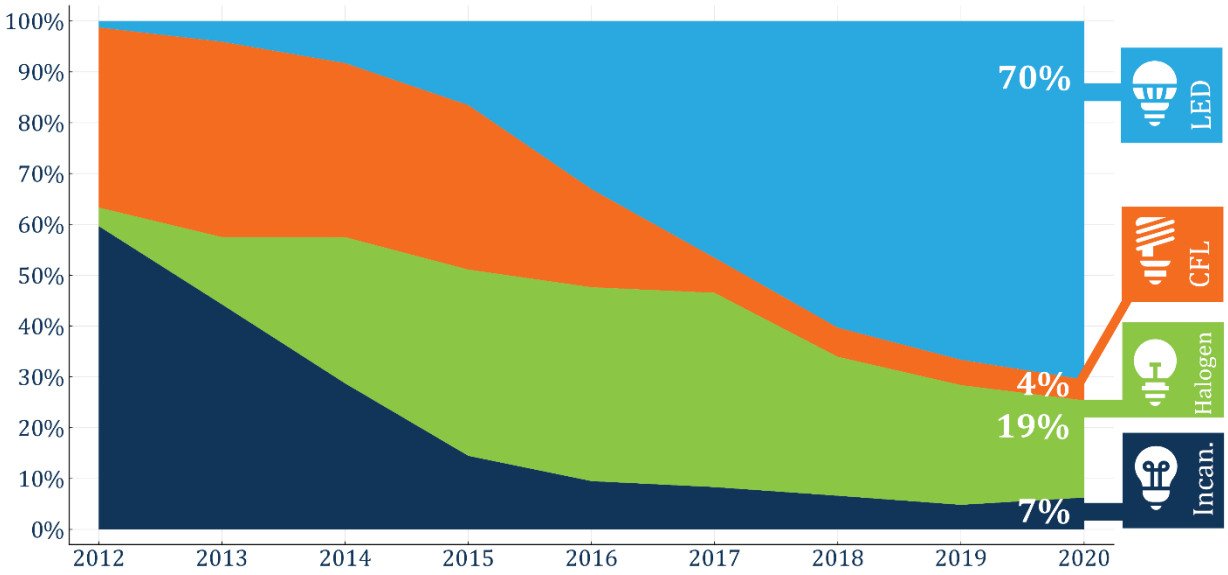
The following four figures show the changes from 2012 to 2020 in the shares of technologies within different lamp applications.

Figure 5 shows the change in technology share from 2012 to 2020 within the **general purpose** lamp application. By 2020, 70% of general purpose lamps sales were LEDs, up from 67% in 2019. This growth came at the expense of halogens and CFLs whose share fell from 24% and 5% in 2019, to 19% and 4% in 2020, respectively. Apex's analysis also showed that among the remaining 7% incandescent general

[18] The lamp applications considered in this study were general purpose, reflector, globe, decorative, and three-way.[19] EISA (Energy Independence and Security Act of 2007) requires most light bulbs to be more efficient than standard incandescent bulbs.

purpose lamps sold in 2020, most are either under 310 lumens or over 2600 lumens, both of which are exempt from EISA[19]. Incandescent lamps in other lumen categories between 310 and 2600 lumens are presumably rough service[20] and 3-way (although if retailers have remaining lamps in stock that are not allowed by EISA they can still sell them).

Figure 5. General Purpose Lamps – Technology Shares, 2012-2020



Data source: Weighted combination of sales data and NEEA shelf data

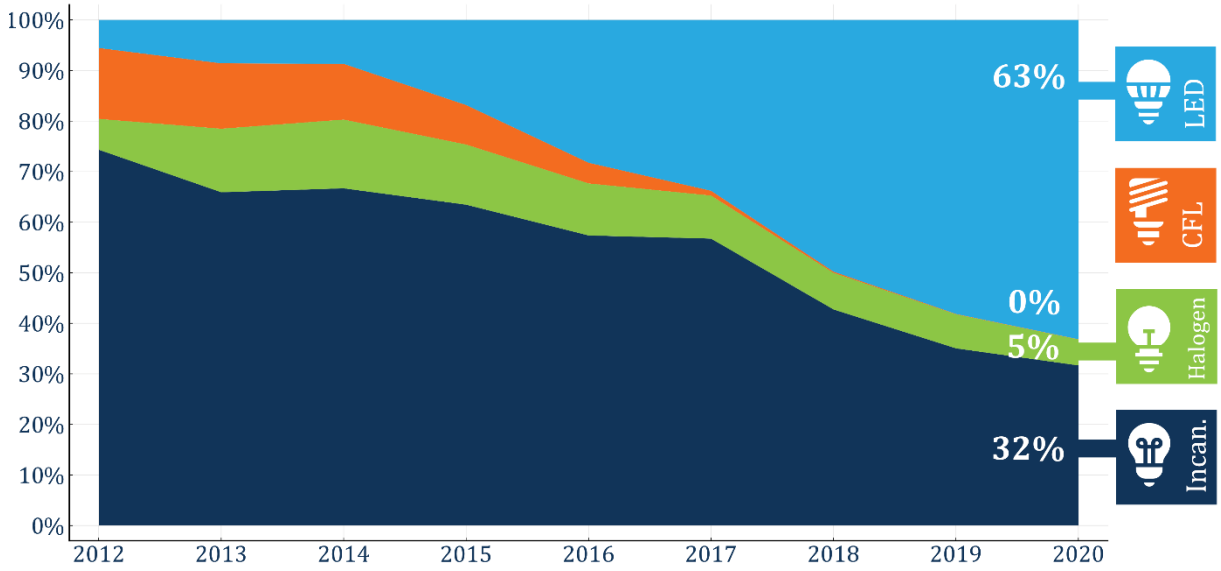
The next three figures, Figures 6, 7, and 8, present information on changes in technology shares from 2012 to 2020 for reflectors and specialty lamps (decorative/mini-base, globe, and three-way).

Figure 6 illustrates changes in technology shares for reflector and specialty lamps combined. As shown, the LED technology share increased from 58% in 2019 to 63% in 2020 at the expense of incandescents which decreased from 35% to 32%, and halogens which decreased from 7% to 5%.

[19] EISA (Energy Independence and Security Act of 2007) requires most light bulbs to be more efficient than standard incandescent bulbs.

[20] Rough service incandescent lamps are designed to be resistant to vibration and other external stresses that can damage the filament of a regular incandescent lamp.

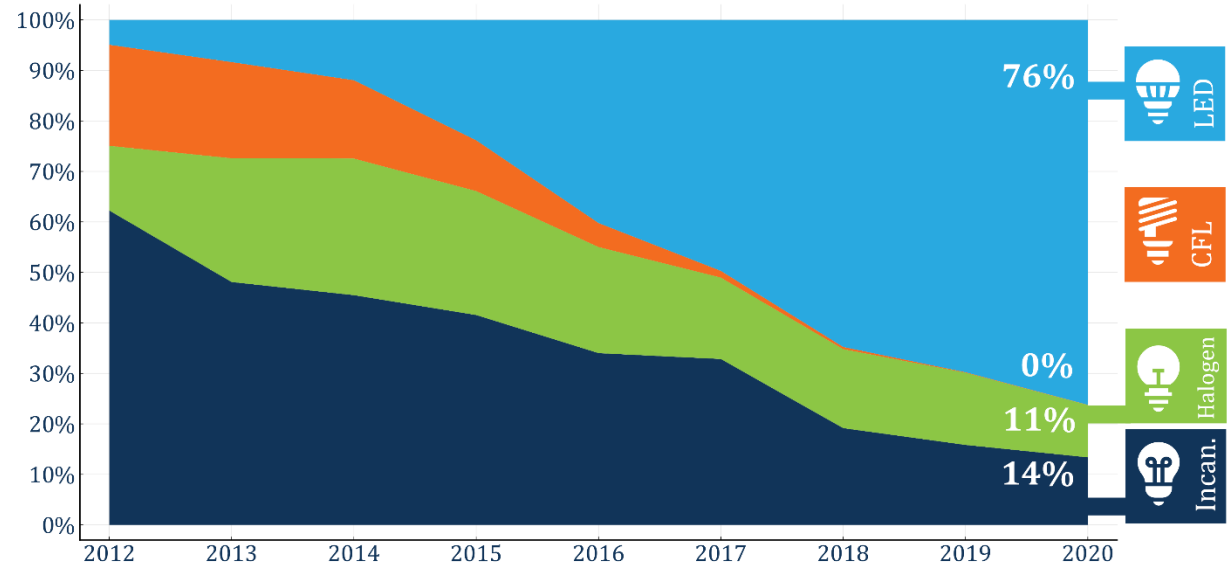
Figure 6. Reflector and Specialty Lamps Combined – Technology Shares, 2012-2020



Data source: Weighted combination of sales data and NEEA shelf data

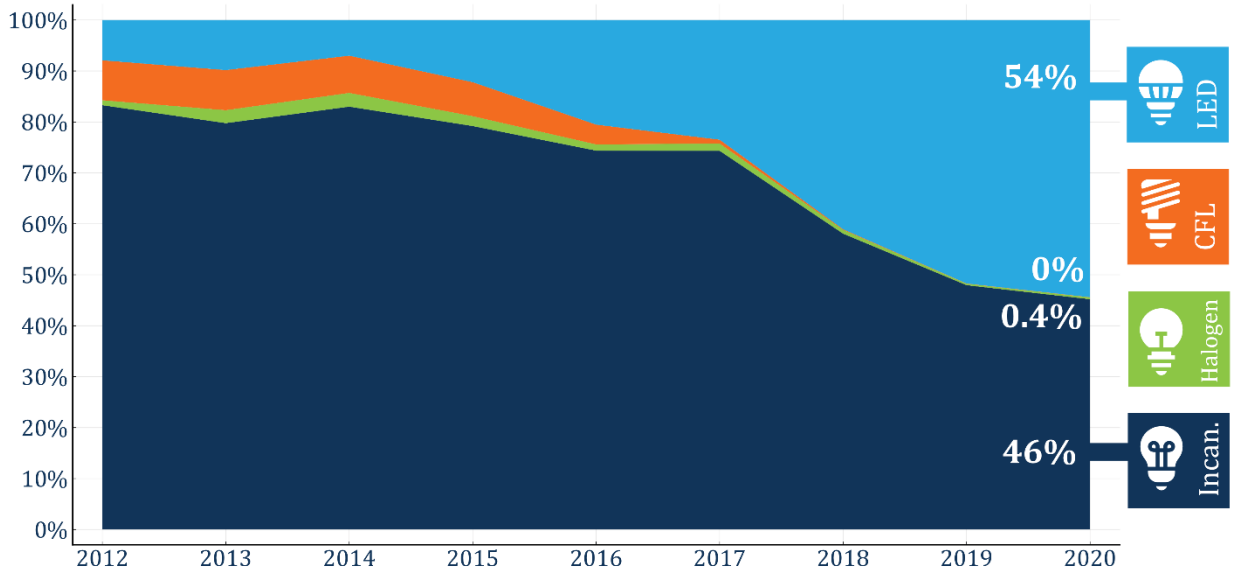
Figure 7 and Figure 8 highlight differences in the speed of change to LED technology between reflectors and decorative/mini-base lamps. In the reflector application (Figure 7), LEDs gained technology share rapidly, most recently increasing from a 70% share in 2019 to a 76% share in 2020, the highest LED share among the applications. By contrast, among decorative/mini-base lamps (Figure 8), LEDs did not reach a majority share until 2019 and still only comprise 54%. Incandescents comprise the remaining 46%.

