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California Statewide Residential Lighting Customer Decision Study

Final Report
Study ID: PGE0419.01

June 18, 2018

Opinion Dynamics

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1. Introduction

Opinion Dynamics was contracted by Pacific Gas and Electric Company (PG&E) in early 2017, on behalf of the California electric investor-owned Utilities (IOUs), to conduct a study to measure lighting awareness, knowledge, and preferences of residential customers in the state of California. By understanding the factors that shape customer purchase decisions and how those factors vary by customer segment, the IOUs can better design and maximize the impact of future residential lighting program interventions.

Through the use of the latent class discrete choice method, Opinion Dynamics estimated the relative importance of different lighting attributes, including price; grouped customers into meaningful segments based on their lighting preferences; determined price elasticities of the major light bulb types; and simulated market shares and adoption rates for the various technologies by varying product pricing. This report details the methodology behind the study and the study results. The IOUs can use the results to inform their program interventions and marketing and targeting tactics.

The residential lighting market is undergoing rapid change, both in terms of product mix and pricing. A benefit of this study is that, in addition to providing results about current market conditions, the study method allows the IOUs to estimate lighting sales under a range of possible market conditions extending the future usability of the results and as a result the shelf life of the study.

2. Executive Summary

2.1 Study Goals and Methodology

This report details the methodology and results from the California Statewide Residential Lighting Customer Decision Study. The goal of the study was to understand the new possible role(s) of the residential lighting programs through 1) measuring the current state of the market in terms of customer lighting knowledge and preferences and 2) assessing the effect of Title 20 lighting standards as well as the Voluntary California Quality LED Lamp Specification[1] on the adoption (diffusion) of LED technology.

Opinion Dynamics conducted a latent class discrete choice (LCDC) study. The study includes a stated preference discrete choice survey experiment—the DC—that we analyzed using latent class analysis (LCA). DC survey experiments involve providing customers with a series of hypothetical product alternatives. Each alternative is described by several attributes (e.g., light color, life, and price attributes for lamps). Customer responses are modeled to determine the relative influence of each attribute on customer purchase decisions. In essence, DC experiments allow us to elicit and "reveal" customer preferences without directly asking customers what attributes matter most, which most people cannot accurately articulate. The LCA leverages the results of the DC experiment combined with other survey results, such as customer demographic characteristics, attitudes toward energy efficiency, current lighting use, and preferred shopping channels, and classifies customers into like segments. In addition to isolating the lamp attributes that drive purchases and identifying different customer segments, the study results allow us to simulate LED adoption and elasticity of the LED product demand.

The LCDC study relied on a quantitative survey with a representative sample of California customers. The target population for this study was all California households. The quantitative survey included two distinct modules: (1) a DC experiment in which we asked respondents to choose what they would purchase from a selection of light bulbs, with randomly assigned attribute levels across key product attributes, which include technology, price, light color, bulb life, annual energy cost, CRI, utility endorsement, and ENERGY STAR certification; (2) questions about customer lighting knowledge and preferences, and customer socio-demographic and household characteristics.

Due to anticipated differences in preferences and therefore purchase decisions between standard and reflector lamps[2], we developed two distinct DC experiments for each product type. To minimize respondent burden, survey respondents received either a standard or a reflector DC module, but not both.

We conducted the survey with a representative sample of California households. We used the address-based sampling (ABS) approach, as it is the most complete sample frame for household surveys in the United States.[3]

Due to the visual requirement of the DC experiment, we administered the survey online. We sent customers invitations and reminders via mail and email to participate in the survey. To assess the presence and magnitude of coverage bias, we administered a brief telephone survey with those who did not have access to the internet. To minimize non-response, we offered customers who completed the survey incentives in the

[1] http://www.energy.ca.gov/business_meetings/2016_packets/2016-12-14/Item_09.pdf
[2] For the purpose of this study, we defined standard lamps as lamps that fit standard medium screw-based light sockets and are used for general service lighting applications. The most common standard lamps are A-series light bulbs. We defined reflector lamps as lamps used in directional lighting applications, with most common reflector lamps being spotlights and floodlights. Appendix E provides images of the most common standard and reflector lamps.
[3] American Association for Public Opinion Research (AAPOR). Address-Based Sampling (2016), 2.

amount of $5 gift cards. We completed a total of 670 surveys, of which 663 were online survey completes that we used in our analysis.

Upon completion of fieldwork, Opinion Dynamics compared the survey sample to the population of California households across a range of socio-demographic and household characteristics and applied raked survey weights to align the survey sample with the population.

Data analysis involved the following activities:

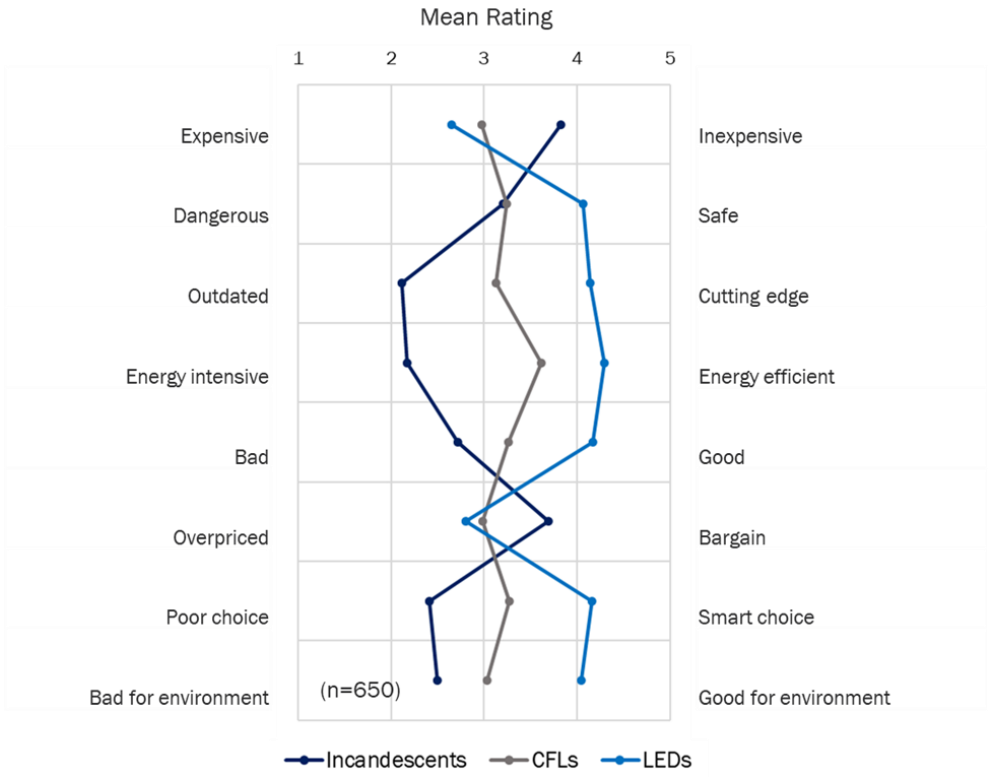
- Latent class modeling, through which we developed the segmentation scheme for standard and reflector products and assessed the importance of different lighting attributes for each segment and across segments
- Market share and demand elasticity simulations, through which we estimated market shares for each technology and developed demand elasticity curves for each segment and across segments
- Analysis of non-discrete choice questions, through which we developed additional insights into customer awareness, knowledge, experience, and shopping behaviors as they relate to lighting products
- Diffusion of innovation simulation, through which we estimated lighting products adoption curve under current market conditions as well as counterfactual market conditions

2.2 Key Findings, Conclusions, and Recommendations

State of the Market Assessment

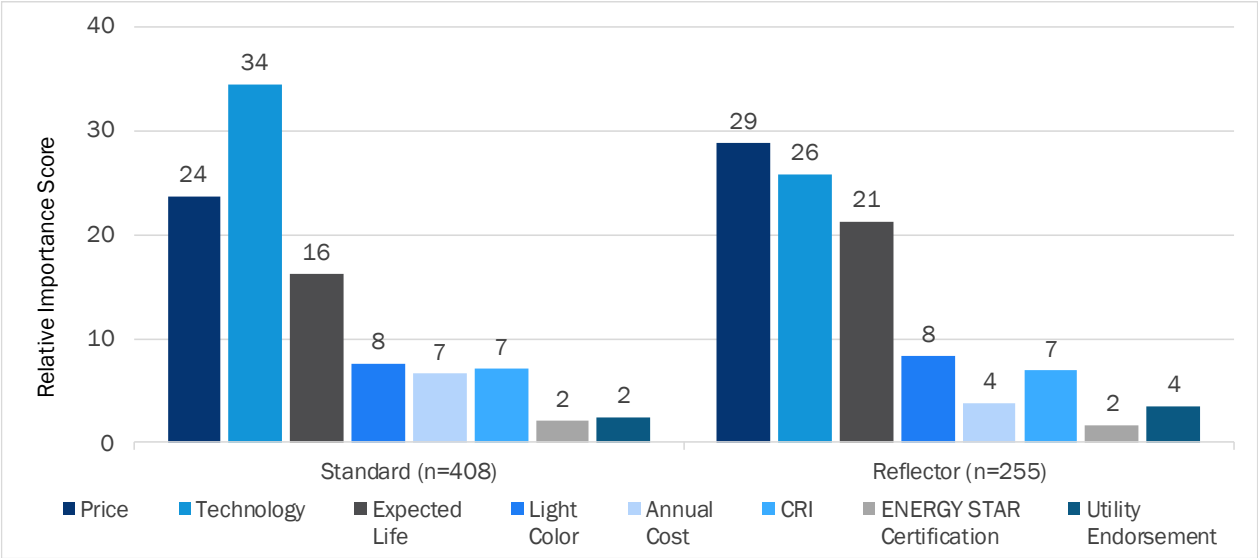
The California lighting market is nearing transformation. The transformative effects are evidenced in the near universal awareness and penetration of energy efficient technologies, knowledge of their benefits, and a natural preference for the technologies. More specifically, only 1% of Californians have not heard of CFLs and only 5% have not heard of LEDs. Survey responses to semantic differential questions, presented in Figure 2-1 below, indicate that customers have a deep understanding of different technologies. For example, customers know that LEDs and CFLs use the least energy, but CFLs, along with incandescents, are not as good for the environment. Customers think of incandescents as inexpensive and a bargain, but also as outdated and energy intensive. Though LEDs were also viewed as the most expensive of the three technologies, they are not perceived as being much more expensive than CFLs.

Figure 2-1. Lighting Product Perceptions



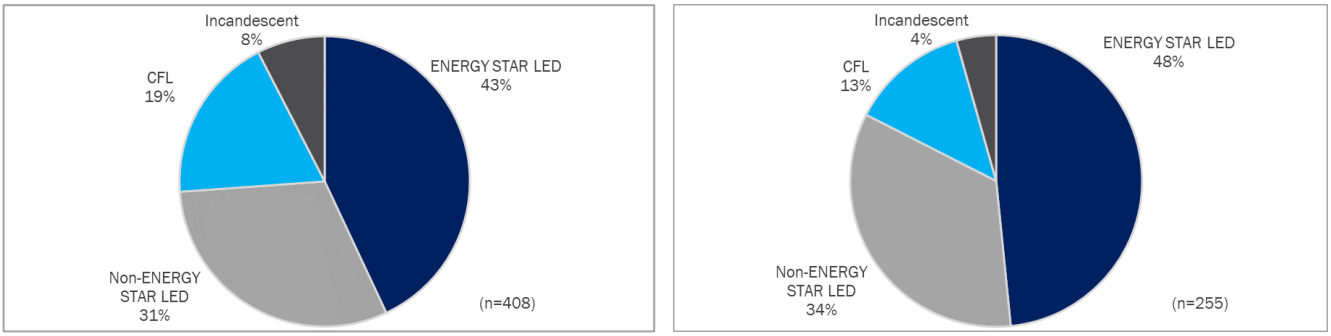
Analysis of relative importance scores for key lighting attributes presented in Figure 2-2 below shows that technology is one of the key drivers of customer purchase decisions, for both standard and reflector products, followed by bulb life. For standard bulbs, technology is especially important to customers, while for reflector products, price and technology are of nearly equal importance. Light color, annual energy cost, and color rendering index (CRI) are of lesser importance. ENERGY STAR certification and utility endorsement are of the lowest importance, relative to other lighting attributes.

Figure 2-2. Relative Importance of Attributes by Bulb Type



Analysis of market shares by technology shows that LEDs dominate the lighting market, representing an estimated 74% of standard bulb sales and 82% of reflector bulbs sales at current prices. Combined, CFLs and LEDs account for over 90% of lighting sales in the California market.

Figure 2-3. Standard and Reflector LED Market Shares



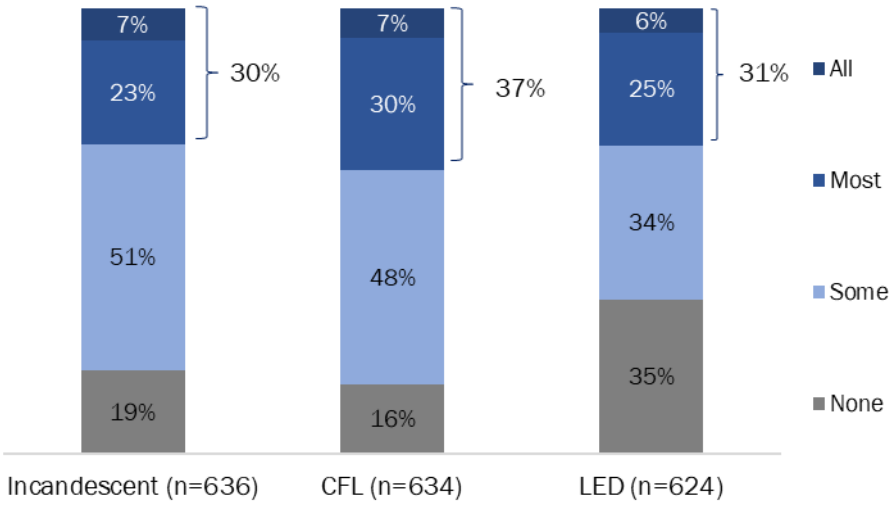
Although price is another important consideration for customers when purchasing light bulbs, our simulations show that demand for LEDs, both standard and reflector, is not price elastic (elasticity of 0.175 and 0.278 respectively, which means that for every 10% decrease in price, the market shares of LEDs will increase by 1.75% and 2.78% respectively)[4], which is likely a function of strong preference for the technology. In fact, market share simulation results show that customers prefer LEDs even when they are priced higher than other technologies.

Given knowledge and preferences for energy efficient lighting, it is not surprising that CFLs and LEDs are saturating customer sockets. Based on the customer self-report, in nearly a third of homes (31%), LEDs are installed in all or most light sockets, and in over a third of homes (37%) CFLs are installed in all or most light

[4] An elasticity (in absolute value) closer to 0 is considered low or relatively inelastic, while an elasticity closer to or greater than 1 is considered high or relatively elastic (Simon and Blume, 1994). An elasticity rating of 0.175 indicates that for every 10% decrease in bulb price, the market share of LEDs will increase only by 1.75%.

sockets (see Figure 2-4 below). Combined, 60% of California homes have CFLs or LEDs in **all** or **most** sockets, and only 1% of homes have neither CFLs nor LEDs installed.

Figure 2-4. Respondent Self-Reported Percent of Sockets Containing Technology

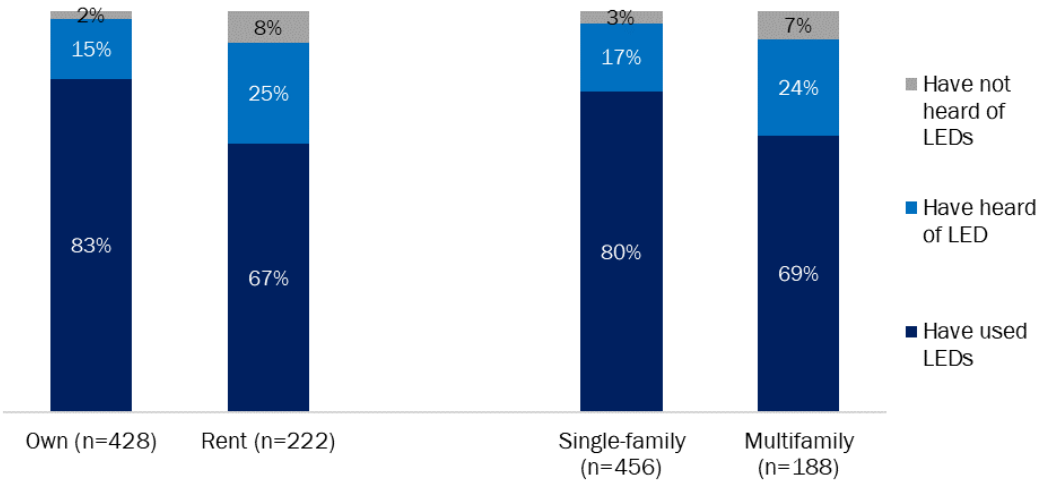


Recommendation 1. These findings suggest diminishing effects from mass market incentive-based energy efficient lighting programs, such as the current upstream residential lighting programs administered by the California IOUs. Many customers are using LEDs and are willing to pay more for them, which signals high free-ridership rates. The IOUs that have not yet done so should consider sun-setting their mass market programs and replacing them with 1) offerings that target customer segments that lag behind in their adoption of energy efficiency lighting products; and 2) offerings that focus on informational and educational interventions as opposed to incentives.

Customer Gaps and Opportunities

While many Californians are knowledgeable about LEDs and prefer them over other bulb technologies, some customers lag behind in their knowledge and adoption of the energy efficient technologies. Based on the customer survey results, renters and customers residing in multifamily properties are disproportionately more likely than homeowners and customers residing in single-family properties to have heard of LEDs but not used them, as shown in the figure below.

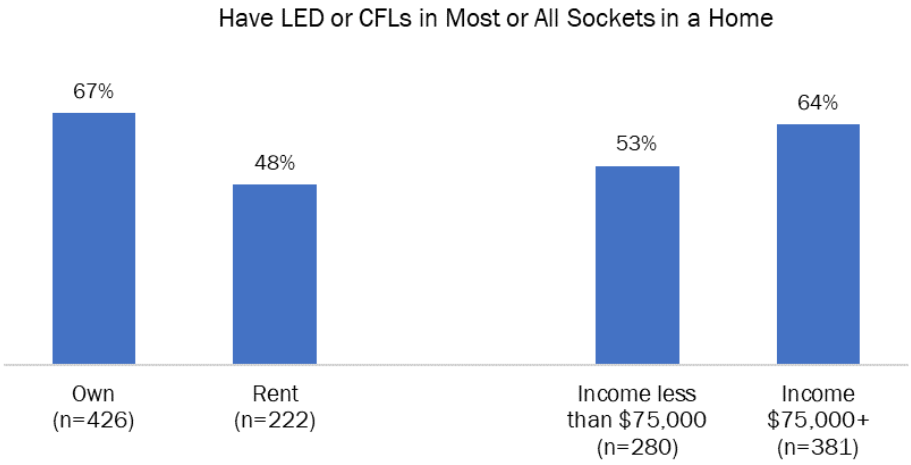
Figure 2-5. LED Awareness and Use by Customer Type



Single-family properties include townhomes.

Furthermore, renters and customers with lower incomes are less likely to have their sockets saturated with CFLs or LEDs. More specifically, 48% of renters have CFLs or LEDs in all or most of their sockets as compared to 67% of homeowners, and 53% of customers with incomes under $75,000 have CFLs and LEDs in all or most of their sockets as compared to 64% of customers with incomes of $75,000 and over (Figure 2-6).

Figure 2-6. Respondent Self-Reported Percent of Sockets Containing Energy Efficient Product by Customer Type



Through the latent class analysis, we developed a segmentation scheme based primarily on customer lighting preferences and the importance of the various lighting attributes. Our segmentation analysis identified five segments that are distinct in their preferences for **standard** lighting products and three distinct segments for **reflector** products (summarized in Figure 2-7 and Figure 2-8 below). Consistent with the previous finding of the transforming market, most segments exhibit natural and strong preference for energy efficient products, despite the varying importance of lighting attributes. Within certain segments, however, the opportunity for

advancement of energy efficient products still exists. Namely, the "Frugal Consumers" segment for both standard and reflector products.

On the standard side, Frugal Consumers represent a one-fifth of the California population (20%). On the reflector side, Frugal Consumers represent over a third (38%) of the eligible population.[5] Frugal Consumers are more likely to prefer incandescent products than other segments (27% market share for standard products and 9% for reflectors). Frugal Consumers may represent the final segment to move fully to energy efficient lighting technologies.

[5] Eligible population is defined as customers with reflectors in their homes.

Figure 2-7. Standard Products Segmentation Summary

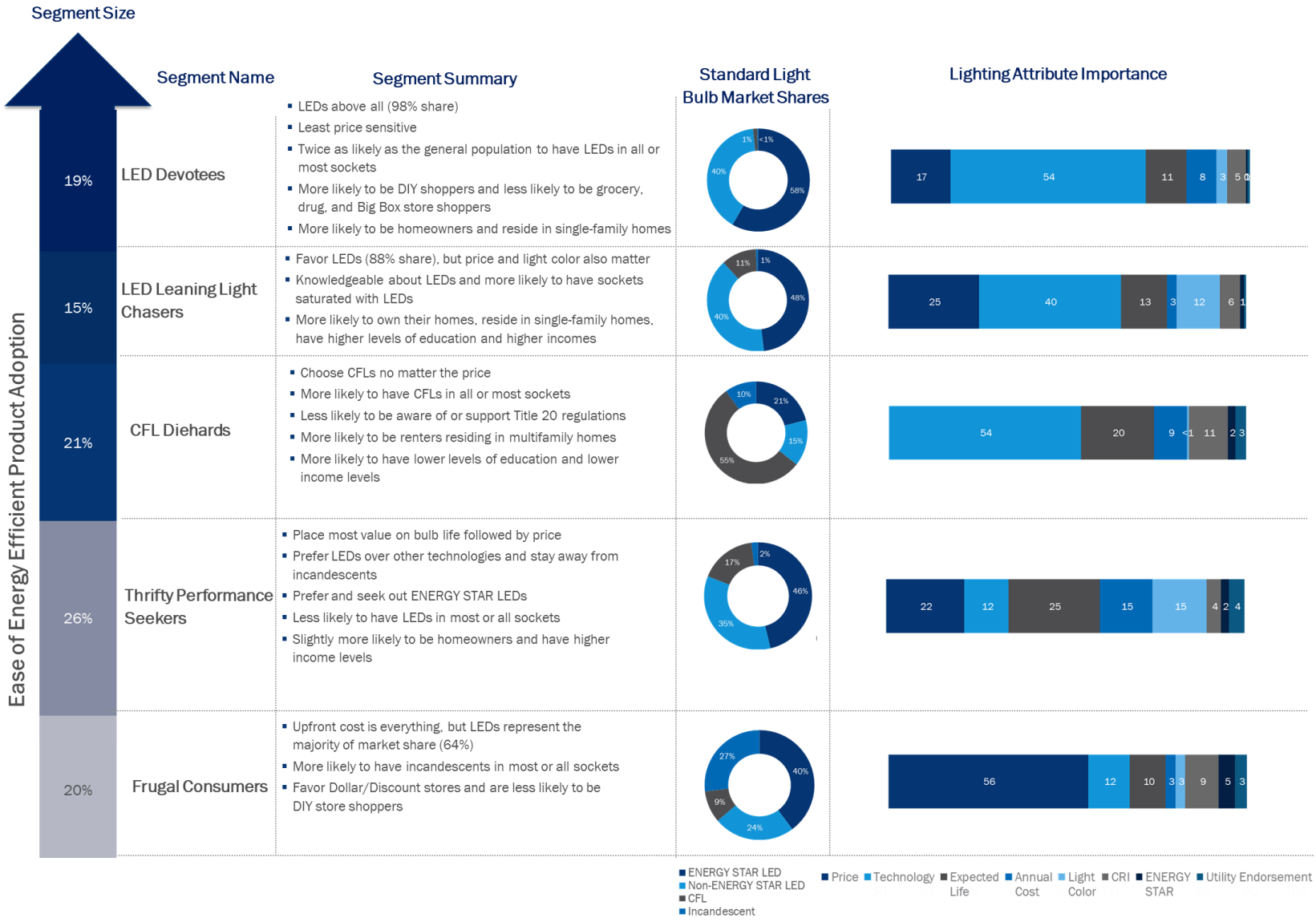
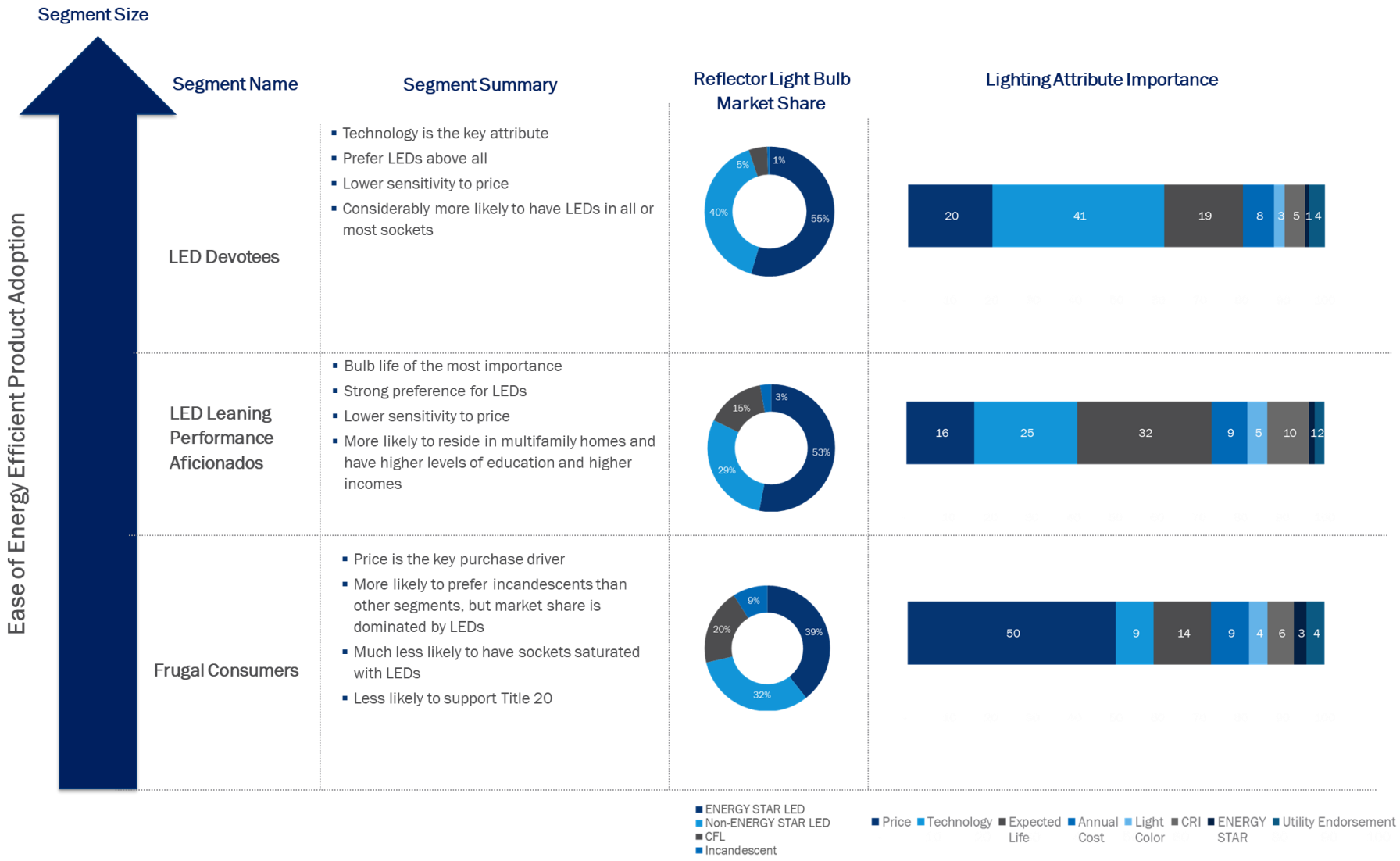


Figure 2-8. Reflector Products Segmentation Summary

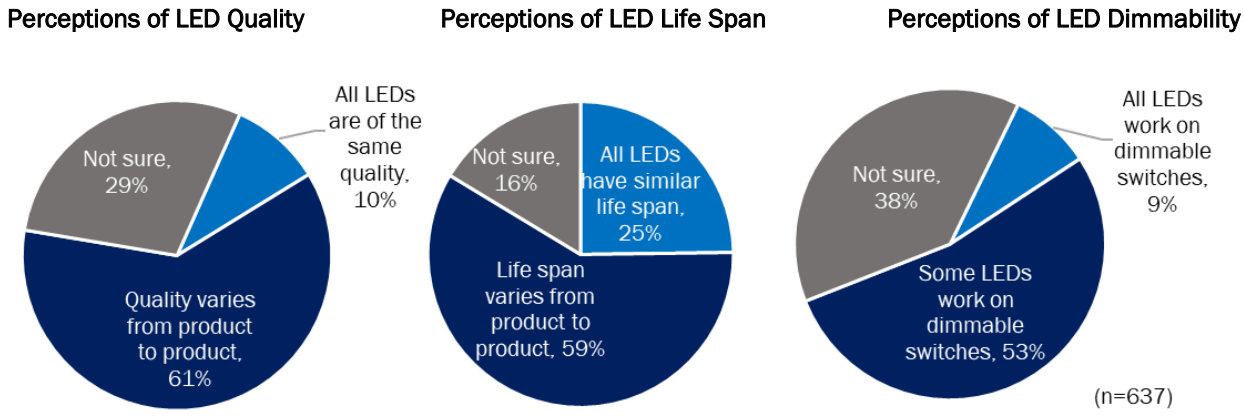


Recommendation 2. We recommend that the IOUs continue targeting underserved customer groups with incentives in the short-term until the effects of Title 20 standards are fully reflected in retailer stocking practices[6], because it will help accelerate the adoption of LEDs. To further improve targeting, the IOUs should consider using the results from the discrete choice modeling exercise and assign segments to each of its customers through a propensity scoring analysis and more precisely identify customers for targeting and outreach. Propensity scoring analysis involves regression modeling and allows to assign all IOU customers in one of the segments derived as part of this study. Reaching underserved customers through targeted retailer outreach can be an effective strategy as well, as these underserved customer segments are more likely to shop at Big Box and Dollar/Discount retailers such as Walmart, Dollar Tree, and Dollar General. It should be noted that a subset of customers from the underserved groups may qualify for the IOUs' Energy Savings Assistance (ESA) program. Finding ways to channel qualifying customers into the ESA program can be a beneficial targeting and outreach strategy that will help the IOUs to further market transformation by capitalizing on the ESA program benefits.

Knowledge Building and Assurance of Satisfaction with LEDs

While customers demonstrate a good understanding of LEDs in general, their knowledge of LED quality markers is lacking. In fact, the indicators of LED quality vary considerably. More specifically, a considerable share of customers either do not know that LEDs vary in quality, life span, and dimming ability or mistakenly believe that all LEDs are equal across those metrics (see Figure 2-9 below). Such misconceptions in the market can lead to customers purchasing an inferior product, being dissatisfied with it, and ultimately becoming reluctant to purchase LEDs. This is particularly true for LED dimming functionality, which is not a feature of all LEDs and, even when present, requires an LED-compatible dimmer for best performance. Customer education could help ensure selection of the right product and prevent customers from unintentionally purchasing non-dimmable products.

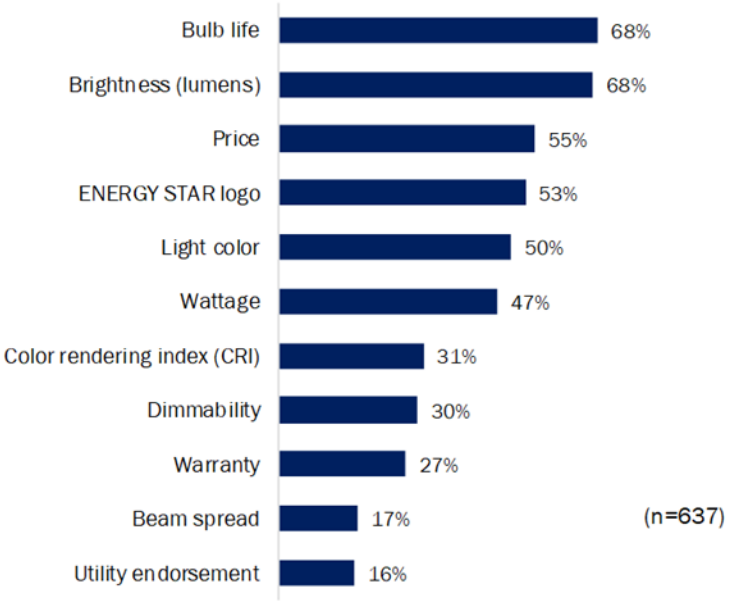
Figure 2-9. Understanding of LED Quality and Features



[6] Full transition to stocking of compliant products can take up to a few years, based on the market response to the first phase of EISA 2007 legislation, which was similar to Title 20 and prohibited the manufacturing of noncompliant products.

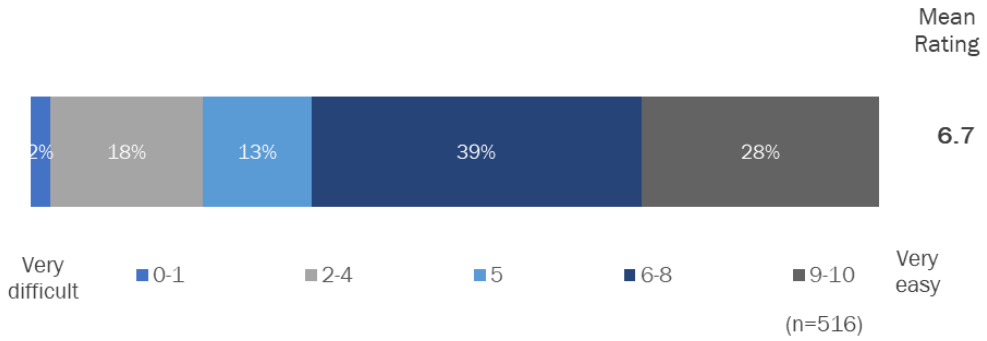
Furthermore, the indicators of LED quality vary, with customers using multiple markers to define what a quality LED means to them. As can be seen in the figure below, some of the key LED quality markers include bulb brightness, wattage, and light color, which suggests that customers conflate their space lighting needs with the ultimate quality of the product. It is therefore possible that even when selecting a high-quality LED, customers may be deeply dissatisfied with it and perceive the product as being of lower quality if it is inappropriate for the lighting needs of the space.

Figure 2-10. LED Quality Markers



Finally, despite a general preference for LEDs, not all customers have an easy time finding the products that fit their needs. Only slightly more than a quarter of Californians (28%) find it very easy[7] to locate and select the correct lighting product.

Figure 2-11. Ease of Finding and Selecting the Right Product



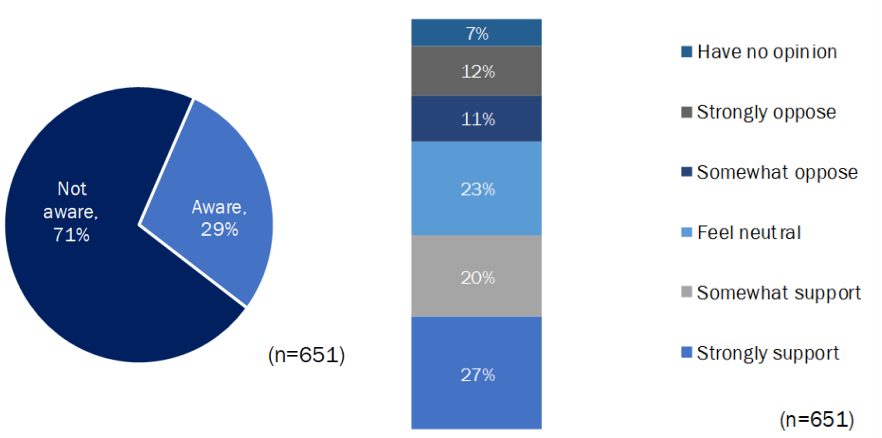
[7] A rating of 9 and 10 on a scale from 0 to 10, where 0 means very difficult and 10 means very easy.

Recommendation 3. We recommend that the IOUs consider continuing educational outreach at point-of-sale to educate customers on the variability in LED technology quality as well as the range of product options in terms of brightness and light color.

Impact of Title 20 Codes and Standards

The study results indicate low resistance to Title 20 standards from the customer perspective. While not many Californians are aware of Title 20 standards (29% awareness), close to half (47%) support them based on a description of the standards that we provided in the survey,[8] close to a quarter (23%) oppose them, and close to a third (30%) feel neutral or have no opinion on the matter.

Figure 2-12. Awareness and Opinions of Title 20



In light of the Title 20 standards, few Californians would seek out noncompliant bulbs. Namely, 13% would purchase noncompliant incandescent light bulbs online, and a very small percentage (3%) would travel outside of California to purchase noncompliant incandescent light bulbs. While these percentages are small, they represent a potential for unrealized savings.

Tier 2 Title 20 standards, scheduled to take effect in the summer of 2019, will further increase the efficiency and performance requirements for LED products. Our study has limited insight into manufacturer and retailer, including online retailer, compliance, and the anticipated speed with which noncompliant products will disappear from the retailer shelves.

Recommendation 4. The IOUs should consider conducting additional research into manufacturer, distributor, and retailer compliance, including compliance of online lighting retailers, and, based on the results of the research, encouraging compliance and ensuring code readiness for Tier 2 standards of Title 20. This will help ensure successful and more rapid market transition. We also recommend that the IOUs supplement this strategy with additional customer education about the rationale behind Tier 2 standards and encourage compliance can further accelerate market transformation.

[8] Includes "strongly support" and "somewhat support."

The Value of Additional Quality Specifications to Customers

CRI is one of the parameters used to set quality specifications for LED products by the CEC as well as part of Tier 2 Title 20 standards.[9] Our research suggests that most customers are unaware of CRI. Overall, 3 in 10 Californians (29%) are somewhat or very familiar with the term CRI. However, when asked to describe, in an open-ended fashion, what CRI represents, over a third (36%) of those familiar with the term provided a correct definition.

Our research, however, is limited in understanding the impact of the various CRI specifications on customer satisfaction with LED products and therefore whether educational efforts around CRI are an important and worthy endeavor.

Recommendation 5. The IOUs should consider conducting additional research into the importance of light rendering accuracy to customer satisfaction with LEDs. Such research could be valuable when deciding on the scope and degree of educational efforts needed around CRI as well as the value of Tier 2 CRI specifications from the customer perspective.

2.3 Areas of Future Research

As described in the Conclusions and Recommendations section above, this research study could not provide additional insight into (1) anticipated supply-side compliance, including online retailer compliance, with the Title 20 standards, both Tier 1 and Tier 2, and (2) the value that customers place on CRI. These two areas can benefit from additional research. Supply-side compliance can be investigated through a shelf stocking study combined with interviews with supply-side market actors (retailers, distributors, and manufacturers), while the value of CRI can be explored through a quality study where customers get to use LED products with various CRI ratings and comment on the observed differences, or lack thereof, in performance.

Additionally, should the IOUs pursue targeted outreach and marketing efforts, a propensity scoring analysis will allow the IOUs to leverage this study's segmentation results by assigning segments to the entire customer population.

[9] CRI is one of the color rendering metrics, which measures lighting fidelity. While this metric is widely used as a marker of lighting color rendering accuracy, it suffers from several key limitations, including methodological issues, inability to convey exact color appearance, and lack of performance for very discrete spectral power distributions.

3. Introduction, Background, and Study Goals

This report details the methodology and results from the California Statewide Residential Lighting Customer Decision Study. The need for this study originally emerged from the rapid changes in the California lighting market and the limited knowledge about how residential customers make lighting purchase decisions and perceive LED lamps. The key goal of the study was originally to inform the design of future residential lighting incentive programs. Among those, upstream lighting programs have been a core component of the California investor-owned utilities (IOUs) in the residential lighting market.

The first tier (Tier 1) of California's Title 20 lighting efficiency standards[10] took effect on January 1, 2018. Under the regulation, the minimum efficacy of most general service lamps manufactured for distribution in the state of California will have to be at least 45 lumens per watt. This means that incandescent and halogen lamps will no longer meet the state standards. Tier 1 also set a series of standards for state regulated LED lamps[11], including an efficacy of 68 lumens per watt (lpw), a color rendering index (CRI) of 82 or higher, a life of 10,000 hours or more. Under Tier 1, qualifying state regulated LEDs must meet a compliance score of at least 282, where compliance is determined by adding efficacy to the CRI multiplied by 2.3. State regulated small diameter directional lamps (SDDLs)[12] have a requirement of either 80 lpw or an efficacy of 70 lpw and a minimum compliance score of 165.

The second tier (Tier 2) of the Title 20 is scheduled to take effect on July 1, 2019 and increases quality standards for state regulated LED lamps, including an increase in efficacy to 80 lumens per watt, a minimum compliance score of at least 297, and a standby power of 0.2 watts.

These new codes and standards are bringing significant change to California's primary lighting programs.[13] As a result, the goal of the study shifted from informing future incentive program design and incentive structures to understanding the new possible role(s) of the residential lighting programs through measuring the current state of the market in terms of customer lighting knowledge and preferences and assessing the effect of Title 20 lighting standards as well as the Voluntary California Quality LED Lamp Specification[14] on the adoption (diffusion) of LED technology. Taking into consideration Title 20 lighting standards, the study explored changes in customer shopping behaviors, such as the likelihood that customers would seek banned incandescent and halogen lamps in other states or online.

This study has two overarching research goals, with multiple associated research objectives. We outline the goals and the associated objectives below.

[10] This specification represents the California Energy Commission's recommendation for minimum requirements for an LED light to be considered "California quality" and are designed to encourage early adoption of Title 20 compliant LEDs. http://www.energy.ca.gov/2017publications/CEC-140-2017-003/CEC-140-2017-003.pdf.

[11] These lamps include Lamps with an American National Standards Institute (ANSI) E12, E17, E26 or GU-24 base, lamps that are capable of brightness between 200 lumens (150 lumens for candelabra bases) and 2,600 lumens, lamps capable of producing white light with a color correlated temperature (CCT) between 2,200 and 7,000 K, lamps with a Duv ±0.012 (chromaticity as defined in ANSI C78.377), and lamps used in retrofit kits, which are products designed to retrofit existing recessed can housings that contains one of the preceding bases.

[12] A state-regulated SDDL is a non-tubular directional lamp with a diameter of 2.25 inches or less that can operate at 12 volts, 24 volts or 120 volts. State-regulated SDDLs are further defined by additional characteristics such as base, lumen output and rated life. SDDLs may be incandescent, halogen or LED.

[13] Along with Title 20 standards, a revision to the California Energy Commission's Title 24 called the Joint Appendix 8 (JA8) which took effect in January 2017 set lighting efficacy standards for new constructions in the state of California. These standards are yet another force driving energy efficient lighting adoption in the state.

[14] http://www.energy.ca.gov/business_meetings/2016_packets/2016-12-14/Item_09.pdf

- Research Goal 1: Understand customer lighting preferences and the effect of various lamp attributes on consumer purchase decisions
  - Explore customers' overall perception of the various lighting technologies in general and LED lamps in particular
  - Explore customer awareness of lighting attributes and identify consumer purchase priorities by lamp attribute
  - Determine the attributes customers consider to be markers of LED lamp "quality"
  - Classify consumers into segments based on their lamp attribute purchase considerations and customer characteristics
  - Explore the likelihood that customers will seek incandescent and halogen lamps outside California (including online) under the Title 20 lighting standards
  - Develop price elasticity curves and estimate CFL and LED market shares under various pricing scenarios
- Research Goal 2: Develop diffusion of LED technology innovation curves
  - Estimate the adoption (or diffusion) of LED technology in the absence of the Title 20 lighting standards, as well as the deployment of the second phase of the Energy Independence and Security Act (EISA) of 2007[15] code changes based on current customer preferences

[15] EISA is a federal law that mandates increased energy efficiency standards for light bulbs. The legislation was implemented over time. The last phase of the law is scheduled to take effect in January 2020 and will ban the sales of most lighting products whose efficacy is below 45 lumens per watt.

4. Study Methodology

To meet these research goals and objectives, Opinion Dynamics conducted a latent class discrete choice (LCDC) study. The study includes a stated preference discrete choice survey experiment—the DC—that we analyzed using latent class analysis (LCA). DC survey experiments involve providing customers with a series of hypothetical product alternatives and asking them to select which product they would purchase. Each alternative has several attributes that vary (e.g., light color, life, and price attributes for lamps). Customer responses are modeled to determine the relative influence of each attribute on customer purchase decisions. In essence, DC experiments allow us to elicit and "reveal" customer preferences without directly asking customers what attributes matter most, which most people cannot accurately articulate. The LCA leverages the results of the DC experiment combined with other survey results, such as customer demographic characteristics, attitudes toward energy efficiency, current lighting use, and preferred shopping channels, and classifies customers into like segments. In addition to isolating the lamp attributes that drive purchases and identifying different customer segments, the study results allow us to simulate LED adoption and elasticity of the LED product demand.

The LCDC study relied on a quantitative survey with a representative sample of California customers. Below we provide details of the survey and sample design, survey administration, and data analysis methodology.

4.1 Survey Design

The quantitative survey included two distinct modules: a DC experiment (in which participants were shown different lamps and asked to choose the products they would buy) and questions about customer lighting knowledge and preferences and customer socio-demographic and household characteristics. Below we detail the survey design approach.