Figure 7. Reflector Lamps Only – Technology Shares, 2012-2020



Data source: Weighted combination of sales data and NEEA shelf data

Figure 8. Decorative/Mini-Base Lamps Only – Technology Shares, 2012-2020

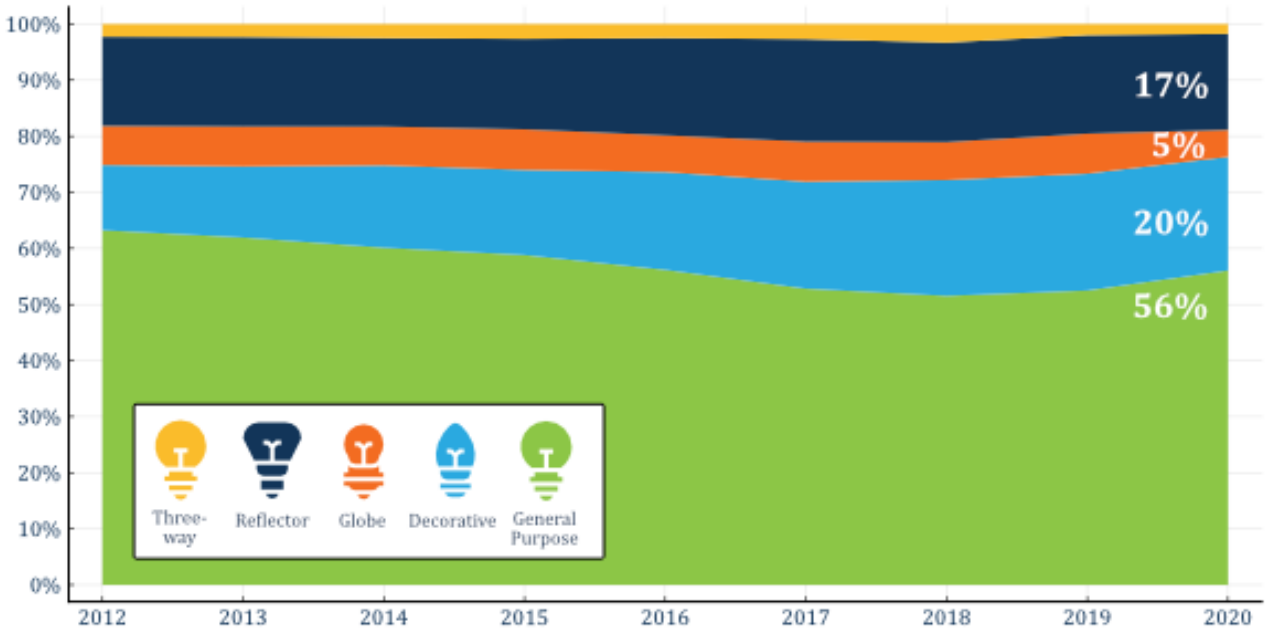


Data source: Weighted combination of sales data and NEEA shelf data

All Lamp Sales – Application Shares

The sales shares of various lamp applications in the residential market have evolved over the last seven years. The sales share for general purpose lamps has declined from 63% in 2012 to 56% in 2020 (Figure 9), likely because sales of longer-lived LEDs are increasing, resulting in less frequent replacement. However, the reader will note that from 2019 to 2020 there was an uptick in the LED share from 52% to 56%. This may be an effect of the COVID-19 pandemic; since people spent more time at home, they may have replaced more lamps than in previous study years.

Figure 9. All Lamp Sales – Application Shares, 2012-2020



Data source: Weighted combination of sales data and NEEA shelf data

Technology Share Within Sales Channels

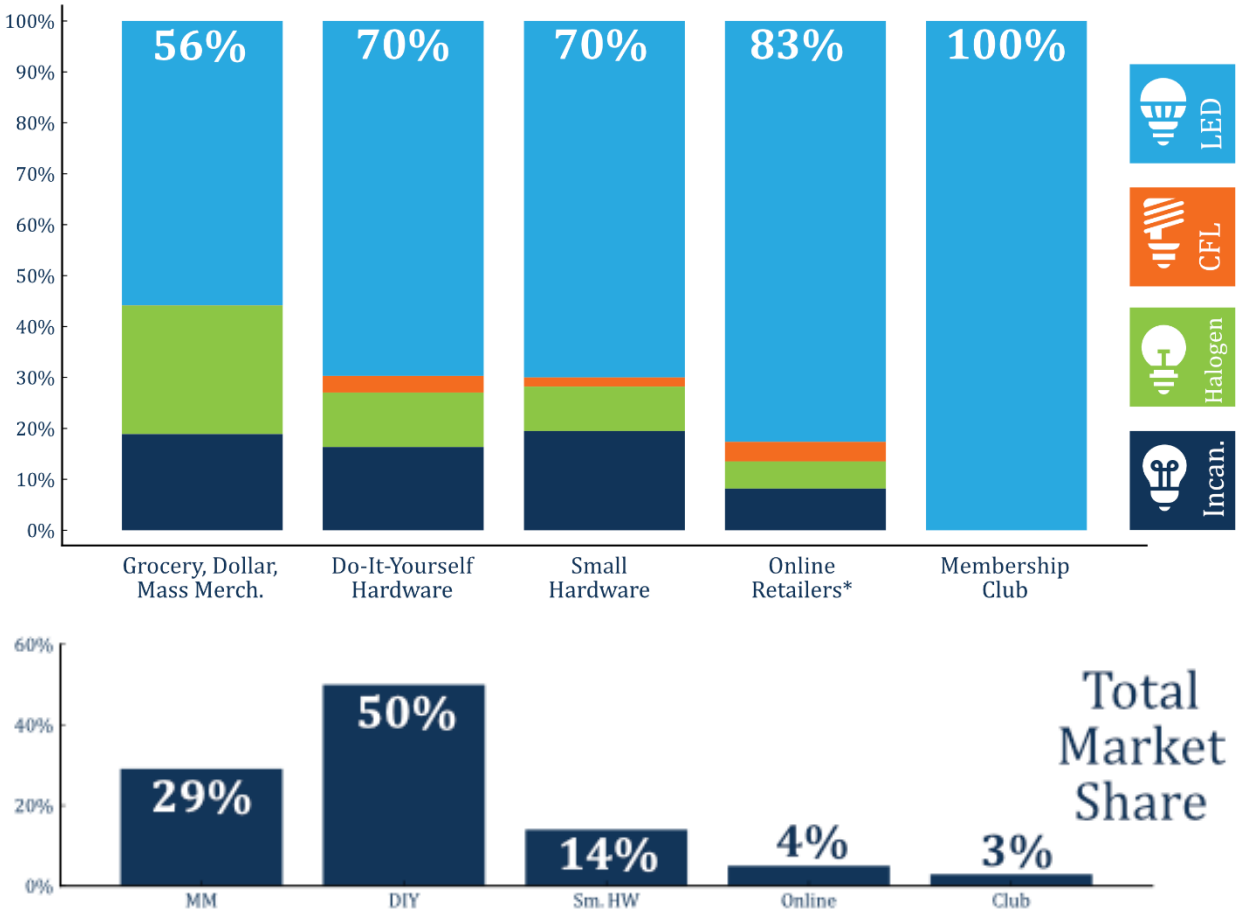
The research team assessed the shares of technologies within various channels (Figure 10). The greatest opportunity to further increase LED technology share continues to be in the combined grocery, dollar, and mass merchandise channel. In this combined channel, the share of LEDs grew rapidly from 46% in 2019 to 56% in 2020 but much room remains for increasing this share, and the channel comprises 29% of the region's total lamp sales.[21] The DIY channel comprises 50% of total lamp sales and its LED share reached 70% in 2020 (up from 67% in 2019), leaving less opportunity for growth. In the small hardware channel, the LED technology share held steady at 70%.[22] However, it only comprises 14% of total lamp sales. For online retailers who make up 4% of total lamp sales, the share of LEDs increased from 80% in 2019 to 83% in 2020. Finally, the membership club stores surveyed[23] exclusively sold LEDs as a corporate policy, and thus have an LED share of 100%. This channel makes up just 3% of total Northwest lamp sales.

[21] These estimates are based on a presentation by a major retailer at the 2014 ENERGY STAR Products Partner Meeting.

[22] These estimates apply a correction to the sales-to-stocking ratio for small hardware stores, as described in Appendix C: Chain Logic Model Methodology.

[23] For the other membership club store in the Northwest, POS data were available.

Figure 10. Retail Channel LED Technology Share and Total Market Share, 2020

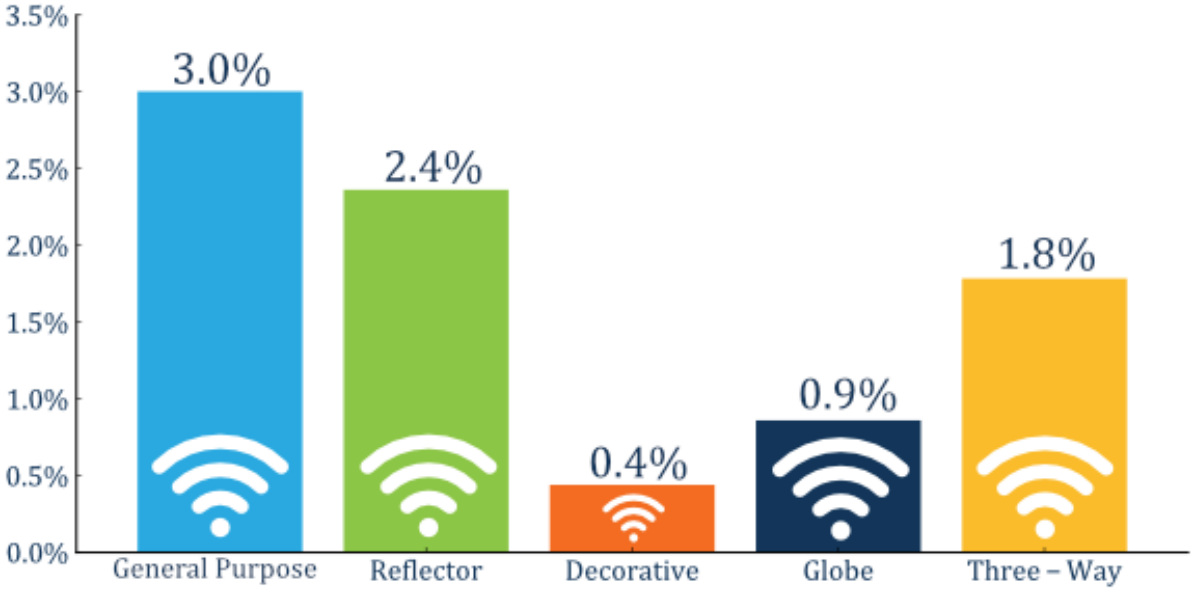


** Estimated proportionally to DIY store sales, as detailed in Appendix C: Chain Logic Model Methodology*
Data source: Weighted combination of sales data and NEEA shelf data

Smart LED Share of LED Sales

The research team analyzed both POS and shelf-stocking data on "smart lamps." All smart lamps encountered over the 2020-2021 analysis period were LEDs. Smart lamps, or Smart LEDs, can be communicated with and controlled wirelessly. Across all applications combined, the share of LEDs comprised by Smart LEDs is still relatively low at 2.3%, although it more than doubled from 1% in 2019. The greatest shares of Smart LEDs are among general purpose LED lamps (3%) and LED reflectors (2.4%) (Figure 11).

Figure 11. Smart LED Share of LED Sales, by Application, 2020



Data source: Weighted combination of sales data and NEEA shelf data

ENERGY STAR Certified LED Lamps – Sales Shares and Lifetime Hours

The research team also analyzed POS and shelf-stocking data on ENERGY STAR-certified LED lamps. These accounted for 61% of all LED sales in 2020 (Figure 12), a slight increase from 59% in 2019. The greatest ENERGY STAR shares were among globes (68% in 2020, up from 63% in 2019) and three-way lamps (64% in 2020, down from 67% in 2019).

The research team also confirmed that the ENERGY STAR-certified LED lamps analyzed through POS and shelf-stocking have considerably longer lifetimes than non-certified LEDs[24] (

Figure 13) (although non-certified LEDs still last longer than other lamp technologies). ENERGY STAR-certified LED lamps were found to have, on average, 40% longer lifetimes than non-certified LED lamps. ENERGY STAR-certified reflectors and general purpose lamps were each found to have a 57% longer lifetime than their non-certified counterparts, the largest lifetime difference among lamp applications.

[24] The research team collected lifetime ratings from LED packages in both the POS data and shelf-stocking surveys.

Figure 12. ENERGY STAR Certified Lamp Share of LED Sales, by Application, 2020

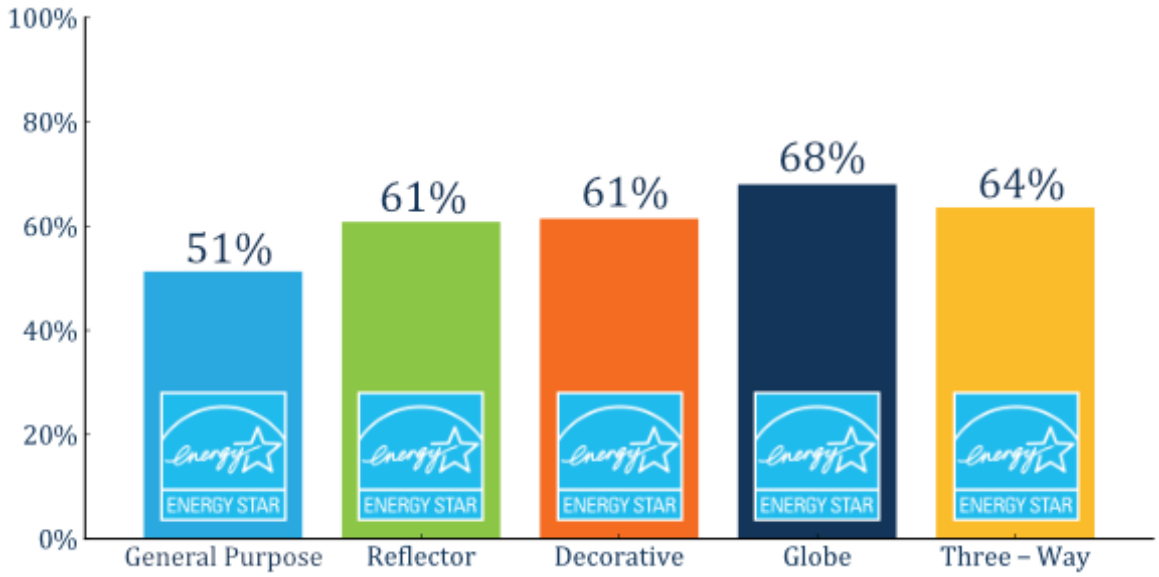
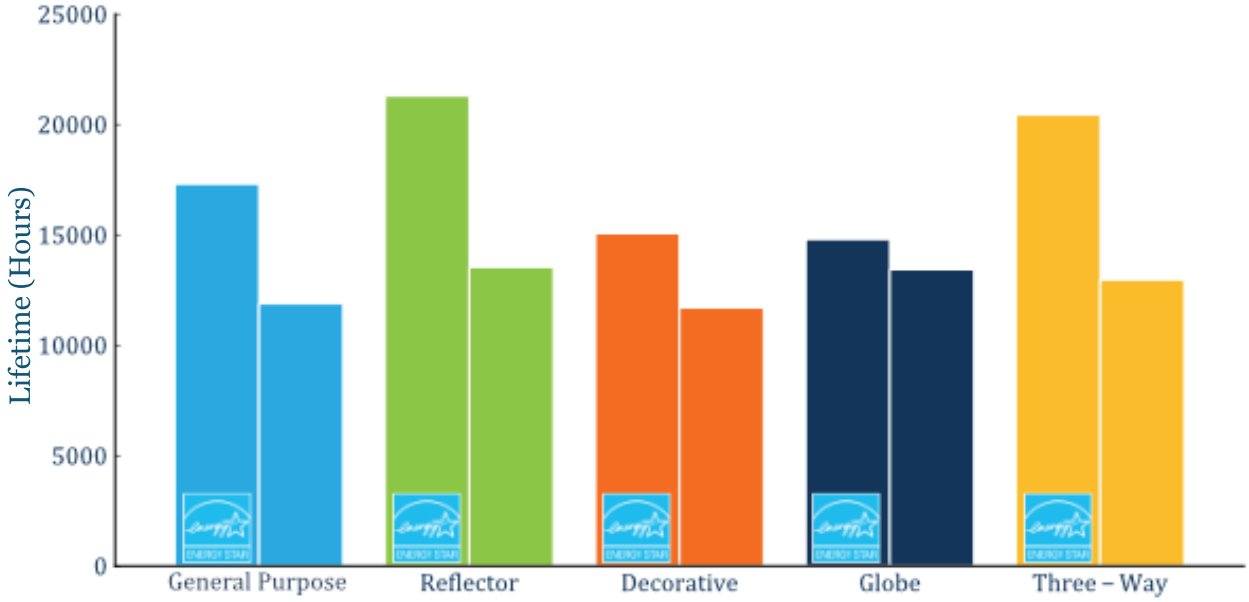
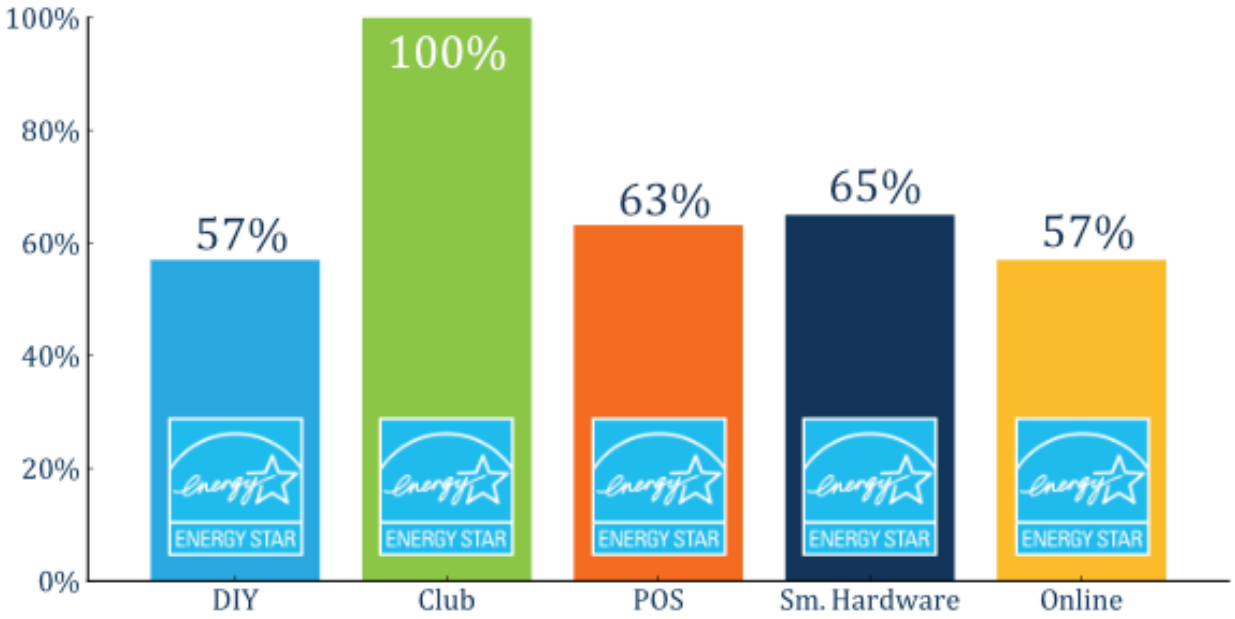


Figure 13. Lifetime Hours for ENERGY STAR LED Lamps and Non-Certified LED Lamps, by Application, 2020



ENERGY-STAR certified LED lamp shares are the highest at membership clubs, where 100% of lamps in stores surveyed were certified (Figure 14)[25]. The lowest shares of ENERGY STAR-certified lamps were found in DIY stores and online, where only 57% of LED lamps were certified.