4.1.1 Discrete Choice Module Design

We developed two DC modules: one for standard lamps[16] and one for reflector lamps. Because purchase of these two lamp types is likely to be driven by differing sets of preferences, we must assess these lamp types independent of each other. Due to survey length considerations, survey respondents received either the standard or a reflector DC module, but not both. As further described in the Sample Design section below, we only asked respondents who said that they had reflectors in their homes to complete the reflector DC module. We randomly assigned respondents with reflectors in their homes to either the standard or the reflector DC module. To achieve sufficient sample sizes for the reflector DC module, we disproportionately assigned customers with reflectors into the reflector module.[17]

As part of each DC module, we presented respondents with a random set of lamp package images with randomly assigned attribute levels across key product attributes, such as technology, price, light color, bulb life, and annual energy cost. Each lamp set included five choices, along with a "none" option to allow respondents to opt out of choosing a product that they would not realistically purchase. We presented respondents with a total of 12 lamp sets and asked respondents to select the lamp that they would purchase from each set. In an ideal world, we would present all possible lamp combinations. However, this is usually

[16] For the purpose of this study, we defined standard lamps as lamps that fit standard medium screw-based light sockets and are used for general service lighting applications. The most common standard lamps are A-series light bulbs. We defined reflector lamps as lamps used in directional lighting applications, with most common reflector lamps being spotlights and floodlights. Appendix E provides images of the most common standard and reflector lamps.

[17] As part of the survey deployment, we channeled 65% of respondents with reflectors in their homes into the reflector module. We channeled the remaining 35% of respondents with reflectors into the standard bulb module.

not possible, as it would require us to present each respondent with a large number of choice sets. The design software that we used to set up the experimental design, StatWizards Design Module, minimizes the number of choice sets a respondent has to assess, while keeping the design balanced and orthogonal[18] and allowing us to model the effects of each attribute independent of all others.

A key step in designing the DC survey was selecting which lamp attributes and associated levels to include. We focused on the attributes that are currently on lamp packages and worked collaboratively with the California electric investor-owned utilities (IOUs) to finalize the list of attributes.

An important component of keeping the DC design realistic is limiting certain attributes and attribute levels to specific lamp types. For example, showing customers an incandescent lamp that is ENERGY STAR® rated or that has a life of 25 years may undermine the credibility and realistic nature of the experiment in the eyes of the customer. Therefore, as part of the DC design, we worked to set appropriate restrictions. Because setting such restrictions may negatively affect the efficiency of the DC experiment, we made sure that our DC design balances the need for restrictions with the potential negative impact on the design efficiency. As a result, as part of the experiment, survey respondents were exposed to some lamp options with an unrealistic combination of attributes. To mitigate any potential negative impact from such unrealistic combinations, we provided instructions prior to the discrete choice experiment noting that some of the products may seem unrealistic but to please imagine that all products are actually available when making their product sections.

4.1.2 Additional Survey Questions

In the survey module that asked questions to assess customer lighting knowledge and preferences and to gather information on customer socio-demographic and household characteristics, we explored the following topic areas with respondents:

- Customer awareness and usage of lighting technologies
- Perceptions of lighting energy use by technology, as well as key associations with each technology type
- Preferred lighting shopping venues
- Markers of lamp quality in general and LED lamp quality in particular
- Awareness of lighting quality markers, such as ENERGY STAR, and importance of such markers in purchase decisions
- Awareness of the new lighting efficiency standards (Title 20) that went into effect in January 2018
- Customer-anticipated behaviors in light of the new lighting efficiency standards and likelihoods that customers will seek incandescent and halogen lamps outside California (including online)
- Socio-demographic and household information, such as housing type, homeownership status, age, education, and household income

[18] In this context, a balanced design is one where all attribute levels are equally represented in the product choices offered; an orthogonal design is one where the levels of any one attribute are not correlated with any other attribute levels in what is presented to the respondent.

4.2 Sample Design

The target population for this study was all California households. We purchased an address-based sample (ABS) of California households from a sample provider. ABS samples draw their frames from address lists of the U.S. Postal Service Computerized Delivery Sequence file and are currently the best possible frame for household surveys in the United States.[19]

Two key competing considerations drove the sampling approach for this study:

- A desire to ensure representativeness and to reduce the need for lengthy screening questions and complex post-stratification weights
- The need to achieve an adequate sample size for the reflector DC module, because not all customers have reflectors in their homes

4.2.1 Ensuring Representativeness of the Survey Results

Survey response rates vary by customer segment and are generally lower among renters, younger customers, and lower-income customers. By drawing a simple random sample of customers, we could run the risk of underrepresenting these "lower response" segments, thus creating the need to weight the data post-fielding to align the survey sample with the population. Depending on the survey sample composition, survey weights can be complex to construct and can increase the variability of the estimates, thus reducing their precision. There are two ways to increase the representativeness of the results without applying weights:

- At the sample design phase, by oversampling customers with a lower probability of survey participation
- At the survey implementation phase, by setting participation quotas based on characteristics that tend to be overrepresented and prohibiting participation once the quotas are reached

The latter approach was less preferable for this survey effort for the following reasons:

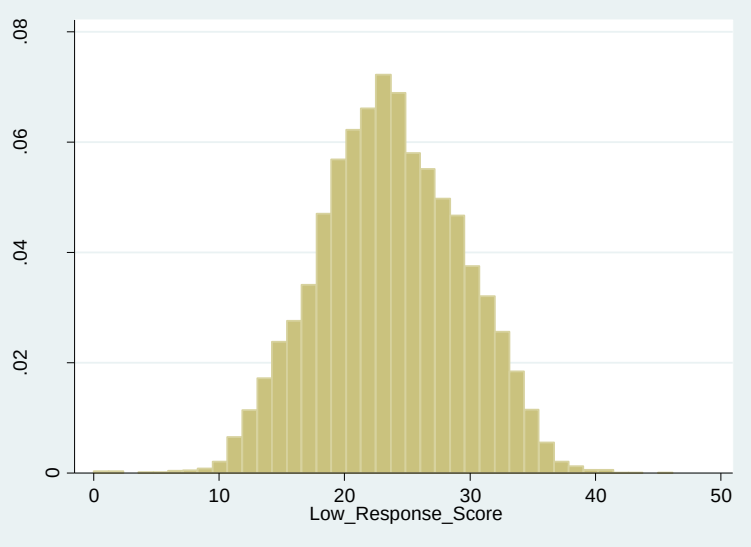
- Higher cost of survey administration – we would have mailed invitations and reminders to customers, but, to meet quotas, we later would have turned some away at a later stage if their quota had already been met
- Customer satisfaction – customers willing to complete the survey may be disappointed when turned down because survey quotas have been met

With these considerations in mind, we chose to design our sample to account for the lower probability of survey participation among certain customer segments. We leveraged the Low Response Score (LRS) developed by the U.S. Census Bureau. The LRS is a regression-based estimate of the likelihood that different census geographies will respond to a Census Bureau survey. The score is developed for each census block group and census tract and ranges from 0 to 46. The higher the score, the higher the probability of nonresponse. Figure 4-1 displays the distribution of census tracts across the LRS. The LRS is normally distributed across census tracts with a smaller number of tracts being a lot more or less likely to respond. For sampling purposes, we grouped census tracts into three LRS-based strata:

[19] American Association for Public Opinion Research (AAPOR). Address-Based Sampling (2016), 2.

- High-response (bottom quartile of the census tracts on LRS)
- Average-response (middle half of the census tracts on LRS)
- Low-response (top quartile of the census tracts on LRS)

Figure 4-1. LRS Distribution Curve



We used the best available assumptions about the anticipated response rates for each of the three categories. We purchased a stratified random ABS sample using the above three LRS strata. We drew a disproportionate sample that oversampled households in the low-response stratum and under-sampled households in the high-response stratum. The initial survey fielding process resulted in a much lower than planned response rate. To achieve the sample sizes needed for successful modeling and to best manage the survey costs, we lowered the number of target completed surveys and drew additional sample. Table 4-1 provides the distribution of the California households across the three LRS strata, anticipated response rates, sample that we drew, targeted number of completed surveys, and the actual number of completed surveys.

Table 4-1. Sample Design

LRS Category	California Population*		Anticipated Response Rate**	Sample		Completed Surveys	
	Household Count	% of Households		Count of Sample Points	% of Sample Points	Target**	Achieved
Bottom 25% of census tracts by LRS	3,279,601	26%	6%	3,212	20%	209	176
Middle 50% of census tracts by LRS	6,669,620	53%	5%	8,423	53%	424	377
Top 25% of census tracts by LRS	2,628,277	21%	4%	4,309	27%	167	117
Total	**12,577,498**	**100%**	**5%**	**15,944**	**100%**	**800**	**670**

* 2010–2015 American Community Survey.
** Adjusted based on the initial fieldwork results.

4.2.2 Achieving Adequate Sample Sizes for the Reflector Discrete Choice Module

Not all customers have recessed fixtures in their homes that generally accommodate reflector light bulbs. In fact, based on the results from the 2012 California Lighting and Appliance Saturation Survey (CLASS) completed by DNV GL, 59% of California homes have recessed fixtures. Recessed fixtures are more likely to be present in certain types of homes, namely single-family homes. Based on the same CLASS study, recessed fixtures were present in 67% of single-family homes compared to 45% of multifamily homes with 2–4 units and 40% of multifamily homes with 5 or more units.

To ensure question relevance and accuracy of the results, only customers with recessed fixtures received a reflector DC module. Customers without reflectors received a standard bulb DC module. But because customers with recessed fixtures in their homes are likely different from those with no reflectors (on such characteristics as homeownership, home type, and other correlated variables, such as education and income, which, in turn, are likely correlated with lighting preferences and use), we could not simply channel all customers with reflectors to the reflector DC module and those without to the standard bulb DC module without risking biased results. Rather, we needed to randomly assign customers with reflectors to either the standard or reflector DC module. However, given the expected incidence rate of households with reflectors and our target sample size, we would have had too few completed reflector bulb DC modules if we had assigned customers with reflectors **equally** to either module.

We therefore assigned customers with recessed fixtures disproportionately to the reflector DC module. We assigned 65% of respondents with recessed fixtures to the reflector DC module and 35% to the standard DC module (as opposed to a random 50%/50% split).

4.3 Survey Administration

4.3.1 Survey Mode

Due to the visual requirements of the DC survey experiment, we administered the survey online. Using our ABS sample, we mailed invitations to customers[20] and provided a web link that they could use to complete the survey. We provided a unique personal identification number (PIN) so that the respondents could complete only one survey and we could link the responses back to the sample frame and auxiliary population and sample data.

We attempted to mitigate nonresponse bias by sending two postcard reminders following the initial invitation. To further improve survey response, we emailed a subset of customers in our sample who had email addresses on file an email invitation and two email reminders.[21]

Requiring that customers complete the survey online could mean that customers without internet access or that are less internet savvy may be excluded from our final sample, which could result in coverage bias. To assess the existence of such bias and correct for it, we provided a telephone number in the postcard reminders that customers could call to complete a short survey. We did not provide the telephone number in the invitations to encourage as many customers as possible to complete the survey online. Recent research shows

[20] To optimize fieldwork costs, some customers in our sample received mailer invitations and some customers received postcard invitations. There was little difference in the survey response rates or sample composition by invitation type.

[21] We attempted this strategy only with a subset of the sample to test the effectiveness of this approach. Response to email outreach was minimal, and we therefore chose not to pursue it with the entire sample.

that withholding the inbound phone number until the postcard reminder increases the percentage of respondents who complete the survey online without reducing the overall response rate.

Telephone respondents completed an abbreviated survey that asked questions about their awareness and usage of different lighting technologies, as well as their demographics. They were not able to complete the DC survey module due to the visual requirements.

4.3.2 Incentives

To encourage survey participation, we offered customers who completed the survey, either online or over the phone, a $5 incentive. Past research suggests that post-paid incentives are one of the most effective ways to increase response rate. The choice of the post-paid incentive amount of $5 was driven primarily by the available budget for this study.

4.3.3 Survey Language

In addition to survey mode, language limitations can also lead to coverage bias. The state of California has a diverse population, with approximately 10% of the adult population speaking English “not well” or “not at all” according to 2014 U.S. Census data. Ideally, we would offer the survey in multiple languages so that all customers could complete it. However, DC surveys are rather complicated and the costs of translation and fielding in more than one language would be quite high and not covered by the study budget. Therefore, we administered the survey in English only.

4.4 Fieldwork Results

Table 4-2 provides the final survey dispositions. Overall, we completed 663 surveys that we could use in the analysis. In addition, we completed five surveys over the telephone.

Table 4-2. Survey Dispositions

Disposition	Count
Completed Interviews (I)	**670**
Internet survey completes	663
Telephone survey completes	5
Internet survey completes (removed from analysis for data quality reasons)	2
Partial Interviews (N)	**87**
Household with Undetermined Survey Eligibility (U1)	**14,667**
Empty	14,649
Mid-interview terminate – break-off (before screeners) – web	9
Answering machine	3
Not available	2
Language problems	2
Mid-interview terminate - break-off (before screeners)	1
Wrong PIN on inbound	1
Not an Eligible Household (X2)	**520**
Mailer returned to sender	520
Total Participants in Sample	**15,944**

We calculated response rates using the Response Rate 4 (RR4) methodology specified by American Association of Public Opinion Research (AAPOR) (see Figure 4-2 for response rate formula). We achieved a 4% survey response rate.

Figure 4-2. Response Rate Formula

$$RR_{(2-level)} = \frac{I + P}{I + P + N + e1(U1 + e2 - U2)}$$

Where:

I = Completed interviews

P = Partial completed interviews

N = Eligible incomplete interviews

X1 = Survey-ineligible household

X2 = Not an eligible household

U1 = Household with undetermined survey eligibility

U2 = Undetermined if eligible household

e1 = Estimated proportion of cases of unknown survey eligibility that are eligible. Calculated as:

$$e1 = \frac{I + P + N}{I + P + N + X1}$$

e2 = Estimated proportion of cases of unknown business eligibility that are eligible. Calculated as:

$$e2 = \frac{I + P + N + X1 + U1}{I + P + N + X1 + U1 + X2}$$

4.5 Survey Data Weighting

Upon completion of fieldwork, Opinion Dynamics compared the survey sample to the population of California households across a range of socio-demographic and household characteristics. We found that the survey sample was skewed in terms of income, education, home type, and homeownership. Our analysis of the survey showed differences in reported lighting awareness, preferences, and behavior across these demographic variables. As a result, we developed and applied raked weights to align the survey sample with the population of California households.

As part of the fielding strategy, to ensure an adequate sample size for the reflector DC module, we channeled respondents with recessed lights in their homes into the reflector DC module at a disproportionately higher rate, thus underrepresenting this segment in the standard DC sample. As a result, the distribution of respondents who received the standard DC module was different from that of the overall sample of survey respondents. We applied a separate set of survey weights to that sample. We used those weights when modeling and simulating standard bulb attribute importance, customer preferences, and market shares.

As discussed in Section 4.3 of this report, to assess the presence and magnitude of the coverage bias and correct for it, we conducted a short telephone survey that explored customer awareness and experience with the various lighting technologies, as well as a range of demographic and household characteristics. Because we completed surveys only with a handful of customers over the phone (n=5), we concluded that the potential for coverage bias was minimal and did not pursue any additional adjustments or analysis.

4.6 Data Analysis Methodology

Data analysis for this study consisted of several distinct components:

- Modeling and simulation of DC results
- Analysis of non-DC survey questions
- Diffusion of innovation curve simulation

4.6.1 Modeling and Simulation of Discrete Choice Results

Modeling and simulation of DC survey results relied on two key analytical steps: LCA, and market share and demand elasticity simulations.

Step 1 – Latent Class Analysis

The first step was developing meaningful and distinct customer segments based on their responses to the DC modules. We used LCA to segment the customers. LCA is a method for assigning customers into segments (the latent classes) based on the relationships between observable (manifest) variables and unobservable variables. Customers within the same LC are homogeneous on certain criteria, while customers in different LCs are dissimilar from each other in certain important ways.

We used Latent Gold to perform LCA. We specified a series of conditional logit models with a different number of LCs in each. We performed goodness of fit and other diagnostic tests, including reviewing Bayesian Information Criterion (BIC) scores, LC membership distribution, Wald tests, and reviewed classification table outputs to identify the best performing models. As part of the modeling process, we included covariates to improve the model performance and accuracy. The analysis produced a five-class model for the standard products and a three-class model for the reflector products.

Step 2 – Market Share and Demand Elasticity Simulations

Using the LCs developed during Step 1, we simulated market shares for each technology and developed demand elasticity curves for each class and across classes. We used the StatWizards market simulator to perform the simulations. We based the market share simulations on the set of product assumptions specified in Table 4-3 below. The assumptions in the table are based on the average product specifications. The prices are based on the current market conditions.[22]

Table 4-3. Market Share Simulation Assumptions

Bulb Type	Bulb Price ($)	Bulb Life (Years)	Annual Energy Cost ($)	Light Color	ENERGY STAR Rating	Utility Endorsement	CRI
Standard Bulbs (60-Watt or Equivalent)							
Incandescent	$1.80	1	$7.25	Warm white	Non-ES	No	100
CFL	$3.70	7	$1.75	Warm white	Non-ES	No	80
Non-ES LED	$3.80	15	$1.00	Warm white	Non-ES	No	80
ES LED	$4.50	25	$1.00	Warm white	ES	No	80
Reflector Bulbs (65-Watt or Equivalent)							
Incandescent	$3.70	1	$7.25	Warm white	Non-ES	No	100
CFL	$4.80	7	$1.75	Warm white	Non-ES	No	80
Non-ES LED	$6.00	15	$1.00	Warm white	Non-ES	No	80
ES LED	$7.00	25	$1.00	Warm white	ES	No	80

[22] Opinion Dynamics conducted secondary research of retailer prices of standard and reflector products both by visiting retailer websites and by conducting in-store visits in the San Francisco Bay area. We visited three stores, a Costco, a Home Depot, and a Target, between October 28 and November 3, 2017. We gathered pricing information from major retailer websites, including Home Depot, Lowe's, Walmart, Costco, and Amazon in January, 2018.

4.6.2 Analysis of Non-Discrete Choice Survey Questions

We relied on frequency distributions, cross-tabulations, measures of central tendency, and correlations to conduct the analysis of the non-DC survey questions. As part of the analysis, we recoded data (e.g., to group similar response categories into a broader category) and combined responses to distinct questions (e.g., prior experience with CFLs and LEDs into prior experience with energy efficient bulbs).

4.6.3 Simulation of Diffusion of Innovation Curves

Diffusion of innovation is a theory that seeks to explain how and at what rate new ideas spread in the market. Under the theory, a technology generally goes through five stages of adoption – innovators, early adopters, early majority, late majority, and laggards. A diffusion model produces a life-cycle sales curve based on several parameters. There are multiple models that project and predict the diffusion of the new technology in the market. The best known and widely used model is the Bass Diffusion model. The Bass diffusion model generates an S-curve and is defined by a differential equation. The Bass model principle is specified in Equation 4-1 below and is read as the portion of the potential market (i.e. those yet to adopt) that adopts at t (time) is equal to a linear function of previous adopters.

Equation 4-1. Bass Model Principle

$$\frac{f(t)}{1-F(t)} = p + \frac{q}{M}[A(t)]$$

Where:

t = time from product launch

M = potential market (the ultimate number of adopters)

p = coefficient of innovation

q = coefficient of limitation

A(t) = cumulative adoptions at time t

f(t) = the portion of M that adopts at time t

F(t) = the portion of M that have adopted at time t

To effectively calibrate the Bass model to the adoption of the LED technology, we specified the following key parameters:

- **Historic adoption of LED technology** – this parameter shapes the slope of the adoption curve and requires at least three historic adoption points. We based the historic adoption estimates on multiple market share studies across the country. Namely, we based the historic estimates of LED adoption on the in-store intercept and lighting baseline studies in Illinois (Ameren Illinois and Commonwealth Edison service territories) and Massachusetts[23]. Both of these states have diverse geographies and

[23] Opinion Dynamics. *Impact and Process Evaluation of Ameren Illinois Company's Residential Lighting Program.* Program Years 4, 6, and 8. Prepared for Ameren Illinois Company. December, 2012, April 2015, and March 9, 2017.
NMR Group. *2015-16 Lighting Market Assessment Consumer Survey and On-site Saturation Study.* Prepared for The Electric and Gas Program Administrators of Massachusetts. August 8, 2016

populations and both states have been running aggressive upstream residential lighting programs, similar to California. We could not find recent studies collecting market share data in the state of California and were this limited in our ability to use California-specific data.

Table 4-4. Historic LED Market Share Estimates

Year	Market Share Estimate
2013	2%
2014	3%
2015	30%
2017	75%

- **Maximum adoptions** – this parameter represents the adoption ceiling given market limitations. We derived these values using the discrete choice survey data and simulating LED market shares at different price points. We modeled LED market shares at current prices and under an aggressive pricing scenario, where LEDs, both standard and reflector, are priced at $1 per bulb. We developed two sets of scenarios separately for standard and reflector products and combined them into a single set of values representative of all LEDs by weighting the results to the anticipated distribution of lighting sales between the standard and reflector products. We used the 90% standard and 10% reflector split. It is based on the analysis of the results from the in-store intercept studies during which interviewers collect data on customer purchases.

Table 4-3 provides the specifications for LED products and alternative options.

Table 4-5. Maximum Adoption Assumptions

Bulb Type	Bulb Price – Current Conditions ($)	Bulb Price – Aggressive Pricing Scenario ($)	Bulb Life (Years)	Annual Energy Cost ($)	Light Color	ENERGY STAR rating	Utility Endorsement	CRI
Standard Bulbs (60-Watt or Equivalent)								
Incandescent	$1.80	$1.80	1	$7.25	Warm white	Non-ES	No	100
CFL	$3.70	$3.70	7	$1.75	Warm white	Non-ES	No	80
Non-ES LED	$3.80	$1.00	15	$1.00	Warm white	Non-ES	No	80
ES LED	$4.50	$1.00	25	$1.00	Warm white	ES	No	80
Reflector Bulbs (65-Watt or Equivalent)								
Incandescent	$3.70	$3.70	1	$7.25	Warm white	Non-ES	No	100
CFL	$4.80	$4.80	7	$1.75	Warm white	Non-ES	No	80
Non-ES LED	$6.00	$1.00	15	$1.00	Warm white	Non-ES	No	80
ES LED	$7.00	$1.00	25	$1.00	Warm white	ES	No	80

Navigant Consulting. *ComEd Residential Lighting Discounts Program Evaluation Report. Program Years 5, 6, 7, 8 and 9.* Prepared for ComEd. March 6, 2014, February 16, 2015, February 13, 2016, and November 10, 2016.

We modeled the adoption curves using StatWizards Bass curve simulator. As part of the simulation process, we modeled LED adoption under four scenarios:

- Natural conditions with current LED pricing
- Natural conditions with aggressive LED pricing (LEDs priced at $1)
- Title 20 standards taking effect in 2018 with a sell-through period of two years. An assumption of a two-year sell-through period is based on the historic evidence of non-compliant product sell-through following the deployment of the first phase of the EISA legislation in 2012.
- EISA 2020 standards taking effect in 2020 with a sell-through period of two years

Along with this report, we provide a simulator tool that will allow the IOUs to alter the simulation parameters of both market shares as well as diffusion of innovation curves.

5. Study Limitations, Challenges, and Threats to Validity

This section summarizes sources of uncertainty for this study and mitigation approaches that we took to ensure valid and reliable results.

5.1 Measurement Error

Measurement error is a key concern when designing a quantitative survey instrument as it can threaten the validity and reliability of survey results. To mitigate measurement error, Opinion Dynamics relied on our extensive knowledge of the lighting market and customer decision-making processes. We used previously fielded and proven survey question wordings and visual aids wherever applicable (e.g., lamp pictures across various technologies).