Figure 14. ENERGY STAR Certified Lamp Share of LED Sales, by Channel, 2020

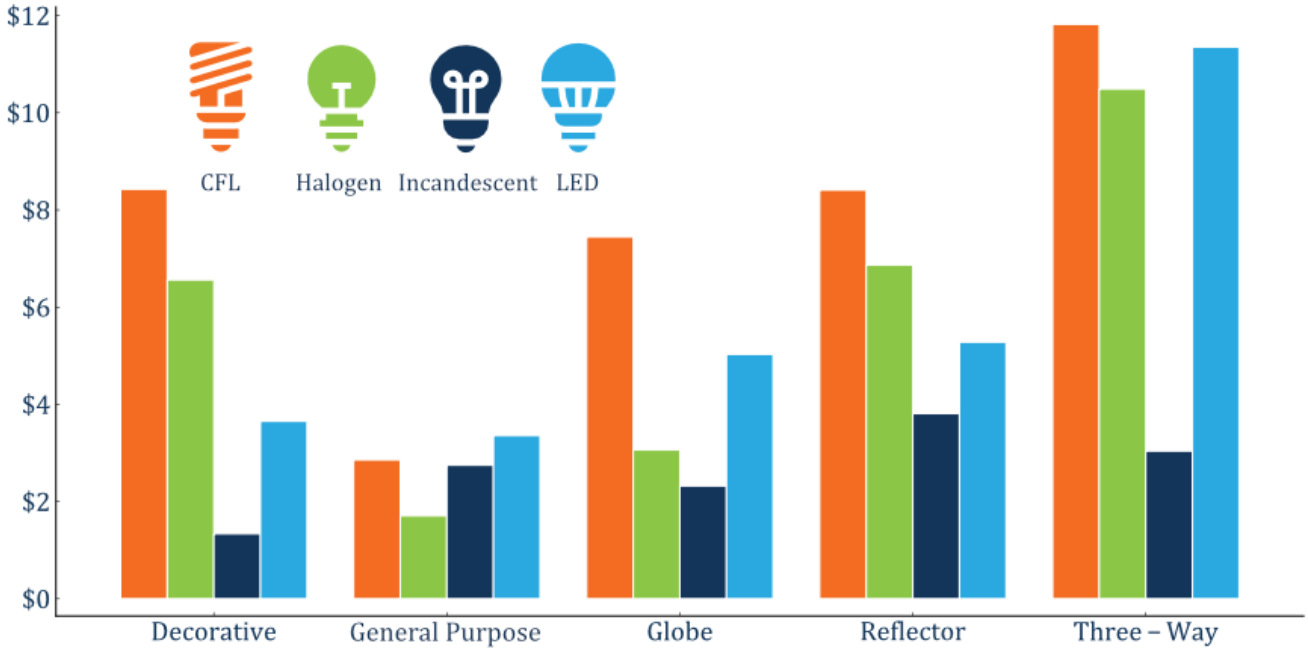


Lamp Prices and Trends

Figure 15 compares the average prices of lamps in 2020, among applications and technologies.

[25] As noted earlier in the report, membership stores exclusively sell LEDs based on corporate policy. While it is not known if the policy specifically requires ENERGY STAR LEDs only, stores visited through the shelf-surveys had 100% ENERGY STAR LEDs.

Figure 15. Average Price per Lamp, by Application and Technology, 2020



Data source: Weighted combination of sales data and NEEA shelf data. Note: LED costs include program incentives and retailer or manufacturer discounts which are not typically available for non-LEDs.

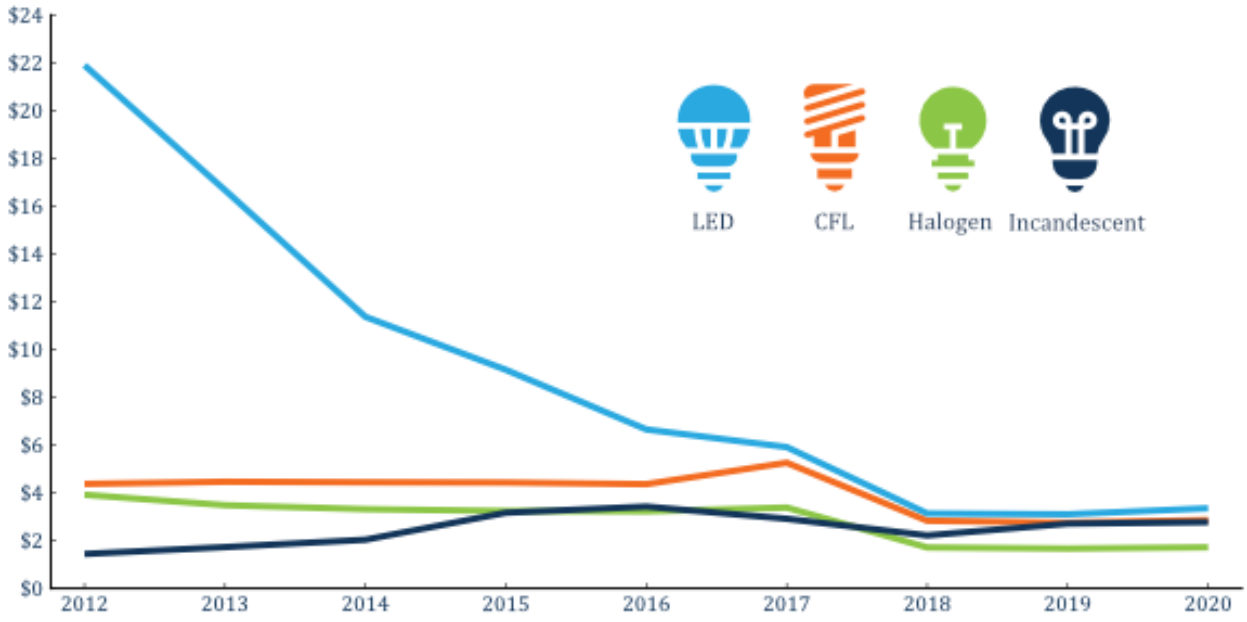
Table 2 provides the numerical prices from Figure 15 for each type of lamp by application and technology. Consistent with 2019, the lowest priced bulb in 2020 was the decorative incandescent and the highest priced lamp was the three-way CFL.

Table 2: Average Price per Lamp, by Application and Technology, 2020

	Decorative	General Purpose	Globe	Reflector	Three-Way
CFL	$8.65	$2.87	$7.34	$8.35	$11.82
Halogen	$6.41	$1.71	$3.05	$6.86	$10.49
Incandescent	$1.33	$2.73	$2.30	$3.81	$3.04
LED	$3.65	$3.36	$5.07	$5.28	$11.37

Figure 16 shows the changes in prices from 2012 to 2020 by technology type just for general purpose lamps. General purpose LED prices, after efficiency program incentives and manufacturer or retailer discounts, steadily declined from 2012 to 2018, but have remained either flat or increased moderately since 2018. General purpose LED lamps cost $3.36 on average in 2020 (Figure 16), an increase of 26 cents, or 8%, from 2019. Prices for general purpose CFL and halogen lamps (which do not typically receive incentives or discounts), also rose slightly between 2019 and 2020, by 10 cents or 4%, and by 4 cents or 2%, respectively.

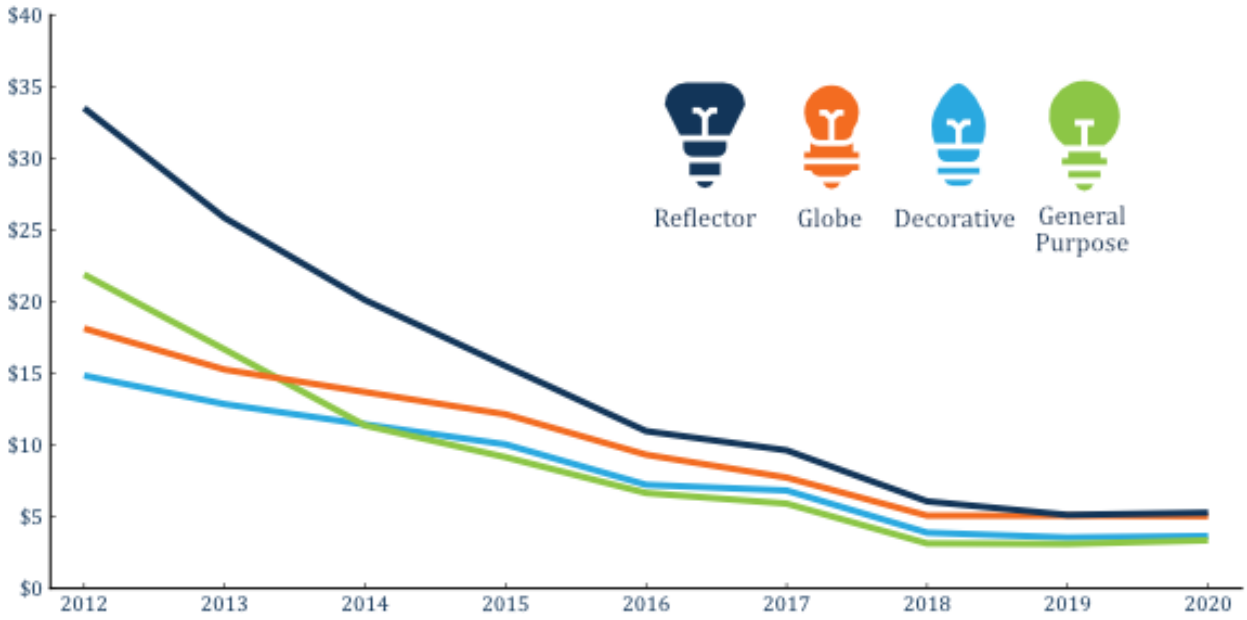
Figure 16. General Purpose Lamps – Average Price ($/lamp) by Technology, 2012-2020



Data source: Weighted combination of sales data and NEEA shelf data

Figure 17 shows differences in average LED prices among different applications. As shown, these differences have narrowed dramatically since 2012, with the largest declines in the average price of reflector lamps.

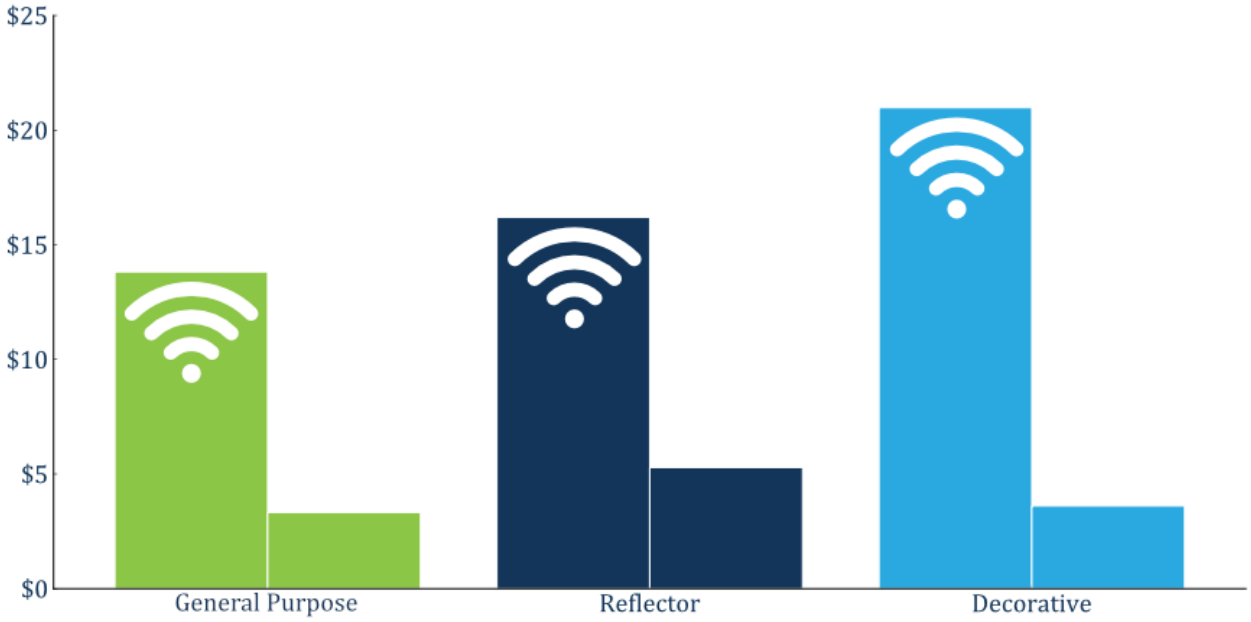
Figure 17. LED Average Price ($/lamp) by Application, 2012-2020



Data source: Weighted combination of sales data and NEEA shelf data. Note: LED costs include program incentives and retailer or manufacturer discounts which are not typically available for non-LEDs.

Figure 18 shows the average prices for smart and standard LEDs in 2020, by application. Smart LED bulbs still cost substantially more than LEDs without smart features. However, the average prices of smart LED general purpose lamps and smart LED reflector lamps have decreased from 2018 to 2020. The average price of general purpose smart LEDs has decreased from $17.89 to $13.84. For smart reflector lamps, the price has decreased from $28.80 to $16.18. The price of smart LED decorative/mini-base lamps dropped from $29.09 in 2018 to $20.97 in 2020. Smart LED globes remained roughly the same price over the 2018-2020 period.

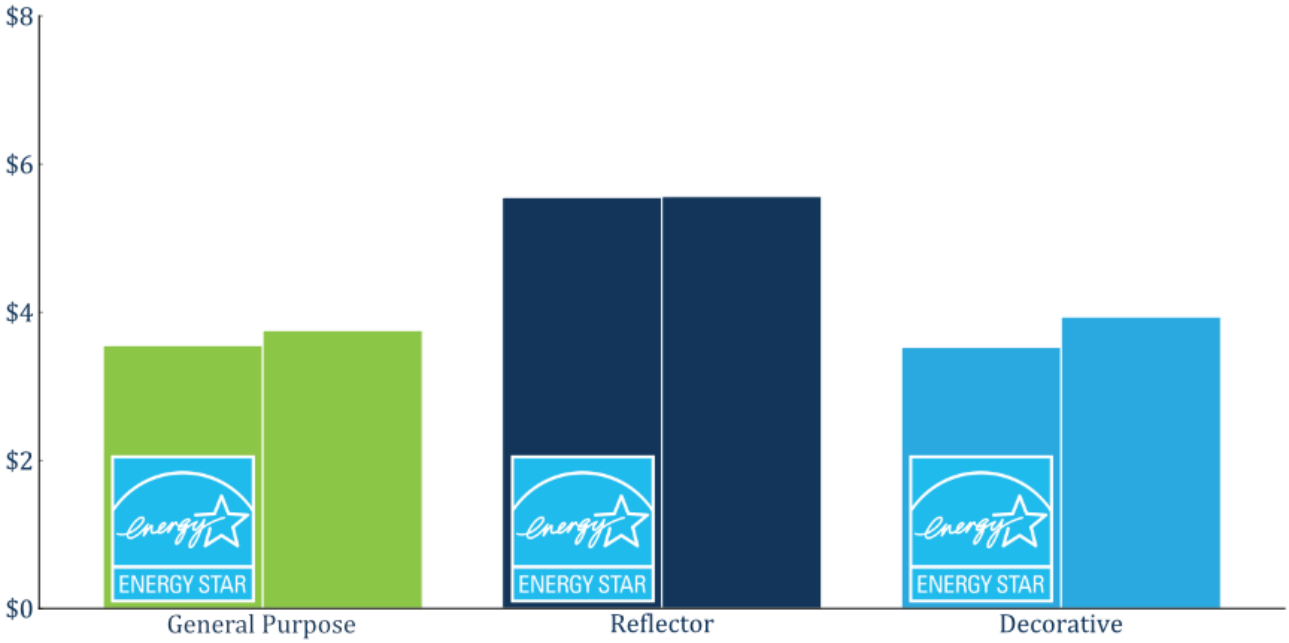
Figure 18. Average Prices for Smart LEDs and Standard LEDs, by Application, 2020



Data source: Weighted combination of sales data and NEEA shelf data

The research team found that ENERGY STAR-certified lamps (after discounts due to efficiency programs or manufacturer or retailer discounts) cost less as a result of these discounts, on average, than non-certified lamps. Figure 19 shows the average prices for ENERGY STAR-certified and non-certified LED bulbs in 2020, by application. The average price of an ENERGY STAR-certified general purpose LED (accounting for program incentives or other discounts) was $3.55, which is 6% less than the average price of a non-certified general purpose LED ($3.77).

Figure 19. Average Prices for ENERGY STAR-Certified (Including Incentives and Discounts) and Non-Certified LEDs, by Application, 2020



Note: Most utility programs only offer incentives for ENERGY STAR LEDs, bringing the average price below the average non-ENERGY STAR prices which typically do not include incentives.

Recap of Key Findings

- **The Northwest lighting market continued its shift toward LEDs across all applications in 2020.** Overall, LEDs accounted for 67% of all lamp sales in 2020, up from 63% in 2019. LEDs made up a larger proportion of general purpose lamp sales (70%) and reflector lamp sales (76%) than decorative/mini-base (54%) or globe (59%).

- **As in 2019, continued gains in LED share in 2020 came at the expense of incandescent and halogen lamps.** While LEDs rose to 67% of total Northwest lamp sales in 2020 from 63% in 2019, incandescents fell to 18% and halogens to 13%.

- **The combined channel of grocery, dollar, and mass merchandise retailers (MM) may present thegreatest opportunity to further increase LED market share.** In the MM channel, the share of LEDs grew rapidly from 46% in 2019 to 56% of lamp sales, but much room for increased market share remains, and the MM channel comprises 29% of all lamp sales. Although the DIY channel comprises 50% of all lamp sales, the LED technology share in DIY reached 70% in 2020. In the membership club, online, and small hardware channels, LEDs make up between 70% and 100% of sales, but these channels account for relatively small portions of overall lamp sales (3%, 4%, and 14%, respectively).

- **Prices for LEDs across all applications (after any efficiency program, manufacturer, or retailer discounts[26]) increased slightly from 2019 to 2020.** General purpose LED lamps cost an average of $3.36 in 2020, an increase of 8% from 2019. General purpose LED prices decreased by 86% since 2012, and general purpose halogen prices dropped by 61% since 2012[27].

- **The sales share for general purpose lamps fell from 63% in 2012 to 56% in 2020, although it increased from 52% to 56% between 2019 and 2020.** The overall decline from 2012 to 2020 is likely because sales of longer-lived LEDs within this application are increasing, resulting in less frequent replacement and thus fewer sales. That said, the sales share for general purpose lamps increased from 52% in 2019 to 56% in 2020. This may be an effect of the Covid-19 pandemic; since people spent more time at home, they may have replaced more lamps.

- **The market share of Smart LEDs more than doubled between 2019 and 2020, but their share is still relatively low at 2.3%.** The market share of Smart LEDs increased from 1% in 2019 to 2.3% in 2020 across all applications. Prices of Smart LEDs are still at least four times more than standard LEDs, a likely factor in their still-modest market share.

- **Among general purpose LEDs, the share of ENERGY STAR-certified LEDs fell between 2019 and 2020, but increased for other applications**. For general purpose LEDs, the share of ENERGY STAR lamps fell from 54% in 2019 to 51% in 2020, the lowest share among applications. However, for reflector LEDs, the share increased from 59% to 61%, and for decoratives from 54% to 61%.

[26] As part of the 2017-2018 LTMT study's analysis for the 2017 calendar year, NEEA conducted an analysis of pre-incentive lamp prices. The resulting memorandum was not formally published but is available on request.

[27] Calculated in real terms with 2012 as the base.

Appendix A: Shelf Survey Sample Design

Section 1. Purpose and Overview

The purpose of this appendix is to describe DNV's sampling approach for the February-March 2021 shelf surveys conducted to gather data for the 2020 market analysis (the "2020-21 Shelf Survey"). Section 2 provides background on the 2020-21 Shelf Survey and Section 3 provides details of the sample design.

Section 2. Background

Shelf surveys involve field researcher visits to retail stores to collect information about the lamps stocked in those stores. Researchers gather detailed information regarding each lamp model including lamp style, manufacturer, wattage, number of lamps per package, package price, and other characteristics.

The evaluation team used the same sampling approach for the 2020-21 shelf survey that was used for the 2018-19 and 2019-20 shelf surveys. Since this year Apex again was able to purchase high quality point-of-sales (POS) data for drug, grocery, and mass merchandise stores, we conducted shelf surveys just in a sample of 34 small hardware, membership club, and do-it-yourself (DIY) stores in NEEA's utility partners' territories within Idaho, Montana, Oregon, and Washington. The sampling approach allowed us to collect critical shelf stocking data using the most efficient sample possible for stores where detailed POS data were not available.

Section 3. Sample Design

The research team used the same sampling frame that was used in previous two years, which is a list of retail stores in the Northwest compiled for NEEA by PECI, Inc. in the mid-2000s. We stratified the 2020-21 shelf survey sample by store type, but only visited those store types for which we did not have detailed POS data. Table 3shows the population and targeted sample of stores by store type for the 2020-21 Shelf Survey. Prior to conducting the 2018-19 Shelf Survey, NEEA asked the research team to update the store sampling frame so that it reflected the number of Home Depot, Lowe's, Costco, Sam's Club, and Wal-Mart stores in Idaho, Montana, Oregon, and Washington as of December 2018. The updated sampling frame showed an increase in DIY stores to 187, an increase in mass merchandise stores to 512, and an increase in membership club stores to 56. Overall, the number of stores in the sample frame increased from 2,538 in December 2017 to 2,611 in December 2018. We used the same sample frame of 2,611 stores for the 2019-20 and 2020-21 Shelf Surveys.