5.2 Sampling Error

When conducting studies that make use of a population sample, one always has to be concerned with sampling error and sample bias. A way to mitigate the sample bias is through sample sizes. As part of this study, we completed a large number of surveys, which helps to increase the precision around survey results and reduce sampling error. The relative precision differs for each survey question and depends on the distribution of responses to each question. A conservative estimate of relative precision is 3%.[24]

5.3 Nonresponse Bias and Coverage Bias

A study can suffer from nonresponse bias if the study participants are different from those who refuse to participate in terms of the study variables of interest. We encouraged more customers to participate by following survey invitations with postcard reminders. To further encourage participation, we offered customers a $5 incentive in the form of an Amazon gift card for completing the survey. Upon completion of the study, we compared our respondent sample to the broader population of California households across key socio-demographic and household characteristics. We found that the sample of survey respondents was skewing disproportionately toward customers with higher income levels, higher levels of education, and customers who own their homes. To correct for observed differences between the sample and the target population, we developed and applied post-stratification weights.

Coverage bias arises from (1) systematic exclusion of certain customer segments from the sample frame and (2) systematically limiting survey access to customers who are different than the rest of the population.

We tried to mitigate the coverage bias in the sample frame by using a high-quality sample source (ABS) from a reputable sample provider.

Due to the visual needs of the DC experiment, the survey had to be administered online. This survey mode limitation means that customers without internet access or who are less internet savvy would be excluded from our final sample, which could lead to coverage bias. To assess the existence of such bias and correct for it, we provided a telephone number in our invitation that customers could call to complete a short survey. We asked these respondents the same questions about their awareness and usage of different lighting technologies and collected the same demographic information as the online survey respondents. Having these data would have allowed us to explore the presence and the extent of coverage bias. Due to a very small

[24] Calculated for 50% proportion, which represents an upper bound to the uncertainty.

number of completed telephone surveys (n=5), we concluded that the presence of the coverage bias is minimal.

5.4 Hypothetical Bias

The LCDC study takes customers through a hypothetical shopping experience and collects information on customers' stated preferences. The advantage of the stated preference approach is that it allows us to explore numerous combinations of lamp attributes and varying attribute levels, but this approach can also result in "hypothetical bias," which, when it happens, usually takes the form of respondents claiming that they would choose the more socially desirable product. As part of the original scope, we had planned to use a mobile shopping mission to collect both stated and revealed preference data and to develop an adjustment ratio to mitigate the "hypothetical bias." Due to changing research objectives and priorities, the mobile shopping mission was not conducted as part of this research effort. The magnitude of the "hypothetical bias" impact on the study results is unknown, although in our design and presentation, we employed mitigating measures that have been shown in the literature to be effective in some circumstances.

5.5 Ability to Perform Subgroup Analysis

This study was designed to measure customer lighting preferences and behaviors at the statewide level. It is possible, and even likely, that variation exists in customer preferences and behaviors in different parts of the state, including for each of the three IOUs as well as between IOU and non-IOU customers. The study's sample design and the resulting sample sizes, along with budgetary considerations, prevented us from developing IOU-specific models and drawing comparisons between the three IOUs and IOU versus non-IOU customers.

6. Detailed Findings

This section provides detailed findings from the study. We first discuss the state of the California lighting market, followed by customer lighting preferences and their drivers. We then provide results on the diffusion of the LED technology in the California market and alternative scenarios for LED adoption under various market conditions.

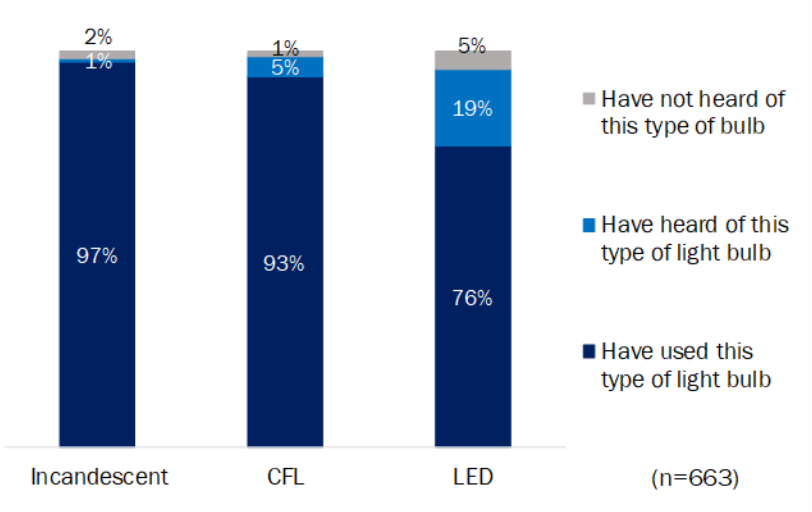
6.1 State of the California Lighting Market

As part of the DC survey, we explored customer knowledge of the various lighting technologies and their attributes, experience with the key lighting technologies and their presence in customer homes, past shopping behaviors, and reactions to the changing lighting codes in the state.

6.1.1 Lighting Awareness and Use

Californians are nearly universally aware of CFLs and LEDs. Only 1% of Californians have not heard of CFLs and only 5% have not heard of LEDs (Figure 6-1). Use of each, CFLs and LEDs, is also high. Most Californians have used CFLs (93%) and approximately three-quarters have used LEDs (76%). Nearly a fifth of customers (19%) have heard of LEDs but have not used them yet.

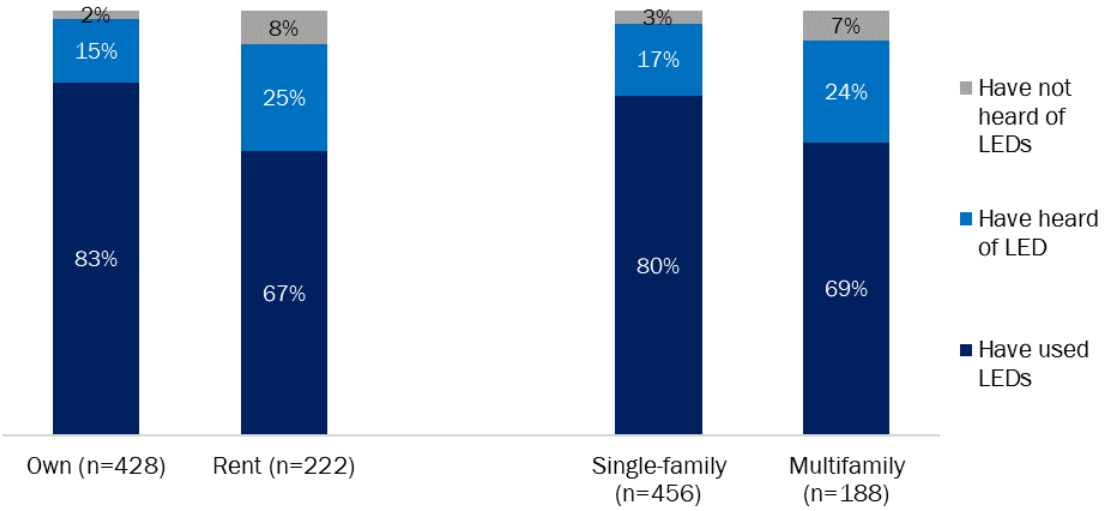
Figure 6-1. Experience with Lighting Technologies



Renters and customers residing in multifamily properties are disproportionately more likely than homeowners and customers residing in single-family properties to have heard of LEDs but not used them[25], as can be seen in the figure below. These customer segments have traditionally been harder to reach and have historically lagged behind other customer segments in energy efficient technology adoption.

[25] Single-family properties include townhomes. Multifamily properties include duplexes.

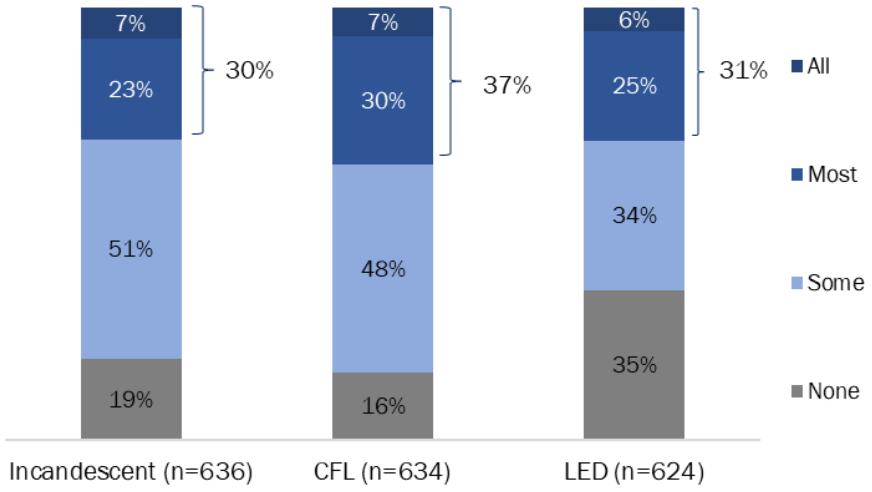
Figure 6-2. LED Awareness and Use by Customer Type



Results are statistically significant at 90% confidence.

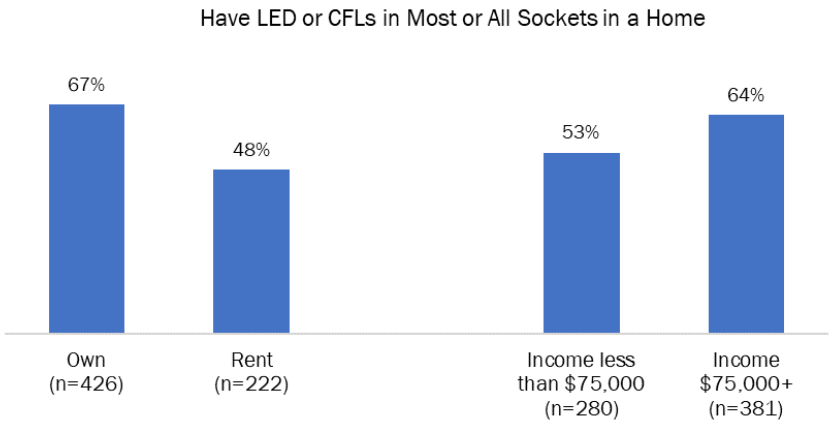
Californians are using energy efficient light bulbs in a considerable number of their light sockets. In more than a third of homes (37%), CFLs take up all or most light sockets, and in nearly a third of homes (31%), LEDs take up all or most light sockets (Figure 6-3). Combined, 60% of California homes have CFLs or LEDs in **all** or **most** sockets, and only 1% of homes have neither CFLs nor LEDs installed.

Figure 6-3. Respondent Self-Reported Percent of Sockets Containing Technology



Renters and customers with lower incomes are less likely to have their sockets saturated with CFLs or LEDs. More specifically, 48% of renters have CFLs or LEDs in all or most of their sockets as compared to 67% of homeowners, and 53% of customers with incomes under $75,000 have CFLs and LEDs in all or most of their sockets as compared to 64% of customers with incomes of $75,000 and over.

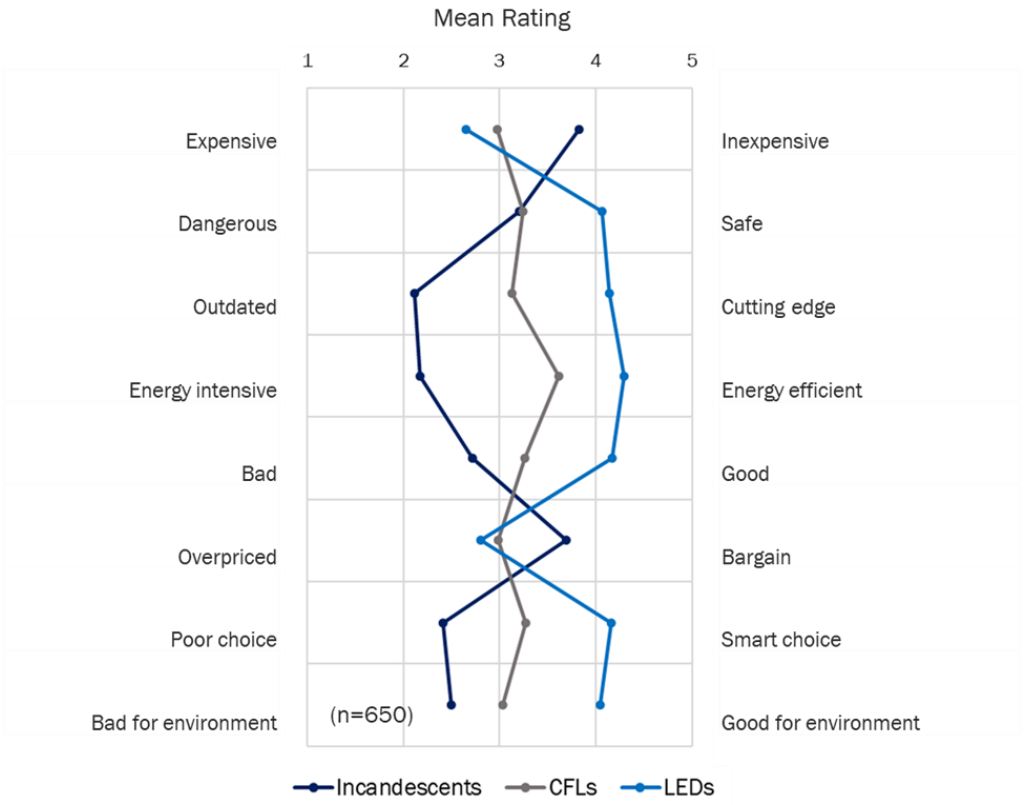
Figure 6-4. Respondent Self-Reported Percent of Sockets Containing Energy Efficient Product by Customer Type



6.1.2 Lighting Product Perceptions

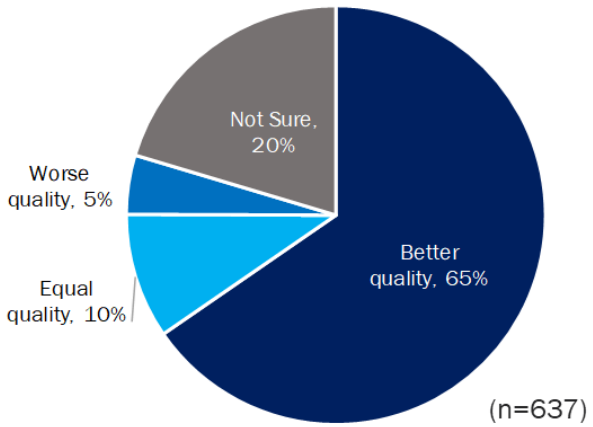
Given their experience with different lighting technologies, it is not surprising that we find that Californians are also aware of the relative benefits and drawbacks of different technologies. As part of the survey, we asked respondents to rate each lighting technology on eight attributes, such as cost, safety, and energy use. Figure 6-5 shows mean responses for each attribute across the three key technologies. The responses indicate that customers have a good understanding of different bulb types. For example, customers know that LEDs and CFLs use the least energy, but CFLs, along with the incandescents, are not as good for the environment. The perception of incandescents as being bad for the environment is possibly a result of the bulbs using the most energy of the three technologies. The perception of CFLs as not being good for the environment is likely linked to the mercury presence. Customers think of incandescents as inexpensive and a bargain, but also as outdated and energy intensive. Though LEDs were also viewed as the most expensive of the three technologies, they were not perceived as being much more expensive than CFLs.

Figure 6-5. Lighting Product Perceptions



About two-thirds of Californians (65%) view LEDs as superior to other lighting technologies in terms of quality, and very few (5%) view LEDs as being of worse quality than other products (Figure 6-6). This finding points to continued future preference for the technology. A fifth of customers, however, are not sure whether LEDs are of comparable to, better, or worse quality than other lighting technologies. This finding points to potential benefit of customer education.

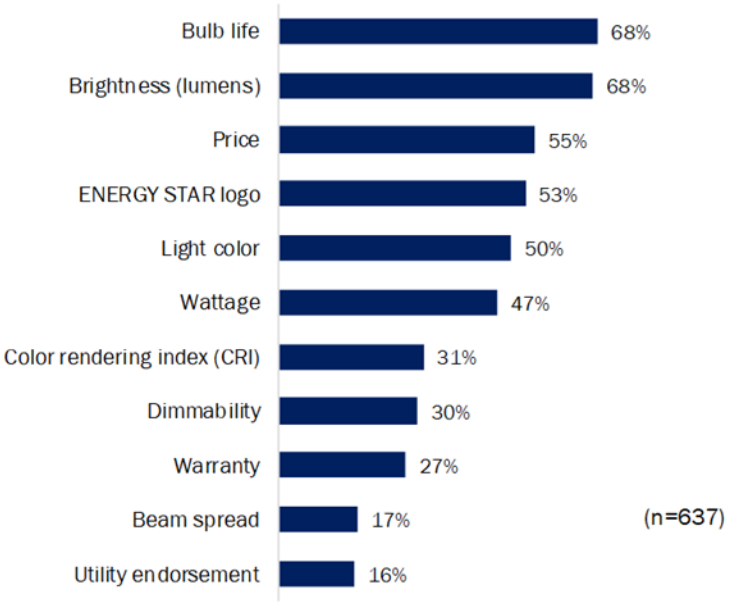
Figure 6-6. Perception of LED Quality Compared to Other Technologies



Most customers (84%) rely on multiple attributes to define LED quality. On average, customers use five markers to define quality LEDs. While the majority of Californians view LEDs as technologically superior to other lighting products, the markers of LED quality are not well-defined for most customers. Many of the attributes that customers use as a measure of quality are not, in fact, different for high versus low quality LEDs. The key markers of LED quality include bulb life (68%), brightness (68%), price (55%), and presence of ENERGY STAR logo (53%). Furthermore, half of Californians associate light color with LED quality (50%) and close to half (47%) associate wattage with LED quality. It is possible that customers associate attributes such as brightness, wattage, and light color with LED quality because of a negative past experience when they selected the wrong LED in terms of brightness and color for the intended application. Providing customers with educational tools can be a valuable strategy to ensuring continued adoption of LEDs.

Among other markers of quality, the color rendering index (CRI) is used by just under a third of customers (31%), and LED dimming functionality by 30% of customers (Figure 6-7).

Figure 6-7. LED Quality Markers



Note: Aided open-ended response. Multiple response question. Responses sum to more than 100%.

While nearly one-third of customers view CRI as a marker of LED quality, most are not familiar with what CRI represents. Of the customers who name CRI as an LED quality marker, only 6% say they are very familiar with the term, 24% say they are somewhat familiar, and the remaining 71% are either not very familiar or not familiar at all. Overall, 3 in 10 Californians (29%) are either very or somewhat or familiar with the term CRI. This could be indicative of customers over-reporting the value of CRI as a quality marker.

We asked respondents who said they were familiar with CRI to describe, in an open-ended fashion, what CRI represents. Slightly over a third (36%) of those familiar with the term provided correct definition.[26] The remaining share of customers either admitted that they really do not know what CRI represents (5%), defined

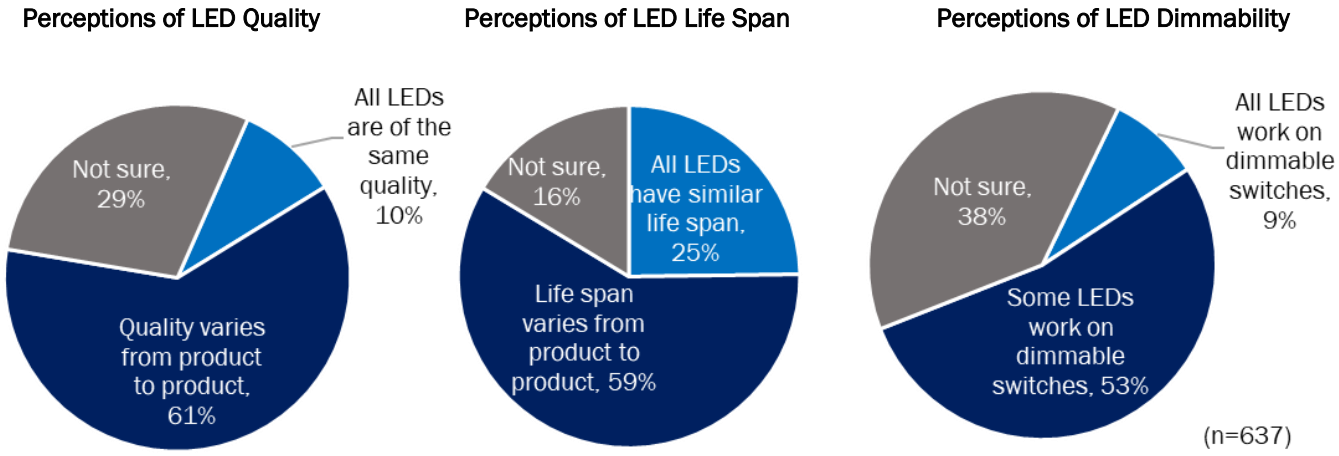
[26] For the purpose of this study, we considered descriptions that mentioned the trueness of light, or the trueness of light as compared to natural light, as correct responses.

the acronym but did not provide its meaning (6%), or mistakenly associated CRI with such attributes as light temperature, color, or light intensity (53%).

With CRI being an important component of the California Energy Commission (CEC) Voluntary Quality LED Lamp Specification and a part of Title 20 Tier 1 and Tier 2 lighting performance criteria, it is beneficial to conduct additional research to further understand customer knowledge of CRI and assess whether and how varying levels of LED CRI affect customer satisfaction with LEDs. Such additional research can help ensure Title 20 Tier 2 code preparedness and allow the IOUs develop an adequate and strategic response.

Despite strong general knowledge of LED technology versus other technologies on the market, not all Californians understand that LED products vary in terms of quality, that LEDs have different life spans, and that not all LEDs are dimmable. When asked whether LEDs vary in quality, nearly 4 in 10 Californians (39%) either did not know whether LEDs vary in quality or erroneously thought that LED quality is the same across products. A similar share of customers (41%) either did not know whether LED life span varies across products or erroneously thought that all LEDs have the same life span. Finally, close to a half of customers (47%) either did not know whether all LEDs work on dimmable switches or erroneously thought that all LEDs work on dimmable switches (Figure 6-8). Customers with lower incomes and lower levels of education, as well as customers under 35 years old and over 55 years old, are less likely to understand the variation in LED quality across products. Such lack of understanding may result in customer disappointment with the technology and reluctance to purchase it in the future. Raising awareness on the varying levels of LED performance can be an opportunity for IOUs to prevent customer backsliding and ensure continued technology adoption.