Table 3: Northwest Lighting Retail Store Population and Sample Points by Store Type, 2020-2021

Store Type	Store Population		2020-2021 Sample	
	Number of Stores	Percent of Stores	Number of Stores	Percent of Stores
Do-It-Yourself	187	7%	11	32%
Drug and Grocery	994	38%	0	0%
Mass Merchandise	512	20%	0	0%
Membership Club	56	2%	3	9%
Small Hardware	862	33%	20	59%
Overall	2,611	100%	34	100%

Table 4 shows the distribution of sample points by store type and state for the 2020-21 shelf survey. The research team completed all 34 shelf surveys in February and March, 2021.

Table 4: Northwest Lighting Retail Store Sample by Store Type and State, 2020-2021 Shelf Survey

Store Type	State				
	ID	MT	OR	WA	Overall
Do-It-Yourself	**3**	**1**	**3**	**4**	**11**
Membership Club	**1**	**1**	**1**	**0**	**3**
Small Hardware	**6**	**4**	**5**	**5**	**20**
Overall	**10**	**6**	**9**	**9**	**34**

Appendix B: Montana POS Data Estimation Method

As described in Appendix A, for the 2020-2021 study, the research team conducted shelf surveys in Idaho, Montana, Oregon, and Washington for DIY, membership club, and small hardware stores because Nielsen does not have POS data for those store types. These sales channels account for 67% percent of all Northwest lamp sales.

For the other store types accounting for 33% of Northwest lamp sales – mass merchandise, grocery, and drug stores – Apex was able to purchase 2020 POS data, but only for Idaho, Oregon, and Washington because Nielsen had stopped offering Montana POS data after 2018.

So starting with the 2019 study, the team had to develop a method by which to "update" Montana's 2018 application and technology shares that were based on 2018 POS data (for mass merchandise, grocery, and drug stores) to 2019 shares. The method was applied again this year to update 2019 shares to 2020 shares.

The method the team developed has two parts. First the team analyzes Wyoming's POS data for the current study year and the previous year to determine the percent change in Wyoming in each application and technology market share between these two years. Those percent changes for Wyoming are then applied to Montana's application and technology shares to derive an estimate of shares for the current study year. So for the 2019 study, the team determined the percent change in Wyoming in each market share between 2018 and 2019, and applied those percent changes to the market shares derived from the team's analysis of the 2018 POS data for Montana (the final year provided by Nielsen). For 2020, the percent change in Wyoming for each share between 2019 and 2020 was applied to Montana's estimated 2019 shares.

The team had a further challenge – the 2018 Montana POS data lacked pricing, wattage, and lumen information, and had no information for a portion of "private label" lamps (e.g. lamps manufactured exclusively for a particular chain store). To compensate for the missing data, the research team used whatever 2018 data Nielsen did provide for Montana to estimate shares of lamp technologies and applications to the extent possible. The team then found the Northwest state with the technology and application shares that appeared to be most similar to Montana (this turned out to be Washington). We then used Washington's 2018 shares to fill gaps in Montana's shares created by missing 2018 POS data. However, the lack of 2018 data for Montana on pricing and wattage precluded the team from calculating or subsequently updating these parameters for Montana for the store types covered by POS data. As a result, for 2018 on, the team was only able to base their pricing and wattage analysis on data from Idaho, Oregon, and Washington.

Table 5 below summarizes the market share changes that occurred in Wyoming and the consequent market shares after applying Wyoming's changes to Montana's 2019 "proxy" technology and application

shares. General purpose LEDs experienced the largest change in market share from 2019 to 2020 in Wyoming, increasing from 43% to 53%, which was a 25% change in Wyoming and after applying the relative difference to Montana, the Montana market share changed by 23%.

Table 5. Summary of Montana Market Share Adjustments

Application	Technology	2019 Wyoming Market Share	WY Market Share % Change	2020 Wyoming Market Share	2019 Montana Market Share	MT Market Share % Change	2020 Montana Market Share
General Purpose	CFL	0%	-96%	0%	0%	-96%	0%
General Purpose	Halogen	32%	-15%	27%	30%	-19%	24%
General Purpose	Incandescent	3%	48%	5%	5%	113%	10%
General Purpose	LED	43%	25%	53%	36%	23%	44%
Reflector	CFL	0%	-100%	0%	0%	-100%	0%
Reflector	Halogen	1%	-83%	0%	1%	-85%	0%
Reflector	Incandescent	1%	-31%	1%	2%	-22%	2%
Reflector	LED	4%	-32%	3%	5%	-35%	3%
Decorative	CFL	0%	0%	0%	0%	0%	0%
Decorative	Halogen	0%	-100%	0%	0%	-100%	0%
Decorative	Incandescent	6%	-47%	3%	7%	-27%	5%
Decorative	LED	2%	-36%	1%	3%	-54%	1%
Globe	CFL	0%	-100%	0%	0%	-100%	0%
Globe	Halogen	0%	-27%	0%	1%	-28%	1%
Globe	Incandescent	5%	-46%	3%	6%	-43%	3%
Globe	LED	1%	30%	1%	2%	31%	2%
Three-Way	CFL	0%	0%	0%	0%	8%	0%
Three-Way	Halogen	0%	0%	0%	0%	129%	0%
Three-Way	Incandescent	2%	-13%	2%	3%	13%	3%
Three-Way	LED	0%	274%	1%	0%	312%	1%

Appendix C: Chain Logic Model Methodology

This Appendix describes the modified method designed by the Study team for the 2018-19 study, and used again for the 2019-20 and 2020-21 studies. Each of the steps is detailed below.

Data

As in prior years, the Study team used the following datasets to estimate market shares:

1. **NEEA shelf survey data:** DNV conducted shelf surveys described elsewhere in this report that builds on a historical data set going back to 2012.

2. **CREED LightTracker**[28] **Point-of-Sale (POS) data:** Apex purchased POS lighting sales data from Nielsen, and the Consortium for Retail Energy Efficiency Data (CREED) team cleaned and corrected it. The cleaning involved web scraping, automated online product lookups, and integration with the product database maintained by the CREED team, all with the ultimate goal of filling gaps in the lamp description data (e.g. wattage, lumens) provided.

Prior to the 2018-2019 residential lighting LTMT study, the sample of stores for shelf surveys included grocery, drug, and mass merchandise (for simplicity, referred to from here on as Mass Merchandise) stores, but contractors did not use the shelf survey data for this channel in the Chain Logic analysis; they only used the POS data. Because the shelf survey data for this channel had been superfluous to the analysis in prior years, the Team did not conduct shelf surveys in this channel in the 2018-19, 2019-20 and 2020-21 studies, decreasing the overall number of stores surveyed from 68 to 34.

Segment the Market into Channels

Consistent with prior years, Apex segmented the market into channels with assigned market shares according to a presentation by a major retailer at the 2014 ENERGY STAR Partners Meeting. The assigned market shares roughly aligned with the Study Team's understanding from other market research endeavors in Illinois and Massachusetts, but a direct quantification of channel market share was difficult because retailers do not share sales data. The channels represented in prior years have been:

1. Do-It-Yourself (DIY) Stores

2. Mass Merchandise, Drug, Grocery, and Membership Club Stores

[28] CREED is a consortium of program administrators, retailers, and manufacturers working together to collect the necessary data to better plan and evaluate energy efficiency programs. LightTracker is CREED's first initiative, focused on acquiring full-category lighting data, including incandescent, halogen, CFL, and LED bulb types, for all distribution channels in the United States.

3. Small Hardware Stores

4. Online Sales

Sales to stocking ratio: The default assumption in the years prior to 2018-19 had been that the number of lamps stocked of lighting products of a particular technology type directly correlated with sales of that technology type. However, evidence from store manager interviews conducted as part of the 2018-2019 shelf survey indicated that this ratio was not applicable for small hardware stores. Store managers reported higher sales of LEDs than stocking suggested, and lower sales of incandescents and halogens. For that reason, the Study team prepared two data sets: one with the prior assumption of a 1:1 lamp sales to stocking ratio, and a second data set with a new assumption for small hardware stores of 2:1 sales to stocking ratio for LEDs, and 1:2 for incandescents and halogens.

The 2020-21 Study team continued to rely on the prior channel types, with two modifications. First, the POS data covers mass merchandise and a membership club retailer with relatively few outlets in the Northwest, but not the largest membership club retailer in terms of outlets. Therefore, Apex broke the "Mass Merchandise and Membership Club" channel into distinct channels for mass merchandise stores and membership club stores. CREED constructs state level sales totals for all states using point-of-sale data and CREED-generated estimates of total bulb sales by state. The Study team estimated the market share of the Mass Merchandise channel at 29.1% and allocated the remaining share of the prior years' 32.0% market share estimate for the channel (2.9%) to membership club stores. Table 4 provides the resulting market share distributions utilized by the Study team for this effort.

Table 4. 2020-2021 Market Share by Retailer Channel, Including Online

Retailer Channel	Market Share
DIY	50.0%
Mass Merchandise	29.1%
Membership Club Stores	2.9%*
Small Hardware	14.0%
Online[29]	4.0%

**The Study team recognizes that combining old and new calculations has resulted in a smaller channel share for Membership Club stores than in prior years and recommends additional investigation to refresh all shares in the next cycle.*

[29] The Study team considered whether the online distribution channel should be adjusted due to the potential that the COVID-19 pandemic shifted more lighting sales from other distribution channels to online. However, through another unpublished client study, team members interviewed corporate retailers across distribution channels who did not report any significant channel shifting during the pandemic. As such, the team did not change these shares, however future research could consider whether the distribution channels used are appropriate.

Assign Site Weights by Region

To extrapolate the sample of stores visited during shelf stocking to the NEEA territory, the Study team calculated weighting values for each channel and region. Oregon represented one region while the other three states were combined into a second region to obtain a statistically valid sample. The regions were:

1. The state of Oregon
2. The three-state region of Washington, Idaho, and Montana

The Study team determined the weights by the ratio of total stores to sampled stores within a channel and region. Multiplying the weights by the bulb counts at the itemized level (product code and store) in the shelf stocking data resulted in an estimate for the total number of bulbs on shelves in the NEEA territory, within the sampled channels. In the 2016-2017 and 2017-2018 studies, contractors calculated store-level averages for bulb metrics, which they later weighted by a factor calculated for each retailer based on total bulbs stocked to calculate weighted averages for prices and wattages at the retail channel and market level.[30] This approach runs the risk, however, of providing skewed results if a retailer carries a disproportionate number of bulbs with a particular characteristic.