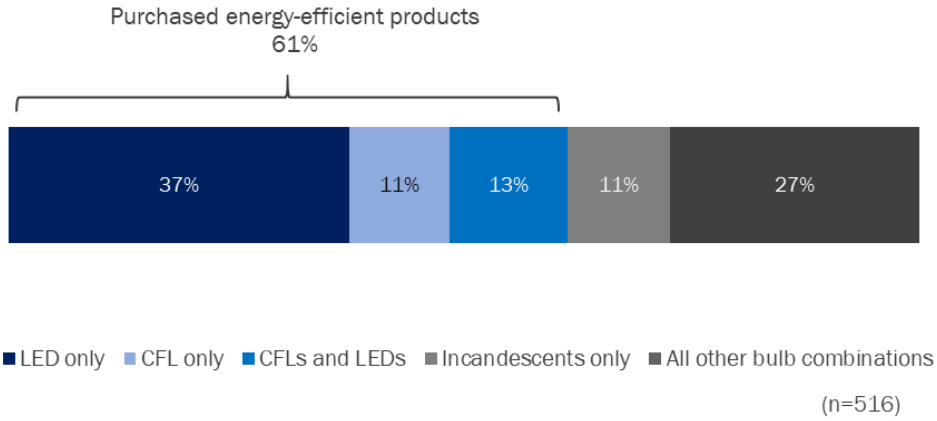
Figure 6-8. Understanding of LED Quality and Features



6.1.3 Lighting Shopping Behaviors

Customer lighting shopping behaviors also point to lighting market transformation. When shopping for light bulbs, Californians prefer energy efficient products. Of the customers who purchased light bulbs in the past year, more than a third (37%) purchased LEDs exclusively, 11% purchased CFLs exclusively, 13% purchased a mix of CFLs and LEDs, and 27% purchased a combination of less energy efficient and energy efficient products. Only 11% of respondents purchased incandescents exclusively (Figure 6-9).

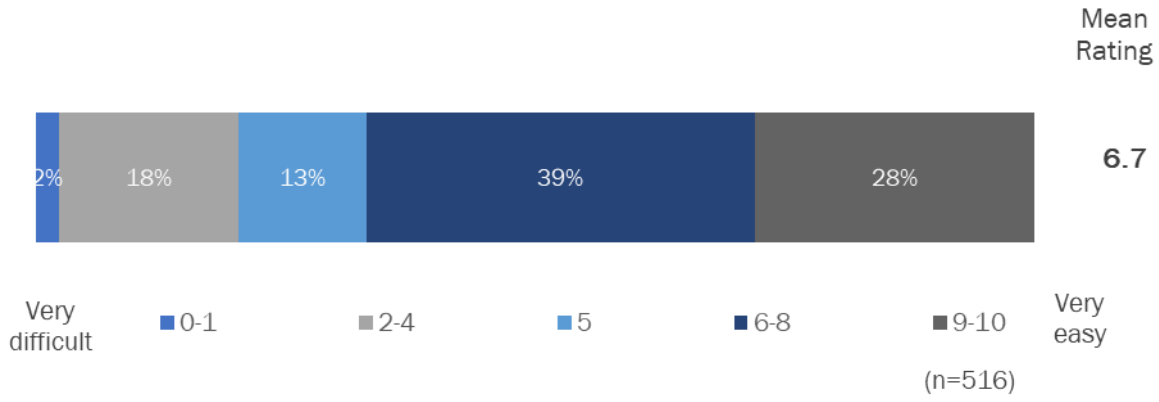
Figure 6-9. Types of Bulbs Purchased in the Last Year



Finding the right lighting product, however, still presents a challenge for many. Only 28% of Californians find it very easy[27] to locate and select the correct lighting product (Figure 6-10). Older customers (age 55+) are more likely to find it difficult to find and select the right lighting product.

When shopping for light bulbs at local retailers, customers sometimes seek help from a store representative. More specifically, 15% of customers who shopped for light bulbs in the past year at their local retailer asked a store representative for assistance on selecting a light bulb to suit their needs. Capitalizing on the opportunities to support customers with their shopping decisions at the point of purchase can help further alleviate the uncertainty that some experience when faced with a wide variety of lighting options and can provide additional education on LED benefits and quality markers, thus furthering market transformation.

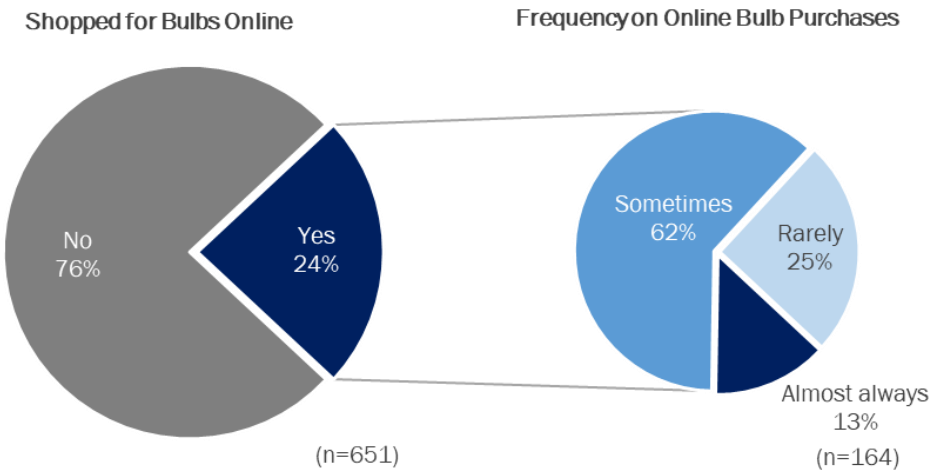
Figure 6-10. Ease of Finding and Selecting the Right Product



When shopping for light bulbs, most customers purchase light bulbs at brick and mortar locations; a quarter (24%) of Californians shopped for light bulbs online. Very few shop for light bulbs online exclusively (Figure 6-12).

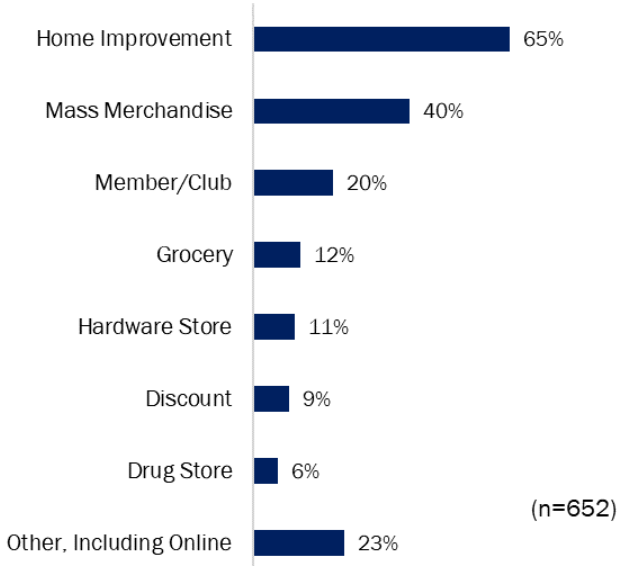
[27] A rating of 9 and 10 on a scale from 0 to 10, where 0 means very difficult and 10 means very easy.

Figure 6-11. Online Light Bulb Shopping Incidence and Frequency



Home improvement stores such as Lowes and Home Depot are the most popular retail locations to buy light bulbs, with 65% purchasing at those types of stores. Mass merchandise stores are the second most popular retail channel, with 40% of respondents purchasing light bulbs at stores like Walmart and Target (Figure 6-12).

Figure 6-12. Types of Stores Where Respondents Shop for Light Bulbs



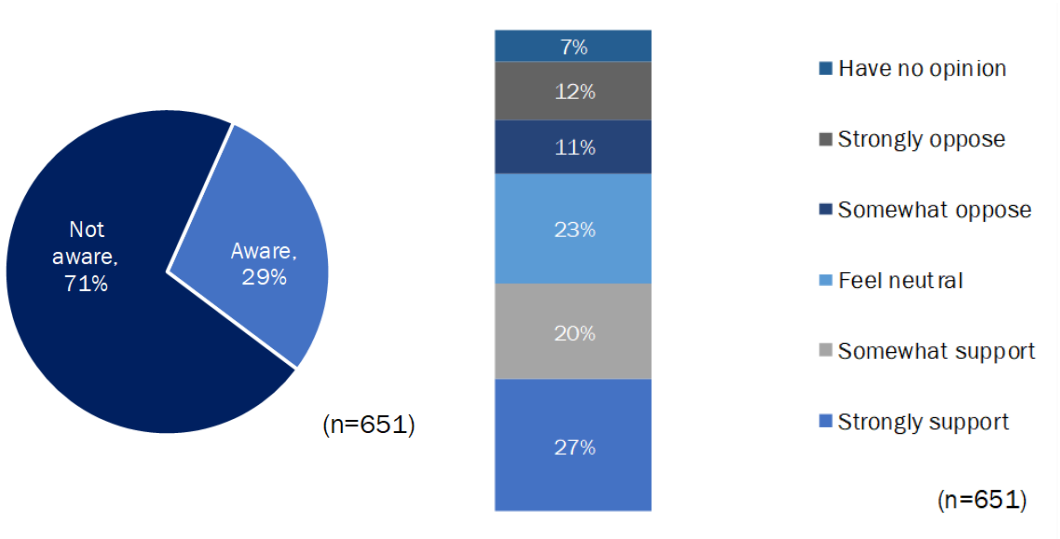
Note: Multiple response question. Responses sum to more than 100%.

6.1.4 Reactions to New Lighting Efficiency Standards

On January 1, 2018, Title 20 Tier 1 lighting standards took effect. Under these standards, general service lamps[28] manufactured on or after January 1, 2018 must have a minimum lamp efficacy of at least 45 lumens per watt and a minimum rated life of at least 1,000 hours. LEDs manufactured on or after January 1, 2018 are held to higher efficacy and quality requirements as well, including a CRI of 82 or greater, minimum efficacy of 68 lumens per watt, and a rated life of 10,000 hours or more, among other factors. Under Title 20, incandescent products will no longer meet the efficacy requirements. Our study explored customer reactions to the changing standards. Namely, we measured customer awareness of the Title 20 standards and explored likely customer behaviors under these new standards.

We presented all respondents with a description of Title 20 standards and asked if they were aware of them. We then asked respondents to share their opinions of Title 20. As can be seen in Figure 6-13, awareness of Title 20 is low (29%). This is not surprising, given that customers generally do not follow changes in lighting standards and that these changes have not been widely publicized in the state. Though most customers have not heard of the standards, close to half (47%) support them based on our description,[29] close to a quarter (23%) oppose them, and close to a third (30%) feel neutral or have no opinion on the matter.

Figure 6-13. Awareness and Opinions of Title 20

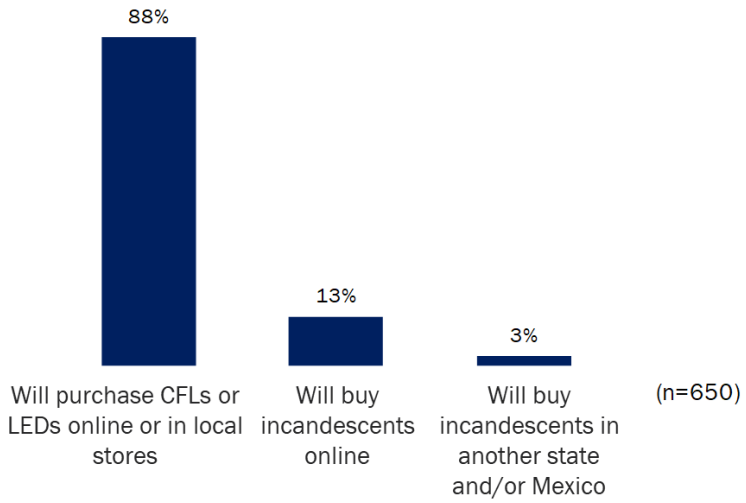


In light of the Title 20 standards, few Californians would seek out noncompliant bulbs. More specifically, 88% of Californians would purchase the CFLs or LEDs that are available at the local retailer. Only 13% would purchase noncompliant incandescent light bulbs online, and a very small percentage (3%) would travel outside of California to purchase noncompliant incandescent light bulbs (Figure 6-14). Taken together, these findings suggest that, though few respondents knew about Title 20 previously, a considerable fraction support the regulation, and further, almost all respondents plan to purchase compliant products.

[28] The definition of general service lamps under Title 20 is broad and covers most lighting products with very few exceptions.

[29] Includes "strongly support" and "somewhat support."

Figure 6-14. Shopping Behaviors When Title 20 Is in Effect



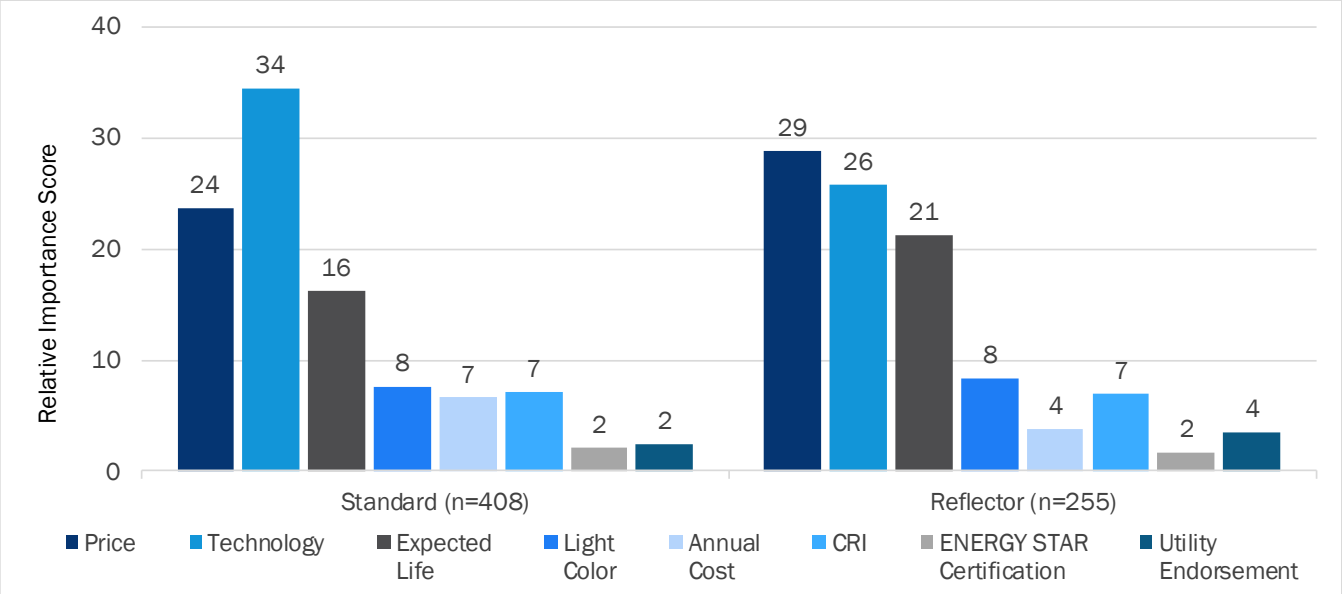
Note: Multiple response question. Responses sum to more than 100%.

6.2 Lighting Product Preferences

Through LCDC modeling, we examined the relative importance of different lighting product attributes to customers, modeled customer lighting preferences, and assessed the impact of changing prices on product demand. Due to notable differences in application and pricing, we modeled results separately for standard and reflector light bulbs. Figure 6-15 provides relative importance scores for key product attributes. The relative importance score for each individual attribute cannot exceed 100 and the sum of individual importance scores across all attributes cannot exceed 100. Relative importance scores can be compared within each product type (e.g., standard vs. specialty products) but not across product types.

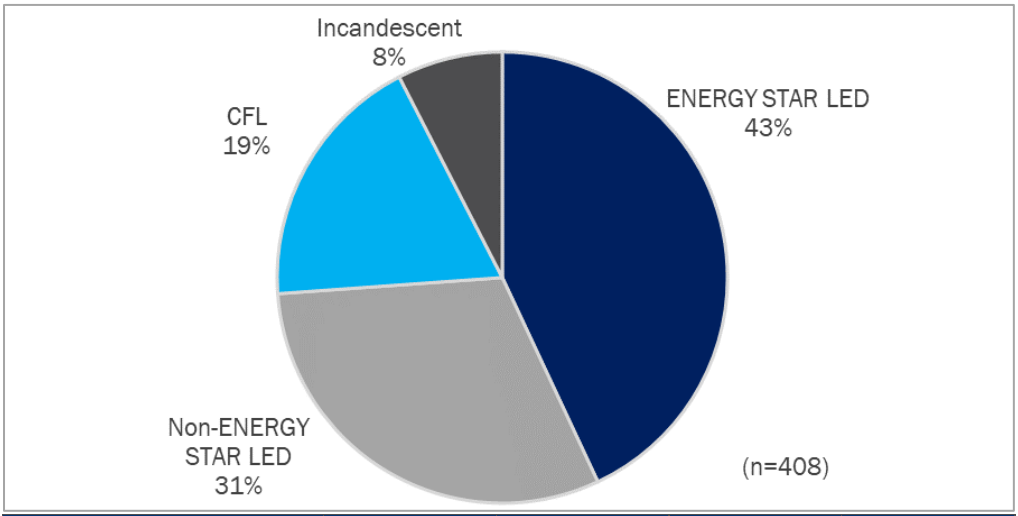
As can be seen in the figure, technology and price are the primary drivers of purchase decisions for standard and reflector products alike, followed by bulb life. For standard bulbs, technology is especially important to customers, while for reflector products, price and technology are of nearly equal importance. Light color, annual energy cost, and CRI are of lesser importance. ENERGY STAR certification and utility endorsement are of the lowest importance, relative to other lighting attributes. In fact, presence of the utility endorsement has a negative effect on customer light bulb preferences. In other words, presence of the utility endorsement is likely to deter customers from purchasing certain light bulbs.

Figure 6-15. Relative Importance of Attributes by Bulb Type



In addition to modeling the relative importance of the various bulb attributes, the DC survey allowed us to simulate market shares for the different bulb technologies for standard and reflector products. Figure 6-16 shows the market shares for standard products. The results suggest that customers prefer LEDs over other technologies at current market prices and with typical product specifications for each technology. ENERGY STAR LEDs account for nearly half of sales (43%) and non-ENERGY STAR LEDs account for close to a third (31%). The cumulative LED market share for standard products accounts for approximately three-quarters of sales (74%), while CFLs account for approximately one-fifth of bulb sales (19%), and incandescents account for the remaining 8%.

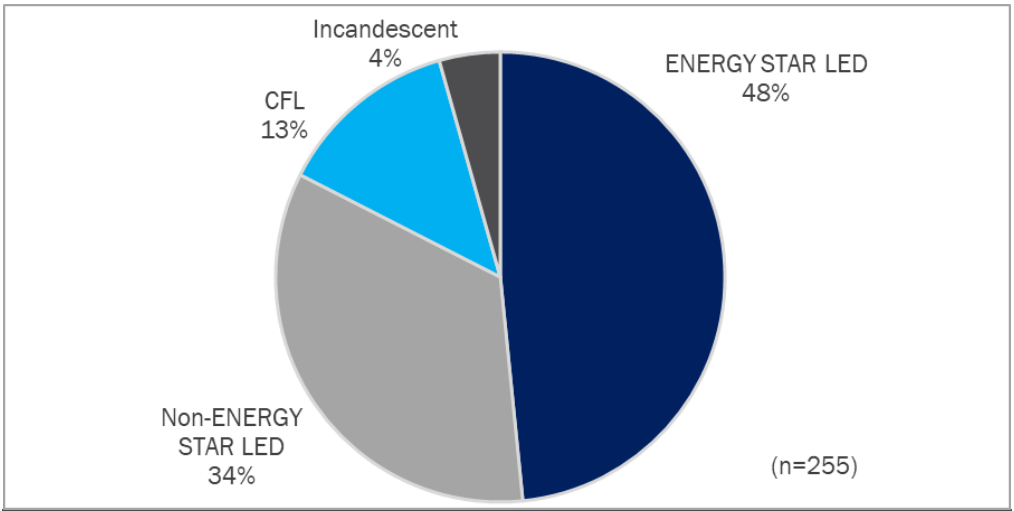
Figure 6-16. Standard Lighting Product Market Shares at Current Market Conditions



Attribute	ENERGY STAR LED	Non-ENERGY STAR LED	CFL	Incandescent
Technology	LED	LED	CFL	Incandescent
Price ($)	$4.40	$3.80	$3.70	$1.80
Expected life (years)	25	15	7	1
Annual cost ($)	$1.00	$1.00	$1.75	$7.25
Light	Warm white	Warm white	Warm white	Warm white
CRI	80	80	80	100
ENERGY STAR certification	Yes	No	No	No
Utility Endorsement	No	No	No	No

Figure 6-17 shows the modeled market shares for the reflector products. The results show that ENERGY STAR LEDs dominate reflector sales at current market prices and with typical product attributes. As can be seen in the figure, ENERGY STAR LEDs capture 48% of reflector bulb sales, and non-ENERGY STAR LEDs account for another 34%. Together, ENERGY STAR and non-ENERGY STAR LEDs account for more than 80% of bulb sales, while CFLs make up just 13%, and incandescents account for the remaining 4% of lighting sales.

Figure 6-17. Reflector Lighting Product Market Shares at Current Market Conditions



Attribute	ENERGY STAR LED	Non-ENERGY STAR LED	CFL	Incandescent
Technology	LED	LED	CFL	Incandescent
Price ($)	$7.00	$6.00	$4.80	$3.70
Expected life (years)	25	15	7	1
Annual cost ($)	$1.00	$1.00	$1.75	$7.25
Light	Warm white	Warm white	Warm white	Warm white
CRI	80	80	80	100
ENERGY STAR certification	Yes	No	No	No
Utility Endorsement	No	No	No	No

In addition to examining the relative importance of the attributes and modeling lighting market shares under current market conditions, we explored how changes in the price of LEDs affect LED market shares. To do so, we simulated market shares as presented above, but varied LED prices to see their effect on market shares. These differing market shares, assuming availability of lower- or higher-cost LEDs, allowed us to estimate price elasticity curves for different lighting product configurations across standard and reflector products. We define price elasticity as:

$$\frac{\%\Delta\ Quantiy}{\%\Delta\ Price}$$

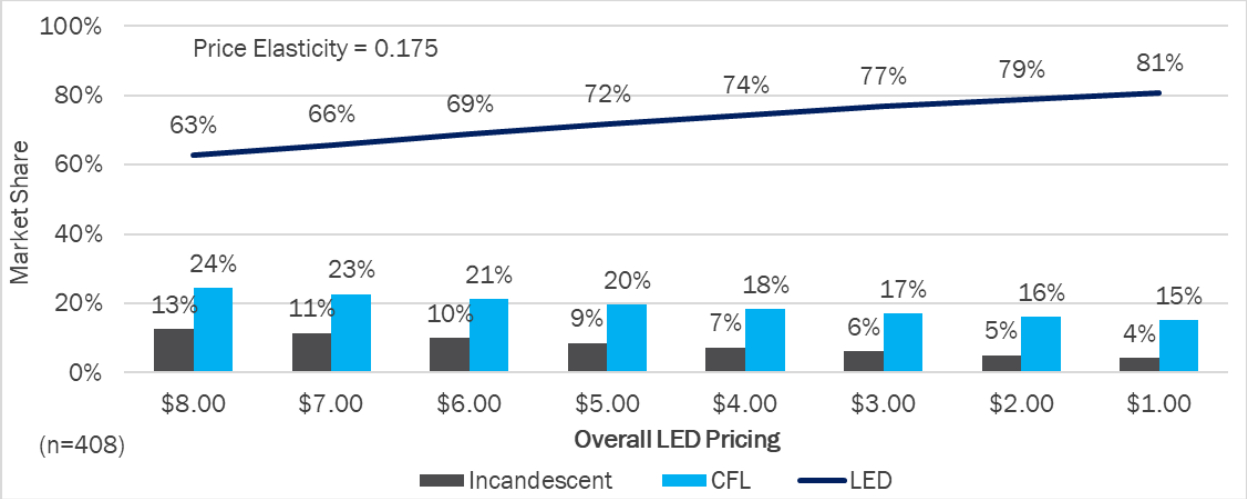
We show price elasticity as a number. For example, a price elasticity equal to 0.50 means that for every 10% drop in price, there will be 5% increase in market share.[30]

Figure 6-18 shows the results of the price sensitivity analysis for standard LEDs. The upward-sloping line reflects the change in LED market share as the price of an LED bulb decreases. The bars below the line represent the market shares for average-priced CFL and incandescent bulbs (priced at $3.70 and $1.80, respectively) at each LED price point.

[30] An elasticity (in absolute value) closer to 0 is considered low or relatively inelastic, while an elasticity closer to or greater than 1 is considered high or relatively elastic (Simon and Blume, 1994).

The results show that price sensitivity for standard LEDs is low at just 0.175, which indicates that for every 10% decrease in bulb price, the market share of LEDs will increase only by 1.75%. LEDs capture the overwhelming majority of market share even when priced well above the alternative products. At $8 per bulb, LEDs still account for nearly two-thirds of the market (63%), while the cheaper CFL and incandescent options capture just 24% and 13% of the market, respectively. As the price of LEDs drops from $8 to $1 per bulb, LED market share increases 18 percentage points to 81%, with the shift in market share coming primarily from incandescent products. Even with LEDs priced at $1 per bulb, some customers will pay more to purchase CFLs (15%) or incandescents (4%). For incandescents, this suggests that a small subset of customers is more comfortable sticking with the technology they know. The relatively high attachment to CFLs in the presence of $1 LEDs suggests that a portion of customers think of CFLs as a superior product, perhaps because they are still unfamiliar with the LED technology.

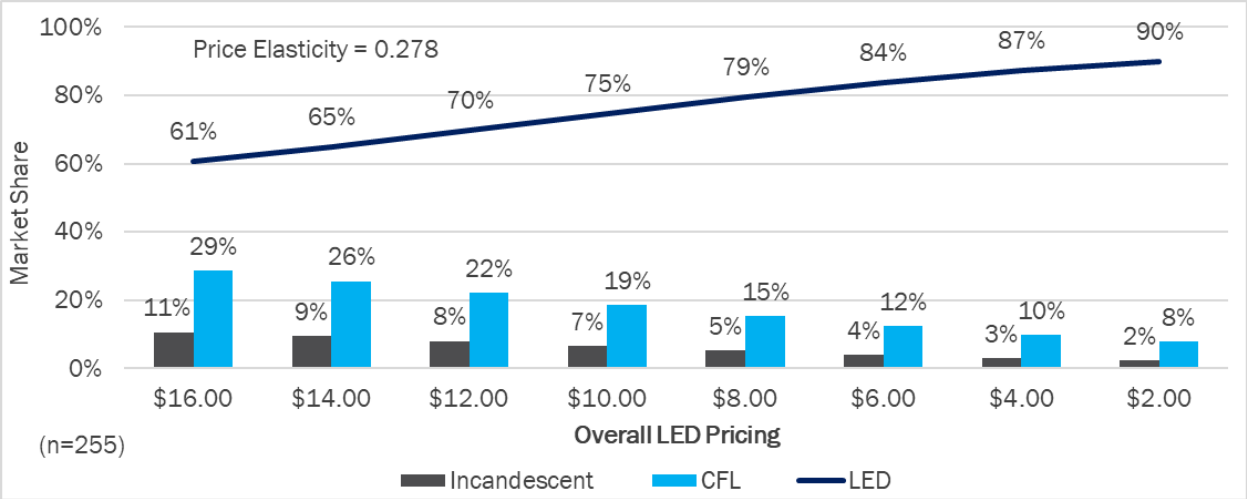
Figure 6-18. Price Sensitivity and Average Price Elasticity for Standard LEDs



Attribute	ENERGY STAR LED	Non-ENERGY STAR LED	CFL	Incandescent
Technology	LED	LED	CFL	Incandescent
Price ($)	Varied	Varied	$3.70	$1.80
Expected life (years)	25	15	7	1
Annual cost ($)	$1.00	$1.00	$1.75	$7.25
Light	Warm white	Warm white	Warm white	Warm white
CRI	80	80	80	100
ENERGY STAR certification	Yes	No	No	No
Utility Endorsement	No	No	No	No

Compared to standard LEDs, reflector LEDs are more price elastic. Still, the price elasticity for reflector LEDs is relatively low at 0.278. This indicates that for every 10% decrease in bulb price, LED market share will increase by 2.78% (Figure 6-19). At the highest price point of $16 for an LED, 61% of customers still prefer LEDs to the cheaper CFL or incandescent products. As the price of reflector LEDs declines from $16 to $2, market share increases steadily from 61% to 90%. The increase in LED reflector market share as LED prices drop occurs at expense of both CFLs and incandescents.

Figure 6-19. Price Sensitivity and Average Price Elasticity for ENERGY STAR Reflector LEDs



Attribute	ENERGY STAR LED	Non-ENERGY STAR LED	CFL	Incandescent
Technology	LED	LED	CFL	Incandescent
Price ($)	Varied	Varied	$4.80	$3.70
Expected life (years)	25	15	7	1
Annual cost ($)	$1.00	$1.00	$1.75	$7.25
Light	Warm white	Warm white	Warm white	Warm white
CRI	80	80	80	100
ENERGY STAR certification	Yes	No	No	No
Utility Endorsement	No	No	No	No

Price elasticity results suggest that customers are willing to pay considerably more for LEDs. The DC survey was a hypothetical shopping experience, so it is possible that customers in an actual store setting might make different choices and be somewhat more inclined to purchase the least expensive product. Still, we know LED use has increased rapidly in recent years, and survey results show strong customer knowledge of the benefits of LED bulbs, indicating that the residential lighting market is quickly approaching transformation.

6.3 Differences in Lighting Preferences by Customer Segment

Through the LCA of the DC survey results, we identified five distinct customer segments for standard products and three distinct customer segments for reflector products. In this section, we describe the segments.

6.3.1 Standard Products Segments

LED Devotees

The “LED Devotee” segment comprises an estimated 19% of the California population. Compared to the general population of Californians, customers in this segment are more likely to own their homes, reside in single-family properties, and have higher levels of education and higher incomes.

This segment is the least price sensitive of the five (relative importance score of 17 out of 100). Technology is the primary consideration when purchasing lighting products (relative importance score of 40 out of 100), and LEDs are the preferred technology. Preference for LEDs is reflected in the market shares: 98% of light bulbs purchased by customers in this segment are LEDs. This segment's market share for ENERGY STAR LEDs is considerably higher than that of any of the other four segments.

Customers in this segment are more knowledgeable about LEDs than the general population and are considerably more likely to have LEDs in all or some of their sockets than the general population (52% vs. 26%). Customers in this segment are more likely than the general population to be aware of the Title 20 standards and are much less likely to seek incandescents online or in other states with Title 20 standards in effect.

LED Leaning Light Chasers

The "LED Leaning Light Chasers" segment comprises an estimated 15% of the California population. This segment is similar in its socio-demographic composition to LED Devotees. Compared to the general population, customers in this segment are more likely to own their homes, reside in single-family properties, and have higher levels of education and higher incomes.

Customers in this segment place greatest importance on technology when shopping for standard light bulbs (relative importance score of 40 out of 100), but price is a strong contributing factor as well (relative importance score of 25 out of 100). This segment is much more likely than any other segment to care about light color (relative importance score of 12 out of 100). Customers in this segment prefer LEDs over other technologies: The market share for LEDs is 88%. Similar to the LED Devotees segment, this segment shows more knowledge about LED technology than the general population does and is considerably more likely to have LEDs in all or some of their sockets.

CFL Diehards

The "CFL Diehards" segment comprises an estimated 21% of the California population. This segment contains more renters and customers residing in multifamily properties compared to the general population. Customers in this segment are also more likely to have lower levels of education and lower income levels.

Technology is the most important factor when making standard light bulb purchase decisions for this segment (relative importance of 54 out of 100), while price and light color are of no importance. When it comes to technology, this segment prefers CFLs over other technologies, with the CFL market share at 55%. With 36% of the market share, LEDs are the second favored technology. Because of the CFL preference, this segment is more likely than the general population to have CFLs in most or all of the lighting sockets.

Thrifty Performance Seekers

The "Thrifty Performance Seekers" segment comprises 26% of the California population. This segment contains slightly more home owners and customers with higher incomes than does the general population.

Customers in this segment place the most value on bulb life followed by price (relative importance scores of 25 and 22 out of 100, respectively). This segment does not place much emphasis on light bulb technology (relative importance score of 12 out of 100), but because of the importance of bulb life, LEDs are a preferred technology, at 81% market share. Preference for LEDs, however, has not yet translated into saturated sockets, as customers in this segment are less likely than the general population to have LEDs in all or most sockets.

Frugal Consumers

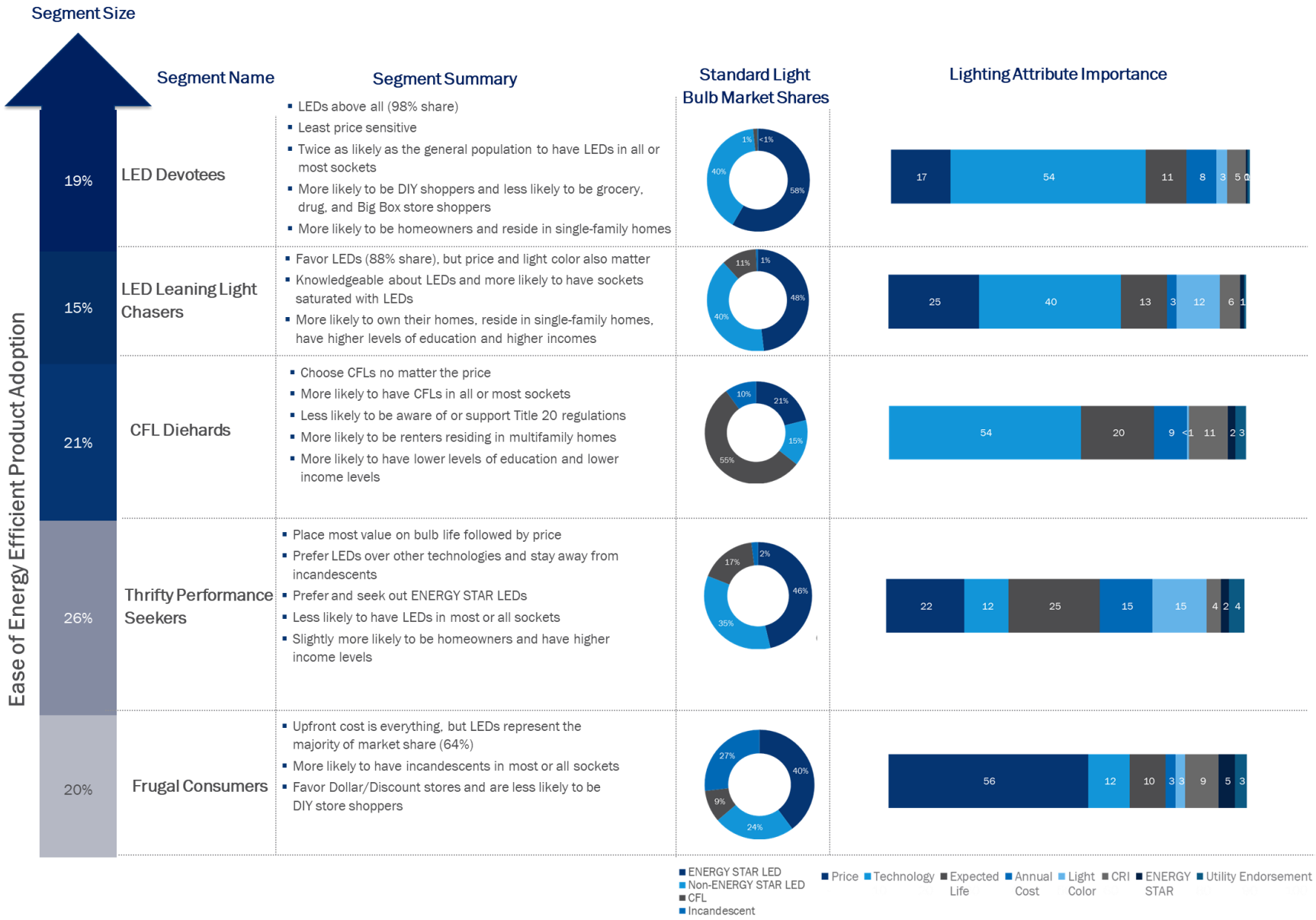
The "Frugal Consumers" segment comprises 20% of the California population and resembles the population across key socio-demographic and household characteristics.

When it comes to light bulb purchases, this segment is the most price sensitive of the five; the relative importance of the price attribute is 56 out of 100. With upfront cost being the key consideration for this segment, LEDs represent 64% of the sales in this segment, despite the fact that they are frequently more expensive than the other technologies. Preference for LEDs among this segment has not quite translated into socket saturation; more than half of the customers in this segment (56%) report having incandescents in most or all of their sockets, which is considerably higher than the rest of the California.

When shopping for lighting products, Frugal Consumers favor discount and dollar stores and are less likely to shop at do-it-yourself (DIY) stores than the general population of Californians.

Figure 6-20 provides segment summaries. The segments are organized based on the assessed likelihood to purchase energy efficient standard technology, with the segment least likely to purchase appearing at the bottom and the segment most likely to purchase placed at the top. A detailed profile for each segment is provided in Appendix A of this report.

Figure 6-20. Standard Products Segmentation Summary



6.3.2 Reflector Products Segments

LED Devotees

The "LED Devotees" segment represents 35% of the general population[31] and resembles the general population across key socio-demographic and household characteristics.

Technology is the primary consideration when purchasing lighting products (relative importance score of 41 out of 100), and LEDs are the preferred technology. Preference for LEDs is reflected in the market shares: 95% of light bulbs purchased by customers in this segment are LEDs. Customers in this segment are more knowledgeable about LEDs than the general population and are considerably more likely to have LEDs in all or most of their sockets (62% vs. 38%).

LED Leaning Performance Aficionados

The "LED Leaning Performance Aficionados" segment represents 27% of the general population. Customers in this segment are more likely than the general population to reside in multifamily homes and have higher levels of education and higher incomes.

This segment values bulb life over other attributes, but also places importance on technology (relative importance scores of 32 and 25, respectively, out of 100). Compared to the other two segments, this segment is the least price sensitive. Reflector market shares among this segment are dominated by LEDs (82%).

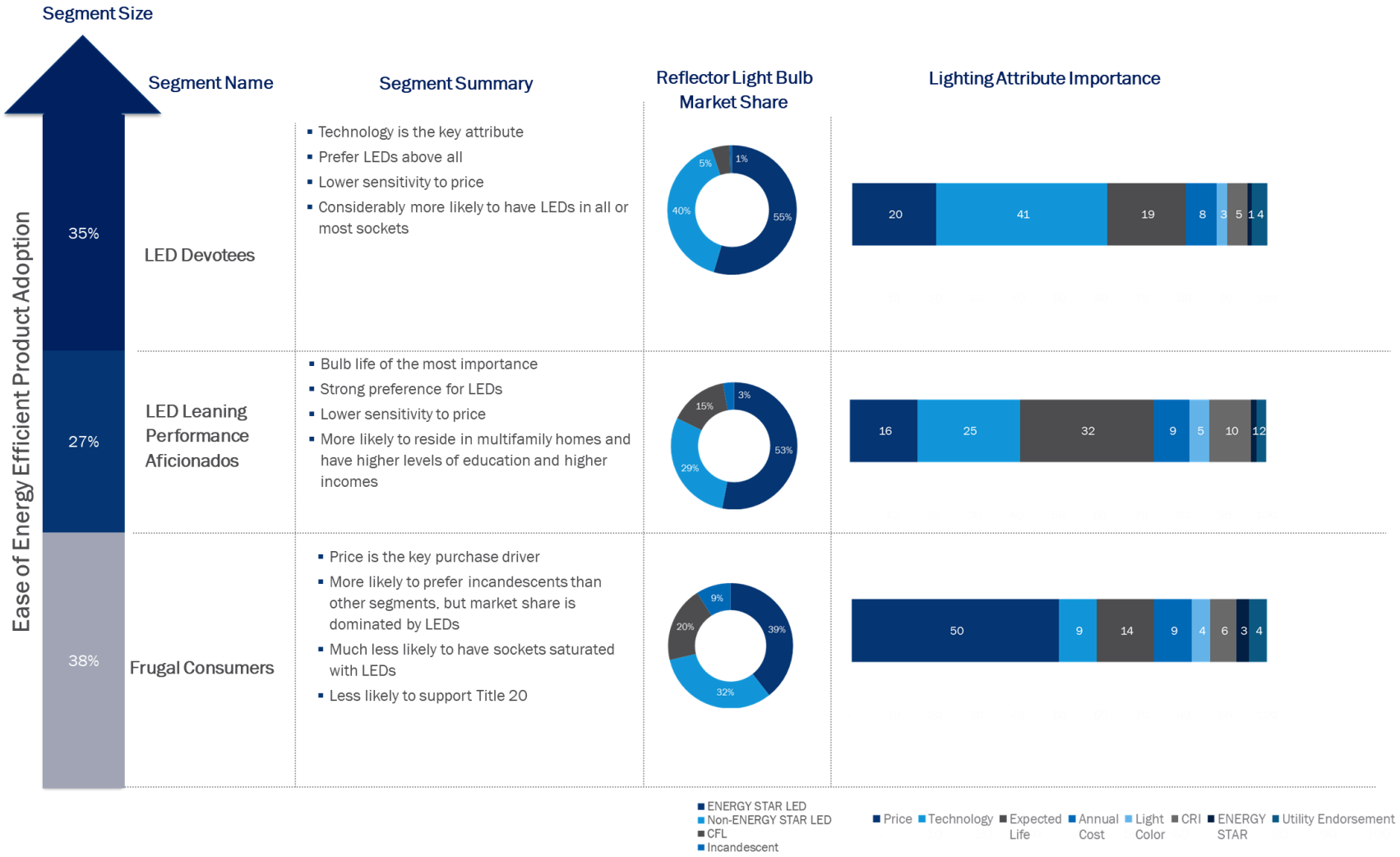
Frugal Consumers

The "Frugal Consumers" segment represents 38% of the general population and resembles the population across key socio-demographic and household characteristics. This segment is the most price sensitive of the three; the relative importance of the price attribute is 50 out of 100. With upfront cost being the key consideration, LEDs represent 71% of market share for this segment, despite the fact that they are frequently more expensive than the other technologies. Preference for LEDs has not quite translated into socket saturation; customers in this segment are significantly less likely than the rest of the population to have their sockets saturated with LEDs. Only 18% of the customers in this segment have LEDs in most or all of their sockets (compared to 38% in general population). While customers in this segment are equally aware of Title 20 as the general population, this segment is less supportive of the standards.

Figure 6-21 provides segment summaries. The segments are organized based on the estimated likelihood of purchase of adoption of energy efficient reflector technology, with the segment least likely to purchase appearing at the bottom and the segment most likely to purchase placed at the top. A detailed profile for each segment is provided in Appendix A of this report.

[31] General population is defined as households with reflector light bulbs. Based on the survey results, 55% of the California residents have reflector light bulbs in their homes.

Figure 6-21. Reflector Products Segmentation Summary



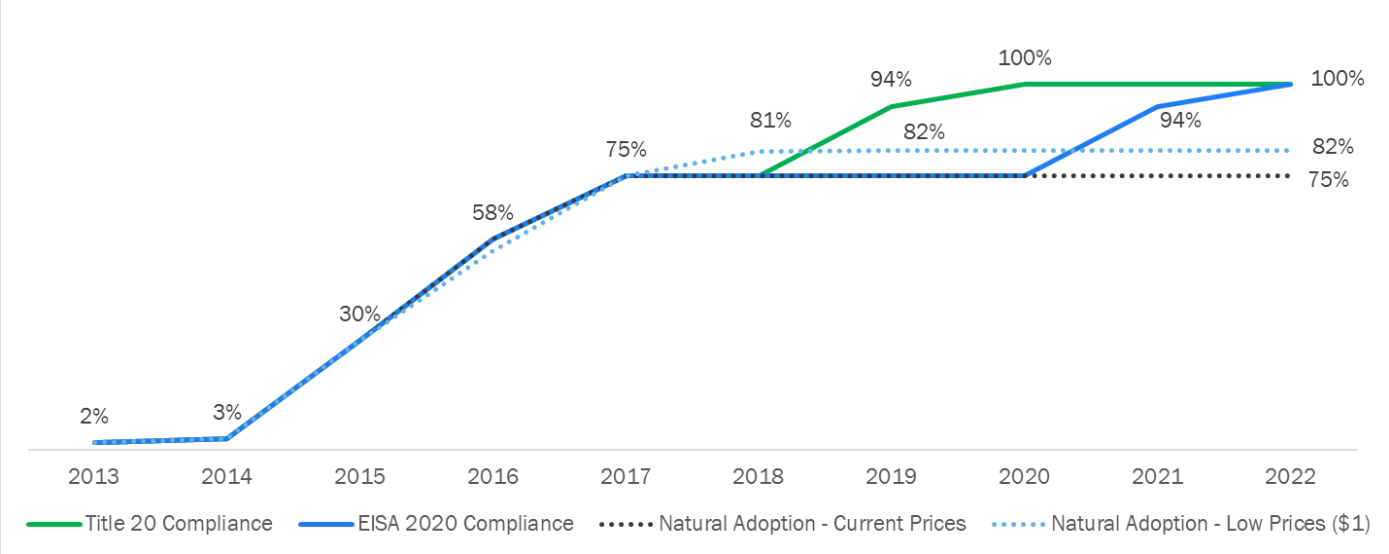
6.4 Diffusion of Innovation

Opinion Dynamics modeled LED adoption under four scenarios:

- Natural conditions with current LED pricing
- Natural conditions with aggressive LED pricing (LEDs priced at $1)
- Title 20 standards taking effect in 2018 with a sell-through period of two years
- EISA 2020 standards taking effect in 2020 with a sell-through period of two years

Figure 6-22 provides the modeling outputs. As can be seen in the figure, under current market conditions, natural adoption of LEDs stops at 75% market share in 2017. Were the LED prices to drop to $1 per bulbs in 2018, LED market shares would increase to 81%, which represents a seven percentage point lift as compared to the current market conditions scenario. Under the aggressive pricing scenario, LED sales are not projected to exceed 82% of the market. Title 20 standards result in a projected increase of LED market share to 94% in 2019 and 100% in 2020. EISA 2020 standards, in the absence of the Title 20 standards, lead to a projected increase of LED market share to 94% in 2021 and 100% in 2022. Overall, Title 20 standards account for a net lift of 25 percentage points in LED market shares from the current conditions scenario and a net lift of 18 percentage points under the aggressive LED pricing scenario.

Figure 6-22. Diffusion of Innovation Curves



7. Conclusions and Recommendations

This section presents our conclusions and recommendations from the completed research. The recommendations specifically focus on the new possible role(s) of the IOUs' lighting programs, which historically have been emphasizing broad mass-market reach and incentive-based interventions as a way of inducing energy efficient lighting product adoption.