To address this risk, the Study team calculated weighted averages using the weighted bulb counts at the itemized product level, rather than weighting and averages at the store level. Because this calculation was performed at the itemized product level, the market shares, bulb totals, and bulb metrics calculated from of those weighted bulb counts were not skewed as in the aforementioned case.

Online Channel Efficiency Mix

Neither the shelf stocking survey nor the POS data addressed the channel market share or efficiency mix for online sales. The Apex team took the following actions in the 2018-2019 study to attempt to secure data directly from online retailers:

1. Reached out to representatives from bulbs.com, 1000bulbs.com, and amazon.com through at least two points of contact per website
2. Reached out to representatives at Philips, Feit, Osram Sylvania, and GE
3. Reviewed recent publicly-available studies
4. Convened an internal discussion on private studies (to which Apex has contributed) that addressed the question of online market share

[30] Prior to this, calculations were not done at the store level prior to adding weights.

The Team was unsuccessful in acquiring direct data for online sales from the market actors listed above. Ultimately, an estimate for the online efficiency mix was informed by two studies from Massachusetts:

1. "RLPNC 17-12 Lighting Decision Making," by NMR Group, finalized on March 2, 2018.[31] Page 16, Figure 13: LED and CFL Market Share by State and Channel.

2. "RLPNC Study 18-10 2018-19 Residential Lighting Market Assessment Study," by NMR Group, finalized on March 19, 2019.[32] Page 37, Table 8: LED Bulbs Obtained.

Starting from RLNPC 17-12, we took the following steps:

1. We calculated the LED and CFL Market Share average across Massachusetts and New York for two channels: DIY and Online. The DIY channel was the most similar to the Online channel in terms of efficient market share, and DIY stores have online marketplaces that likely compete on price and offerings with Online retailers.

2. We extracted the ratio of inefficient bulbs (Halogen and Incandescent) between Online and DIY channels from this study. In Massachusetts and New York, inefficient bulb share constituted about half as much share in the Online channel as the DIY channel.

3. We applied this value to the known DIY shares from NEEA shelf stocking surveys to estimate market share for inefficient bulbs in the Online channel, then scaled the efficient bulb shares to fill in the complete Online market channel.

This calculation resulted in estimates for market share by technology and lamp style, but did not provide information on pricing, wattage, or other bulb metrics. We assumed that those metrics were the same in the Online channel as in the DIY channel due to the similarity between the two channels.

Finally, we used the RLNPC 18-10 study to verify the prior Online channel share estimate. That study showed that 7% of LEDs in Massachusetts and New York were obtained online. From qualitative assessment within the study, it is likely that these states purchase online more than other areas. Using the within-channel calculations above and an assumption of 4% channel share, we estimated that 5.4% of LEDs in NEEA territory were purchased online. Given that 7% is most likely an upper bound, we determined the prior 4% online market share estimate to remain accurate for 2019.

Determine the Efficiency Mix within Channels

The Study team multiplied the count of lamps of each UPC at each store by its site weight to arrive at a "weighted bulb count." The UPCs were bucketed into one of six lumen bins according to their lumen output rating, three of which correspond to those reported in prior years. The UPC and store-level

[31] http://ma-eeac.org/wordpress/wp-content/uploads/RLPNC_1712_DecisionMaking_12Feb2018_Final-1.pdf
[32] http://ma-eeac.org/wordpress/wp-content/uploads/RLPNC_1810_LtgMarketAssessment_FINAL_2019.03.29.pdf

weighted bulb count within each channel were then used to calculate the following metrics by lamp style and technology:

1. **Market share:** The total weighted bulbs of a given technology within a lamp style are divided by the total bulbs of that lamp style. The result is market share by technology, within a given lamp style (e.g., percent of general purpose lamps that are LEDs or percent of globe lamps that are Halogens).

2. **Price:** For a given lamp style and technology, the weighted average price by weighted bulb count (e.g., the average price of an LED Reflector bulb).

3. **Wattage:** For a given lamp style and technology, the weighted average wattage by weighted bulb count (e.g., the average wattage of an LED Reflector bulb).

4. **Efficacy:** For a given lamp style and technology, the weighted average efficacy, in lumens/watt, by weighted bulb count (e.g., the average efficacy of an LED Reflector bulb).

5. **Lifetime:** For a given lamp style and technology, the weighted average lifetime, in hours, by weighted bulb count (e.g., the average lifetime of an LED Reflector bulb).

Diagrams of the methodology employed for this purpose prior to the 2018-2019 analysis (Figure 20) and the methodology used in the current year, 2018-19, and 2019-20 years (Figure 21), are shown below. Prior to the 2018-2019 analysis, the total bulb count for each site was used to weight the store-level average bulb metrics. That method had the potential to skew results for stores where the share of a given bulb application (e.g., technology, lamp style) was substantially different than others. For example, if one store sold only CFLs, its influence on average price would be calculated from its total bulb sales versus other stores in the prior method. In the updated method, it would be calculated directly from its CFL sales versus CFL sales at other stores. The differences are demonstrated in the two following figures.

Figure 20. Prior Method for Calculating Within-Channel Bulb Metrics

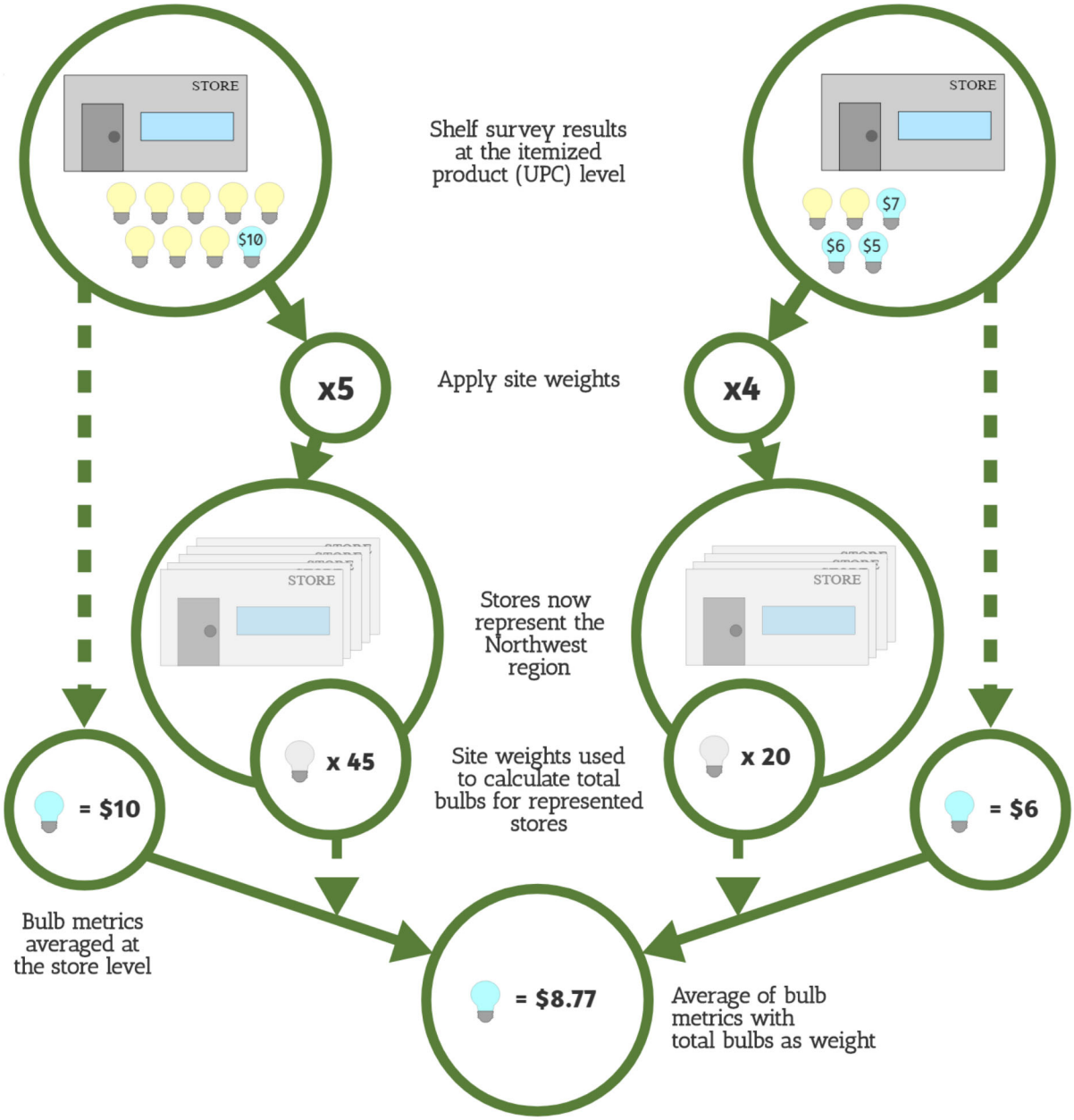
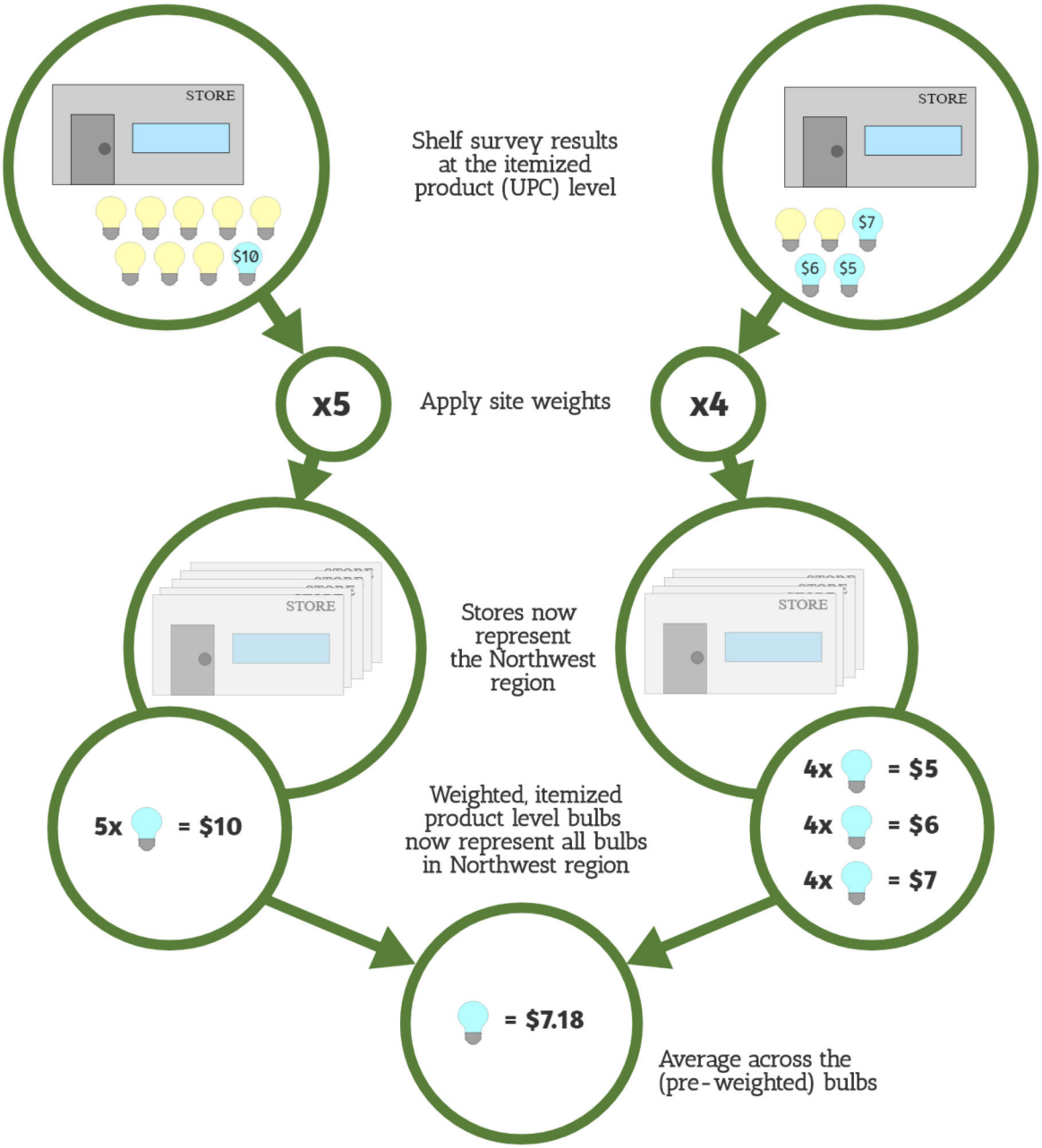