State of the Market Assessment

Conclusion 1. The California lighting market is nearing transformation. The transformative effects are evidenced in the near universal awareness and penetration of energy efficient technologies, knowledge of their benefits, and a natural preference for the technologies. More specifically, only 1% of Californians have not heard of CFLs and only 5% have not heard of LEDs. Survey responses indicate that customers have a deep understanding of different technologies. For example, customers know that LEDs and CFLs use the least energy, but CFLs, along with incandescents, are not as good for the environment. Customers think of incandescents as inexpensive and a bargain, but also as outdated and energy intensive. Though LEDs were also viewed as the most expensive of the three technologies, they are not perceived as being much more expensive than CFLs.

Technology is one of the key drivers of customer purchase decisions, and LEDs are a preferred technology, followed by CFLs. Analysis of market shares by technology shows that LEDs dominate the lighting market representing an estimated 74% of standard bulb sales and 82% of reflector bulbs sales at current prices. Combined, CFLs and LEDs account for over 90% of lighting sales in the California market. Although price is another important consideration for customers when purchasing light bulbs, our simulations show that demand for LEDs, both standard and reflector, is not price elastic (elasticity of 0.175 and 0.278 respectively, which means that for every 10% decrease in price, the market shares of LEDs will increase by 1.75% and 2.78% respectively)[32], which is likely a function of strong preference for the technology. In fact, market share simulation results show customer prefer LEDs even when they are priced higher than other technologies.

Given knowledge and preferences for energy efficient lighting, it is not surprising that CFLs and LEDs are saturating customer sockets. Based on the customer self-report, in nearly a third of homes (31%), LEDs take up all or most light sockets, and in over a third of homes (37%) CFLs take up all or most light sockets. Combined, 60% of California homes have CFLs or LEDs in **all** or **most** sockets, and only 1% of homes have neither CFLs nor LEDs installed.

Title 20 lighting standards that went into effect on January 1, 2018 increase efficacy standards for most lighting products and set high performance standards for LEDs, thus facilitating the shift of the remaining market share of less efficient products to LEDs.

Recommendation 1. This study suggests diminishing effects from mass market incentive-based energy efficiency lighting programs, such as the current upstream residential lighting programs administered by the California IOUs. Many customers are using LEDs and are willing to pay more for them, which signals high free-ridership rates. The IOUs that have not yet done so should consider sun-setting their mass market programs and replacing them with 1) offerings that target customer segments that lag behind in their adoption of energy

[32] An elasticity (in absolute value) closer to 0 is considered low or relatively inelastic, while an elasticity closer to or greater than 1 is considered high or relatively elastic (Simon and Blume, 1994). An elasticity rating of 0.175 indicates that for every 10% decrease in bulb price, the market share of LEDs will increase only by 1.75%.

efficiency lighting products; and 2) offerings that focus on informational and educational interventions as opposed to incentives.

Customer Gaps and Opportunities

Conclusion 2. While many Californians are knowledgeable about LEDs and prefer them over other bulb technologies, some customers lag behind in their knowledge and adoption of the energy efficient technologies. Based on the customer survey results, renters and customers residing in multifamily properties are disproportionately more likely than homeowners and customers residing in single-family properties to have heard of LEDs but not used them (25% vs. 15% and 24% vs. 17% for renters vs. owners and multifamily vs. single-family residents respectively[33]). Furthermore, renters and customers with lower incomes are less likely to have their sockets saturated with CFLs or LEDs. More specifically, 48% of renters have CFLs or LEDs in all or most of their sockets as compared to 67% of owners, and 53% of customers with incomes under $75,000 have CFLs and LEDs in all or most of their sockets as compared to 64% of customers with incomes of $75,000 and over.

Our segmentation analysis identified a price sensitive segment ("Frugal Consumers") which represents an estimated fifth of the California population (20%) and among which preference for incandescent technology is relatively high (27% market share).

Recommendation 2. We recommend that the IOUs continue targeting underserved customer groups with incentives in the short-term until the effects of Title 20 standards are fully reflected in retailer stocking practices[34], because it will help accelerate the adoption of LEDs. To further improve targeting, the IOUs should consider using the results from the discrete choice modeling exercise and assign segments to each of its customers through a propensity scoring analysis and more precisely identify customers for targeting and outreach. Propensity scoring analysis involves regression modeling and allows to assign all IOU customers in one of the segments derived as part of this study. Reaching underserved customers through targeted retailer outreach can be an effective strategy as well, as these underserved customer segments are more likely to shop at Big Box and Dollar/Discount retailers such as Walmart, Dollar Tree, and Dollar General. It should be noted that a subset of customers from the underserved groups may qualify for the IOUs' Energy Savings Assistance (ESA) program. Findings ways to channel qualifying customers into the ESA program can be a beneficial targeting and outreach strategy that will help the IOUs to further market transformation by capitalizing on the ESA program benefits.

[33] Single-family properties include townhomes.
[34] Full transition to stocking of compliant products can take up to a few years, based on the market response to the first phase of EISA 2007 legislation, which was similar to Title 20 and prohibited the manufacturing of noncompliant products.

Knowledge Building and Assurance of Satisfaction with LEDs

Conclusion 3. While customers demonstrate a good understanding of LEDs in general, their knowledge of LED quality markers is lacking. In fact, the indicators of LED quality vary considerably. More specifically, a considerable share of customers either do not know that LEDs vary in quality, life span, and dimmability or mistakenly believe that all LEDs are equal across those metrics. Such misconceptions in the market can lead to customers purchasing an inferior product, being dissatisfied with it, and ultimately becoming reluctant to purchase LEDs. This is particularly true for LED dimming functionality, which is not a feature of all LEDs and, even when present, requires an LED-compatible dimmer for best performance. Customer education could help ensure selection of the right product and prevent customers from unintentionally purchasing non-dimmable products.

Furthermore, the indicators of LED quality vary, with customers using multiple markers to define what a quality LED means to them. As can be seen in the figure below, some of the key LED quality markers include bulb brightness, wattage, and light color, which suggests that customers conflate their space lighting needs with the ultimate quality of the product. It is therefore possible that even when selecting a high-quality LED, customers may be deeply dissatisfied with it and perceive the product as being of lower quality if it is inappropriate for the lighting needs of the space.

Finally, despite a general preference for LEDs, not all customers have an easy time finding the products that fit their needs. Only slightly more than a quarter of Californians (28%) find it very easy[35] to locate and select the correct lighting product.

Recommendation 3. We recommend that the IOUs consider continuing educational outreach at point-of-sale to educate customers on the variability in LED technology quality as well as the range of product options in terms of brightness and light color.

Impact of Title 20 Codes and Standards

Conclusion 4. The study results indicate low resistance to Title 20 standards from the customer perspective. While not many Californians are aware of Title 20 standards (29% awareness), close to half (47%) support them based on a description of the standards that we provided in the survey,[36] close to a quarter (23%) oppose them, and close to a third (30%) feel neutral or have no opinion on the matter. In light of the Title 20 standards, few Californians would seek out noncompliant bulbs. Namely, 13% would purchase noncompliant incandescent light bulbs online, and a very small percentage (3%) would travel outside of California to purchase noncompliant incandescent light bulbs. While these percentages are small, they represent a potential for unrealized savings.

Tier 2 Title 20 standards, scheduled to take effect in the summer of 2019, will further increase the efficiency and performance requirements for LED products. Our study has limited insight into manufacturer and retailer, including online retailer, compliance, and the anticipated speed with which noncompliant products will disappear from the retailer shelves.

Recommendation 4. The IOUs should consider conducting additional research into manufacturer, distributor, and retailer compliance, including compliance of online lighting retailers, and, based on the results of the research, encouraging compliance and ensuring code readiness for Tier 2 standards of Title 20. This will help ensure successful and more rapid market transition. We also recommend that the IOUs supplement this

[35] A rating of 9 and 10 on a scale from 0 to 10, where 0 means very difficult and 10 means very easy.

[36] Includes “strongly support” and “somewhat support.”

strategy with additional customer education about the rationale behind Tier 2 standards and encourage compliance can further accelerate market transformation.

The Value of Additional Quality Specifications to Customers

Conclusion 5. CRI is one of the parameters used to set quality specifications for LED products by the CEC as well as part of Tier 2 Title 20 standards. Our research suggests that most customers are unaware of CRI. Overall, 3 in 10 Californians (29%) are somewhat or very familiar with the term CRI. However, when asked to describe, in an open-ended fashion, what CRI represents, only over a third (36%) of those familiar with the term provided a correct definition.

Our research, however, is limited in understanding the impact of the various CRI specifications on customer satisfaction with LED products and therefore whether educational efforts around CRI are an important and worthy endeavor.

Recommendation 5. The IOUs should consider conducting additional research into the importance of light rendering accuracy to customer satisfaction with LEDs. Such research could be valuable when deciding on the scope and degree of educational efforts needed around CRI as well as the value of Tier 2 CRI specifications from the customer perspective.

8. Suggestions for Future Research

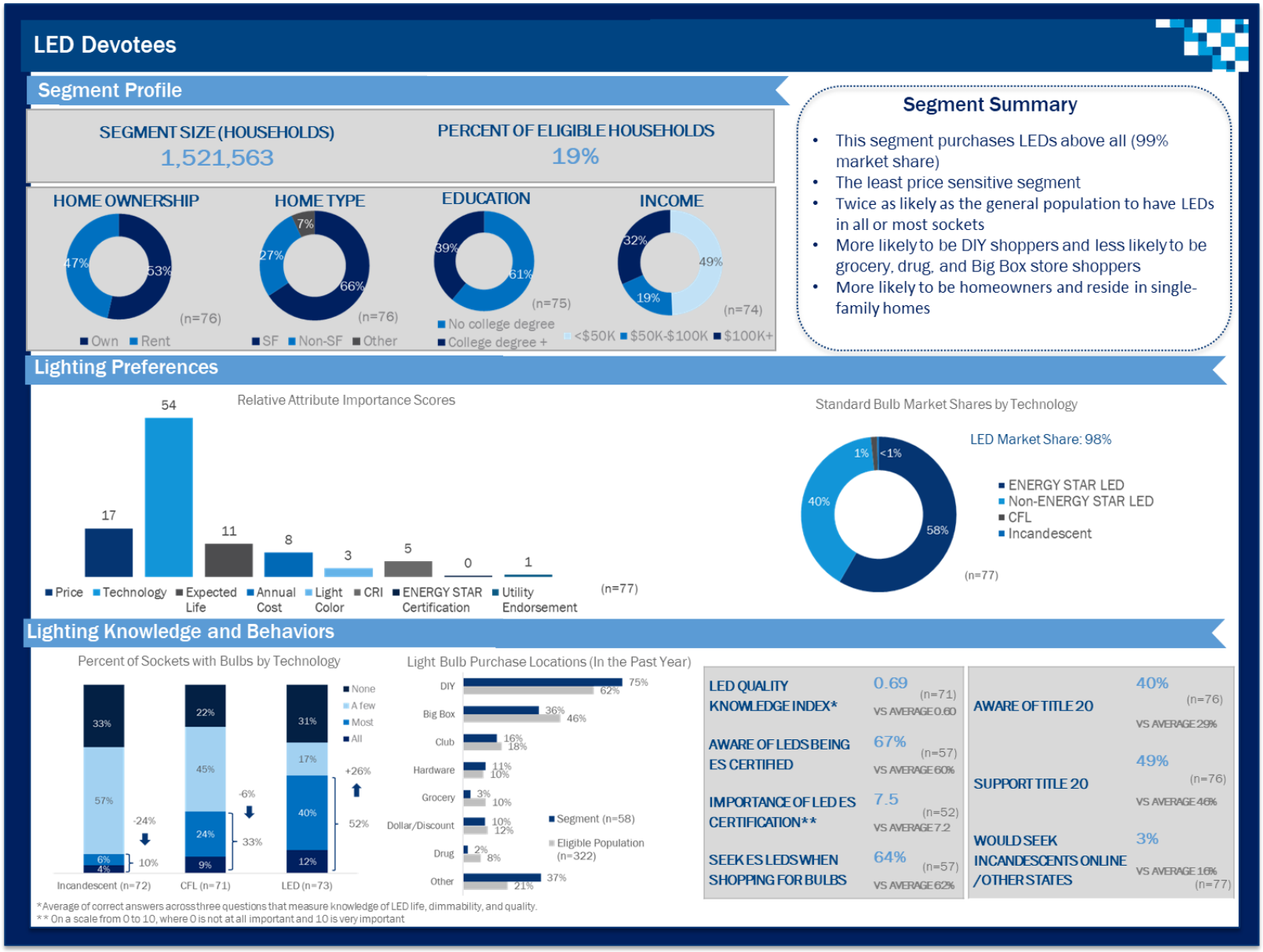
This research study could not provide additional insight into (1) anticipated supply-side compliance, including online retailer compliance, with the Title 20 standards, both Tier 1 and Tier 2, and (2) the value that customers place on CRI. These two areas can benefit from additional research. Supply-side compliance can be investigated through a shelf stocking study combined with interviews with supply-side market actors (retailers, distributors, and manufacturers), while the value of CRI can be explored through a quality study where customers get to use LED products with various CRI ratings and comment on the observed differences, or lack thereof, in performance.

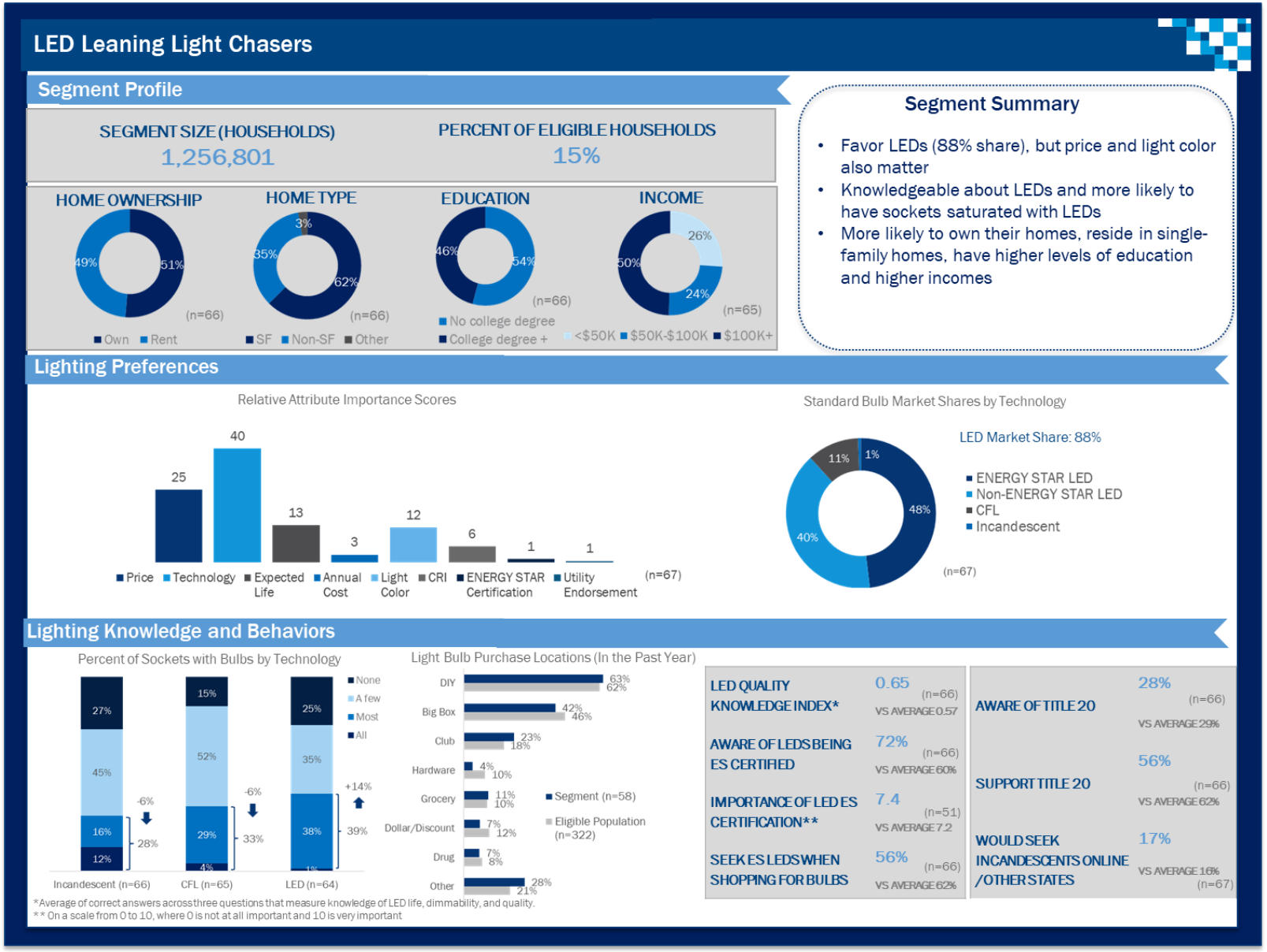
Additionally, should the IOUs pursue targeted outreach and marketing efforts, a propensity scoring analysis will allow the IOUs to leverage this study's segmentation results by assigning segments to the entire customer population.

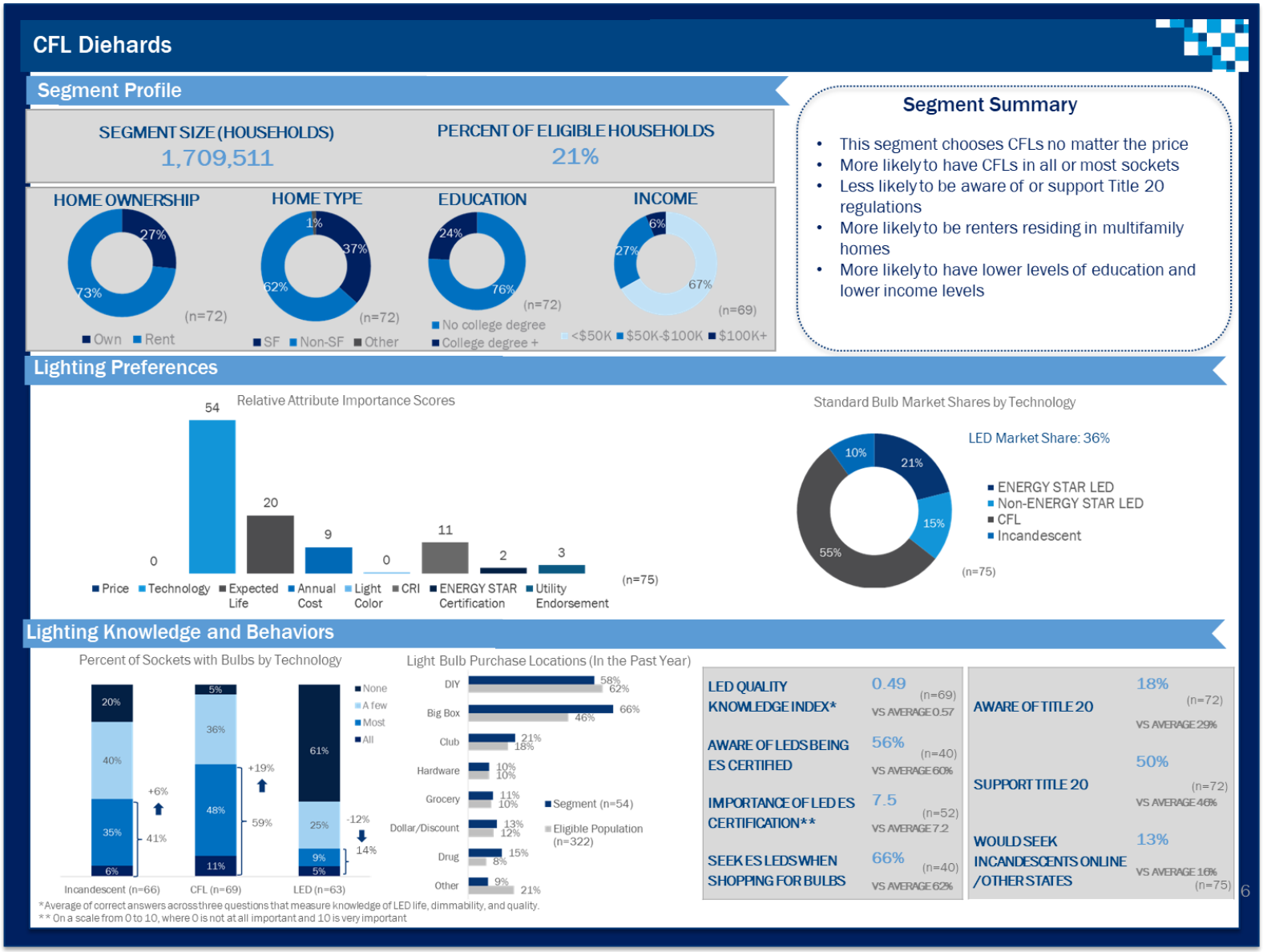
Appendix A. Detailed Segment Profiles

This appendix contains detailed segment profiles.