Figure 21. Current Method for Calculating Within-Channel Bulb Metrics



The result of this analysis is one table for each metric, for each channel. These tables are provided in the following form:

Table 5. Example Result Table

(Channel XX)	Lamp Style					
Bulb application	General Purpose	Reflector	Decorative	Globe	Three-Way	All Styles
CFL	$x.xx	$x.xx				
Halogen	$x.xx	…				
Incandescent			…			
LED						
Overall						

The study team performed this analysis within each of the lumen bins to capture these metrics at a further level of detail.

Compute Overall Efficiency Mix and Bulb Metrics

To calculate market shares within lamp style and lumen bins, we combined data from the prior section with the channel shares of total lamp sales. The method we employed for market shares was equivalent to the Chain Logic Model detailed in prior reports. We used the formula below;

Table 6 details the meaning of each variable.

$$\text{Share}_{\text{s,total}} = \frac{\sum_{\text{channels}}\left(\text{Share}_{\text{s,channel}} \times \text{Share}_{\text{channel,total}}\right)}{\sum_{\text{channels}}\left(\text{Share}_{\text{channel,total}}\right)}$$

Table 6. Market Share Calculation Inputs, with Example Data

		$Share_{channel,total}$	$Share_{s,channel}$	$Share_{s,total}$
Channel	Bulb Tech	Channel Share of Total Market	Bulb Tech Share of Lamp Style within Channel	Bulb Tech Share of Lamp Style (Overall)
Mass Merchandise	LED	29.1%	45%	58%
DIY		50%	68%	
Membership Club		2.9%	100%	
Sm. HW		14%	43%	
Online		4%	50%	

For bulb metrics such as price and wattage, the Study team's method differed from prior years. In prior years, the above calculation would be performed with the share within channel $Share_{s,channel}$ swapped for a bulb metric such as price. However, average bulb metrics are a different type of calculation. Whereas a market share calculation is technically a value for all bulbs within the channel (number of bulbs of a given kind divided by *all bulbs*), a bulb metric is only a calculation for bulbs of that kind.

Directly substituting values in the equation used to calculate channel share to calculate variables like average price and wattage ignores that channel share (Table 4) is a measurement of total lamps within a channel while the other metrics are limited to total lamps of a given technology. When channels have very different market shares by technology, the prior Chain Logic Method would apply too little weight to the channels with higher internal market share of that technology, and too much weight to the channels with lower internal market share of the technology. For example, Costco sells only LEDs, and accounts for roughly 3% market share for all bulbs. It follows that it must account for more than 3% of LEDs sold, because other stores do not sell only LEDs. However, its weight in a calculation of LED wattage would be 3% using the prior method.

We add an additional adjustment term to account for the disparate technology and lamp style market shares between channels. The additional weighting term, in the case of Costco, would increase the weighting of its bulb metrics to above 4% for LEDs, as expected. The formula for that calculation is below;

Table 7 details the meaning of each variable.

$$\text{Metric}_{s,t,total} = \frac{\sum_{channels}\left(\text{Metric}_{s,t,channel} \times \text{Share}_{s,channel} \times \text{Share}_{channel,total}\right)}{\sum_{channels}\left(\text{Share}_{s,channel} \times \text{Share}_{channel,total}\right)}$$

Table 7. Bulb Metric Calculation Inputs, by Channel, with Example Data

A	B	$Metric_{s,t,channel}$	$Share_{channel,total}$	$Share_{s,channel}$	$Metric_{s,t,total}$
Channel	Bulb Tech	Average Bulb Price (Within Channel)	Channel Share of Total Market	Bulb Tech Share of Lamp Style	Average Bulb Price (Overall)
POS	LED	$2.72	29.1%	45%	$3.15
DIY		$3.13	50%	68%	
Membership Club		$2.73	2.9%	100%	
Sm. HW		$4.36	14%	43%	
Online		$3.18	4%	50%	

These values are tabulated within lumen bins and across all lumen bins, for all metrics detailed above (price, wattage, efficacy, and lifetime).

In order to demonstrate how this methodology is different than the one used prior to the 2018-2019 analysis, we provide an example diagram of the calculations below. Figure 22 shows the prior calculation method, while Figure 23 shows the current calculation method. Similar to the issue with weighting by total lamps in calculating within-channel shares, weighting channels by only their total lamps skews results when the efficiency mix is different by channel. However, for this calculation we must employ a second weighting scheme instead of a more granular calculation as with within-channel bulb metrics,

because of the unknown difference in sales to stocking ratio by channel. For example, we do not know whether a single lamp package turns over 100 times per year for DIY stores versus 15 times at Small Hardware stores. Therefore, we cannot guess the absolute sales numbers for either channel and must combine them with the market share percentages presented in Table 4. The adjustment factor is therefore also calculated using percentages instead of product-level weighting.

Figure 22. Method for Combining Bulb Metrics across Channels Prior to 2018

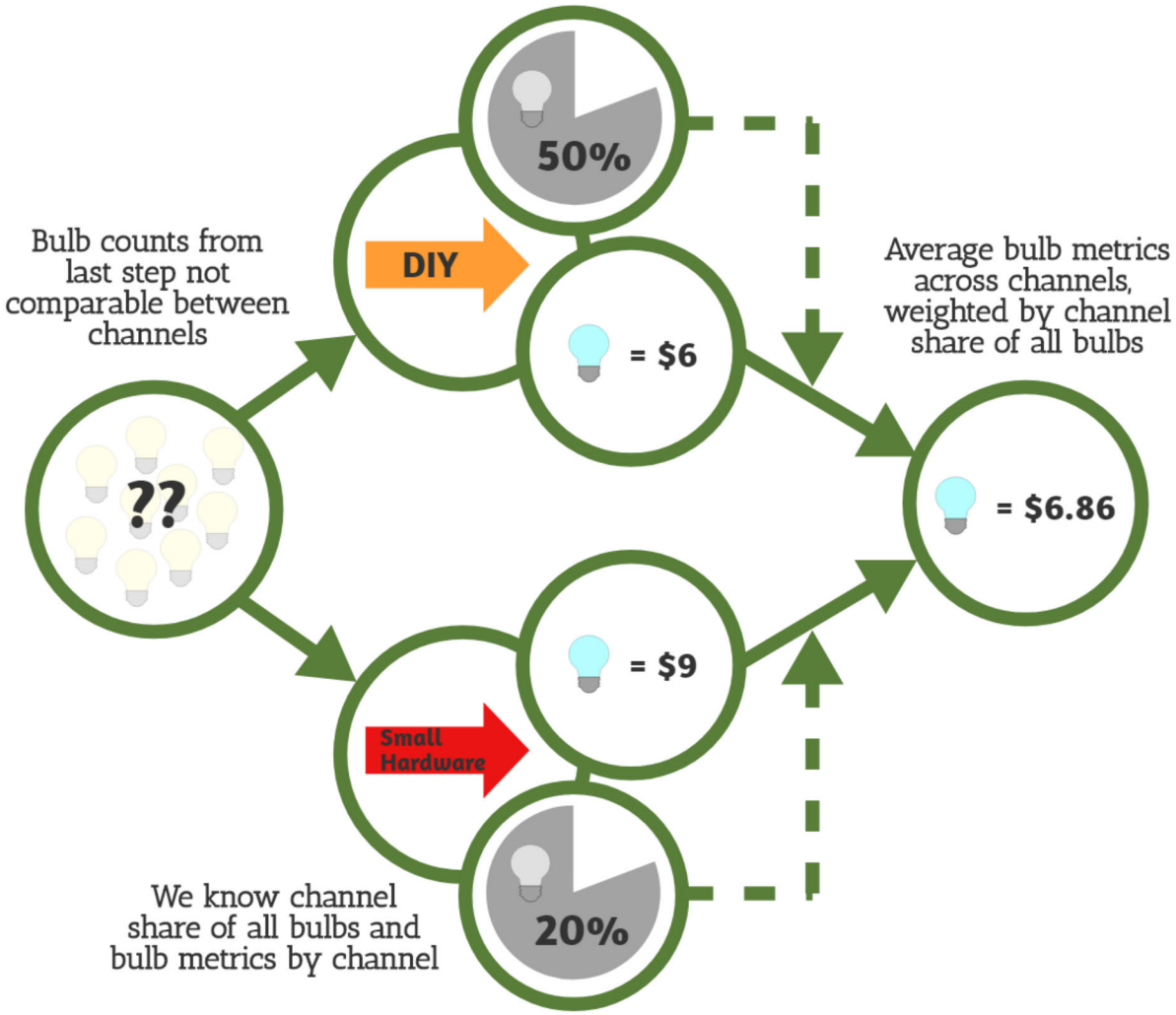


Figure 23. Current Method for Combining Bulb Metrics across Channels