Standard Bulb Segments




LED Leaning Light Chasers
Segment Profile
SEGMENT SIZE (HOUSEHOLDS)
1,256,801
PERCENT OF ELIGIBLE HOUSEHOLDS
15%
HOME OWNERSHIP
49%
51%
(n=66)
Own
Rent
HOME TYPE
3%
35%
62%
(n=66)
SF
Non-SF
Other
EDUCATION
46%
54%
(n=66)
No college degree
College degree +
INCOME
26%
50%
24%
(n=65)
<$50K
$50K-$100K
$100K+
Segment Summary
Favor LEDs (88% share), but price and light color also matter
Knowledgeable about LEDs and more likely to have sockets saturated with LEDs
More likely to own their homes, reside in single-family homes, have higher levels of education and higher incomes
Lighting Preferences
Relative Attribute Importance Scores
25
40
13
3
12
6
1
1
(n=67)
Price
Technology
Expected Life
Annual Cost
Light Color
CRI
ENERGY STAR Certification
Utility Endorsement
Standard Bulb Market Shares by Technology
LED Market Share: 88%
11%
1%
48%
40%
(n=67)
ENERGY STAR LED
Non-ENERGY STAR LED
CFL
Incandescent
Lighting Knowledge and Behaviors
Percent of Sockets with Bulbs by Technology
27%
45%
16%
12%
-6%
28%
15%
52%
29%
4%
-6%
33%
25%
35%
38%
1%
+14%
39%
Incandescent (n=66)
CFL (n=65)
LED (n=64)
None
A few
Most
All
Light Bulb Purchase Locations (In the Past Year)
DIY
63%
62%
Big Box
42%
46%
Club
23%
18%
Hardware
4%
10%
Grocery
11%
10%
Dollar/Discount
7%
12%
Drug
7%
8%
Other
28%
21%
Segment (n=58)
Eligible Population (n=322)
LED QUALITY KNOWLEDGE INDEX*
0.65
(n=66)
VS AVERAGE 0.57
AWARE OF LEDS BEING ES CERTIFIED
72%
(n=66)
VS AVERAGE 60%
IMPORTANCE OF LED ES CERTIFICATION**
7.4
(n=51)
VS AVERAGE 7.2
SEEK ES LEDS WHEN SHOPPING FOR BULBS
56%
(n=66)
VS AVERAGE 62%
AWARE OF TITLE 20
28%
(n=66)
VS AVERAGE 29%
SUPPORT TITLE 20
56%
(n=66)
VS AVERAGE 62%
WOULD SEEK INCANDESCENTS ONLINE /OTHER STATES
17%
VS AVERAGE 16%
(n=67)
*Average of correct answers acrossthree questions that measure knowledge of LED life, dimmability, and quality.
** On a scale from 0 to 10, where 0 is not at all important and 10 is very important


CFL Diehards
Segment Profile
SEGMENT SIZE (HOUSEHOLDS)
1,709,511
PERCENT OF ELIGIBLE HOUSEHOLDS
21%
HOME OWNERSHIP
27%
73%
(n=72)
Own
Rent
HOME TYPE
1%
37%
62%
(n=72)
SF
Non-SF
Other
EDUCATION
24%
76%
(n=72)
No college degree
College degree +
INCOME
6%
27%
67%
(n=69)
<$50K
$50K-$100K
$100K+
Segment Summary
This segment chooses CFLs no matter the price
More likely to have CFLs in all or most sockets
Less likely to be aware of or support Title 20 regulations
More likely to be renters residing in multifamily homes
More likely to have lower levels of education and lower income levels
Lighting Preferences
Relative Attribute Importance Scores
54
20
9
0
11
2
3
0
Price
Technology
Expected Life
Annual Cost
Light Color
CRI
ENERGY STAR Certification
Utility Endorsement
(n=75)
Standard Bulb Market Shares by Technology
LED Market Share: 36%
10%
21%
15%
55%
ENERGY STAR LED
Non-ENERGY STAR LED
CFL
Incandescent
(n=75)
Lighting Knowledge and Behaviors
Percent of Sockets with Bulbs by Technology
20%
40%
35%
6%
+6%
41%
5%
36%
48%
11%
+19%
59%
61%
25%
9%
5%
-12%
14%
None
A few
Most
All
Incandescent (n=66)
CFL (n=69)
LED (n=63)
Light Bulb Purchase Locations (In the Past Year)
DIY
58%
62%
Big Box
66%
46%
Club
21%
18%
Hardware
10%
10%
Grocery
11%
10%
Dollar/Discount
13%
12%
Drug
15%
8%
Other
9%
21%
Segment (n=54)
Eligible Population (n=322)
LED QUALITY KNOWLEDGE INDEX*
0.49
(n=69)
VS AVERAGE 0.57
AWARE OF LEDS BEING ES CERTIFIED
56%
(n=40)
VS AVERAGE 60%
IMPORTANCE OF LED ES CERTIFICATION**
7.5
(n=52)
VS AVERAGE 7.2
SEEK ES LEDS WHEN SHOPPING FOR BULBS
66%
(n=40)
VS AVERAGE 62%
AWARE OF TITLE 20
18%
(n=72)
VS AVERAGE 29%
SUPPORT TITLE 20
50%
(n=72)
VS AVERAGE 46%
WOULD SEEK INCANDESCENTS ONLINE /OTHER STATES
13%
VS AVERAGE 16%
(n=75)
*Average of correct answers across three questions that measure knowledge of LED life, dimmability, and quality.
** On a scale from 0 to 10, where 0 is not at all important and 10 is very important

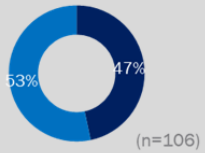
Thrifty Performance Seekers

Segment Profile

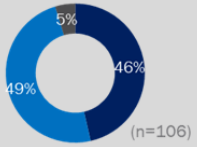
SEGMENT SIZE (HOUSEHOLDS)
2,089,493

PERCENT OF ELIGIBLE HOUSEHOLDS
26%

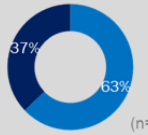
HOME OWNERSHIP



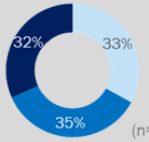
HOME TYPE



EDUCATION



INCOME

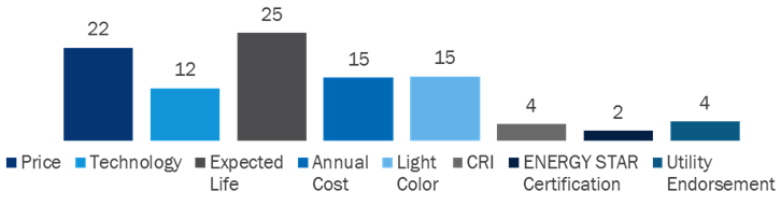


Segment Summary

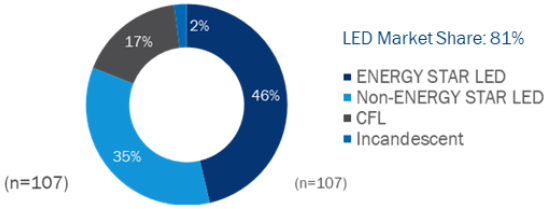
- Place the most value on bulb life, followed by price
- Prefer LEDs over other technologies and stay away from incandescents
- Prefer and seek out ENERGY STAR LEDs
- Less likely to have LEDs in most or all sockets
- Slightly more likely to be homeowners and have higher income levels

Lighting Preferences

Relative Attribute Importance Scores

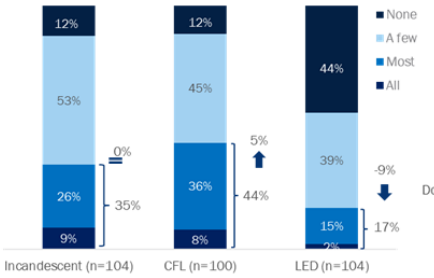


Standard Bulb Market Shares by Technology

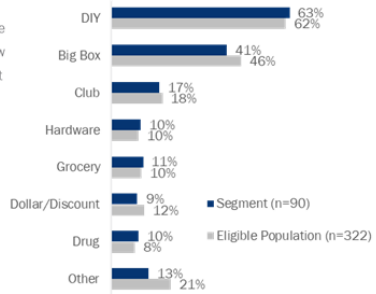


Lighting Knowledge and Behaviors

Percent of Sockets with Bulbs by Technology



Light Bulb Purchase Locations (In the Past Year)



LED QUALITY KNOWLEDGE INDEX*	0.56 (n=104) VS AVERAGE 0.57	
AWARE OF LEDS BEING ES CERTIFIED	60% (n=107) VS AVERAGE 60%	
IMPORTANCE OF LED ES CERTIFICATION**	7.7 (n=71) VS AVERAGE 7.2	
SEEK ES LEDS WHEN SHOPPING FOR BULBS	73% (n=71) VS AVERAGE 62%	
AWARE OF TITLE 20	27% (n=106) VS AVERAGE 29%	
SUPPORT TITLE 20	51% (n=106) VS AVERAGE 46%	
WOULD SEEK INCANDESCENTS ONLINE /OTHER STATES	11% VS AVERAGE 16% (n=106)	

*Average of correct answers across three questions that measure knowledge of LED life, dimmability, and quality.
** On a scale from 0 to 10, where 0 is not at all important and 10 is very important

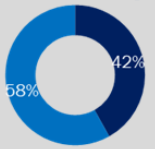
Frugal Consumers

Segment Profile

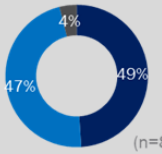
SEGMENT SIZE (HOUSEHOLDS)
1,595,108

PERCENT OF ELIGIBLE HOUSEHOLDS
20%

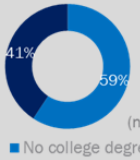
HOME OWNERSHIP



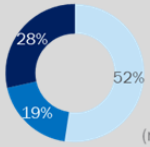
HOME TYPE



EDUCATION



INCOME

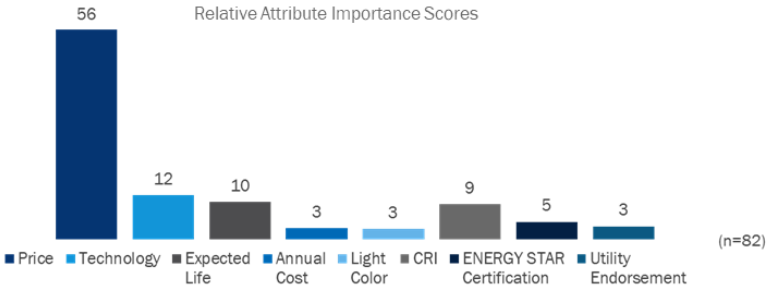


Segment Summary

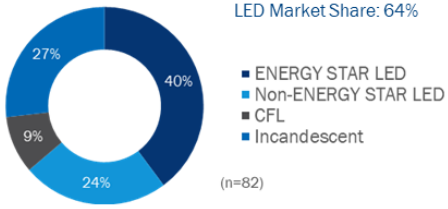
- Upfront cost is everything
- More likely to have incandescents in most or all sockets
- Favor Dollar/Discount stores and are less likely to be DIY store shoppers

Lighting Preferences

Relative Attribute Importance Scores

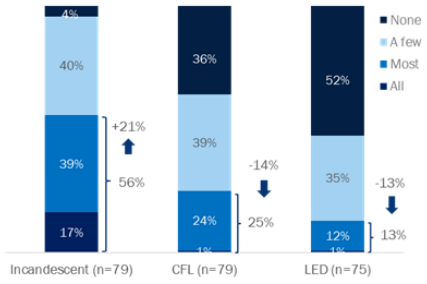


Standard Bulb Market Shares by Technology

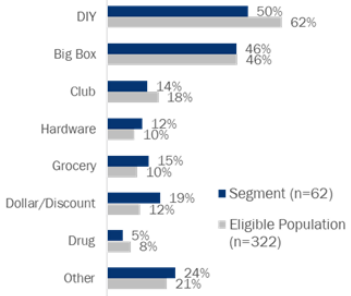


Lighting Knowledge and Behaviors

Percent of Sockets with Bulbs by Technology



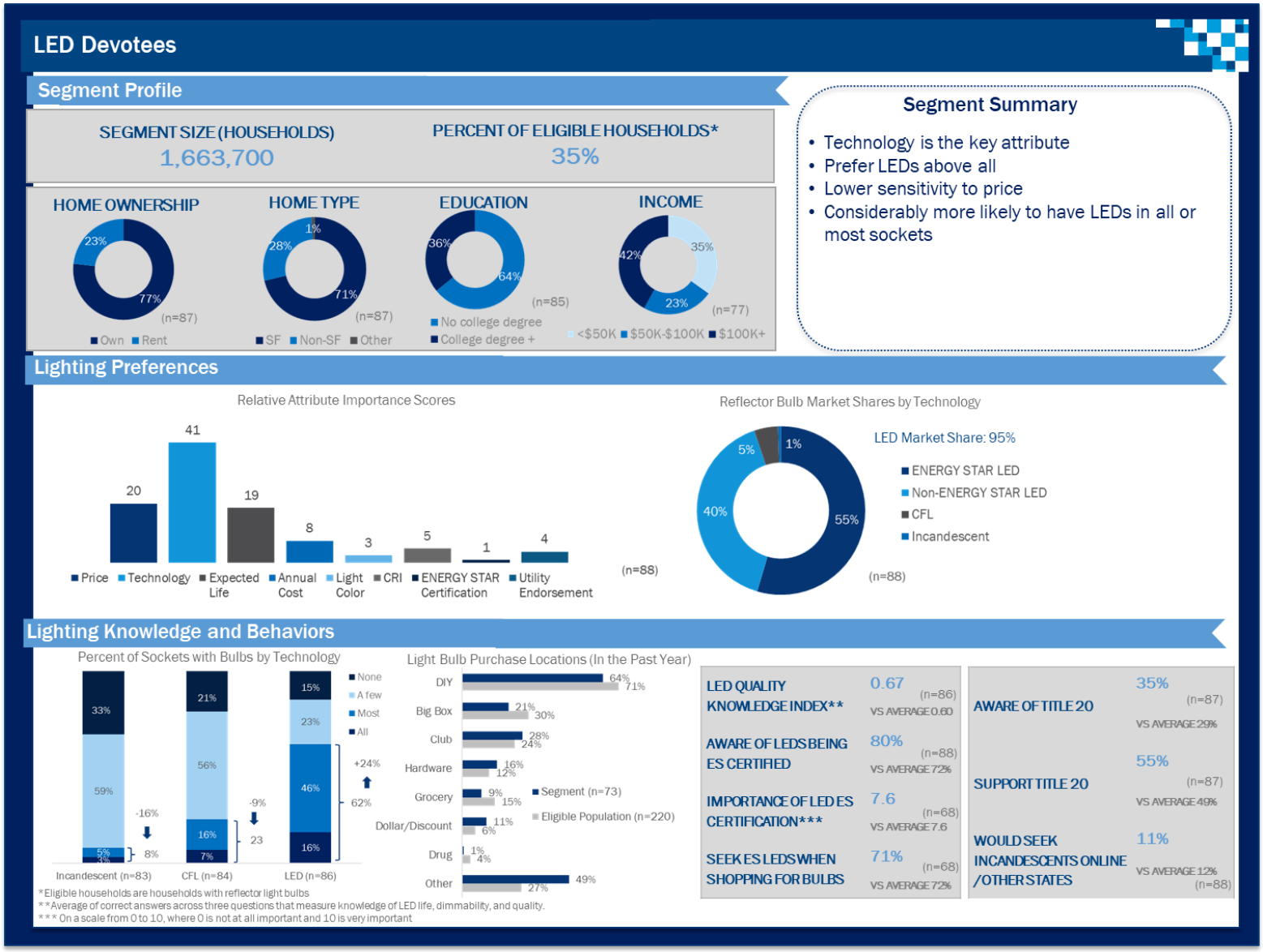
Light Bulb Purchase Locations (In the Past Year)

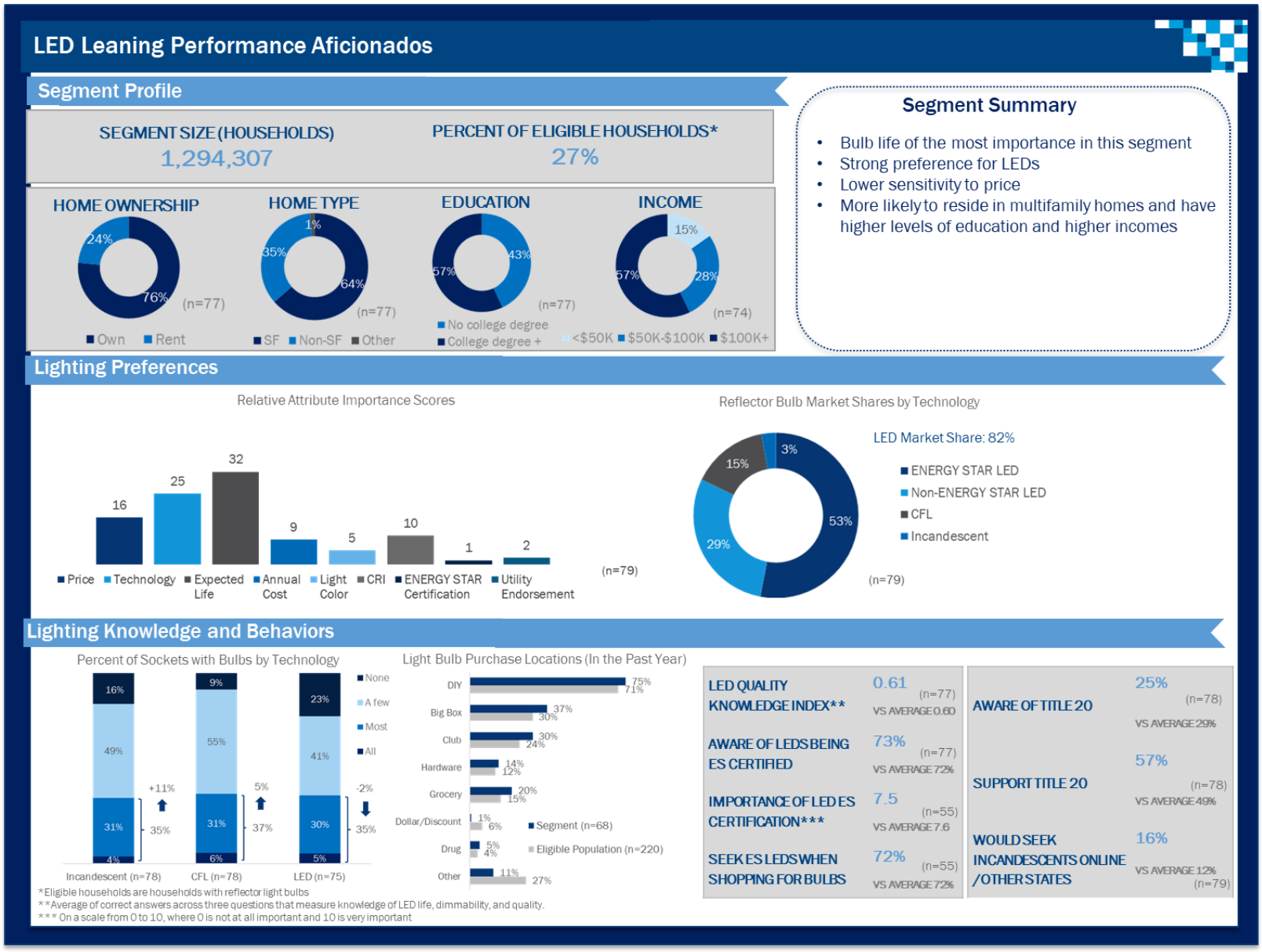


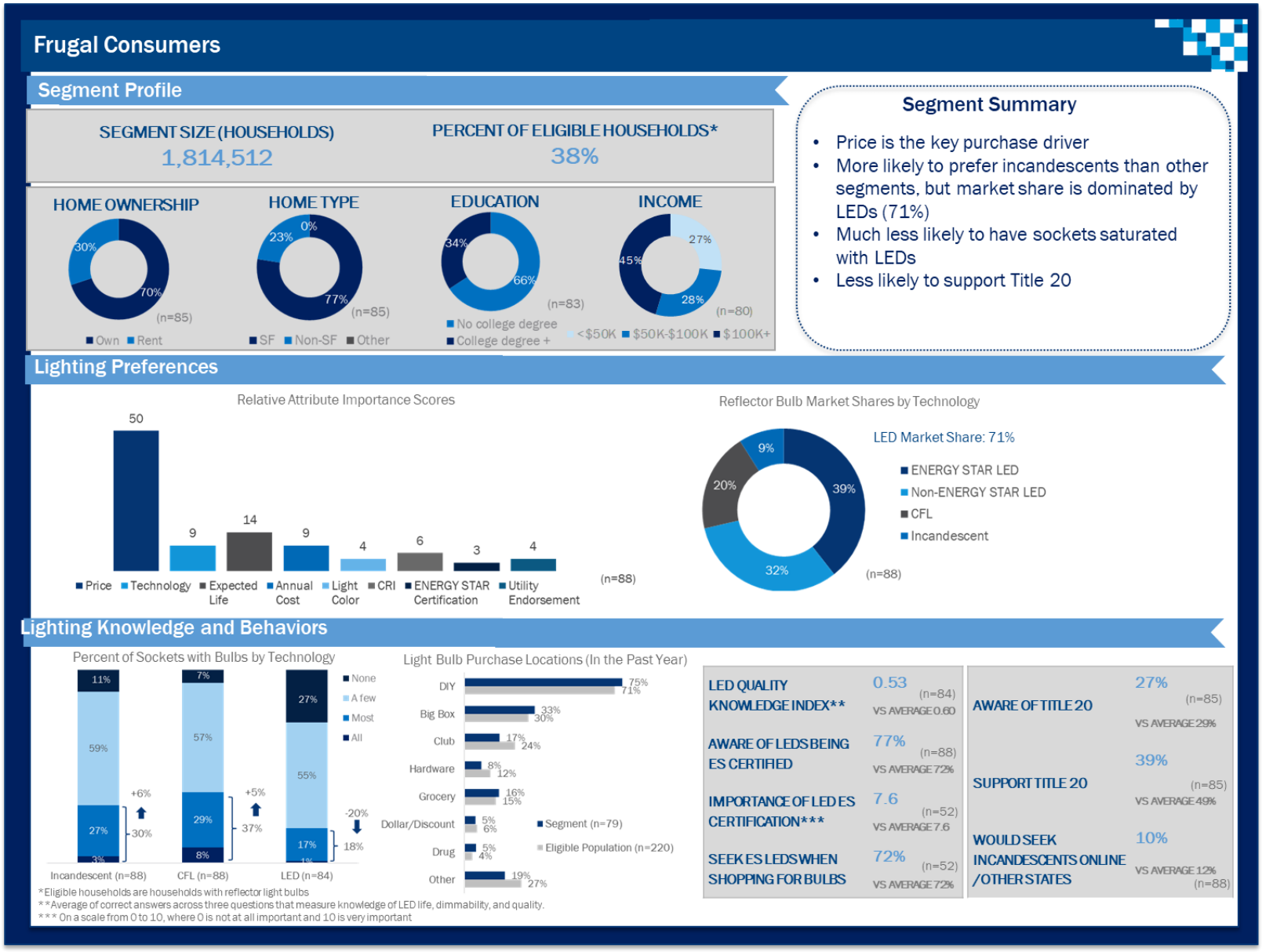
LED QUALITY KNOWLEDGE INDEX*	0.56 (n=80) VS AVERAGE 0.57	AWARE OF TITLE 20	27% (n=81) VS AVERAGE 29%
AWARE OF LEDS BEING ES CERTIFIED	60% (n=81) VS AVERAGE 60%	SUPPORT TITLE 20	51% (n=81) VS AVERAGE 46%
IMPORTANCE OF LED ES CERTIFICATION**	7.7 (n=52) VS AVERAGE 7.2	WOULD SEEK INCANDESCENTS ONLINE /OTHER STATES	11% VS AVERAGE 16% (n=81)
SEEK ES LEDS WHEN SHOPPING FOR BULBS	73% (n=40) VS AVERAGE 62%		

*Average of correct answers acrossthree questions that measure knowledge of LED life, dimmability, and quality.** On a scale from 0 to 10, where 0 is not at all important and 10 is very important

Reflector Bulb Segments




LED Leaning Performance Aficionados
Segment Profile
SEGMENT SIZE (HOUSEHOLDS)
1,294,307
PERCENT OF ELIGIBLE HOUSEHOLDS*
27%
HOME OWNERSHIP
24%
76%
(n=77)
Own
Rent
HOME TYPE
1%
35%
64%
(n=77)
SF
Non-SF
Other
EDUCATION
43%
57%
(n=77)
No college degree
College degree +
INCOME
15%
57%
28%
(n=74)
<$50K
$50K-$100K
$100K+
Segment Summary
Bulb life of the most importance in this segment
Strong preference for LEDs
Lower sensitivity to price
More likely to reside in multifamily homes and have higher levels of education and higher incomes
Lighting Preferences
Relative Attribute Importance Scores
16
25
32
9
5
10
1
2
(n=79)
Price
Technology
Expected Life
Annual Cost
Light Color
CRI
ENERGY STAR Certification
Utility Endorsement
Reflector Bulb Market Shares by Technology
LED Market Share: 82%
3%
15%
53%
29%
(n=79)
ENERGY STAR LED
Non-ENERGY STAR LED
CFL
Incandescent
Lighting Knowledge and Behaviors
Percent of Sockets with Bulbs by Technology
16%
49%
31%
4%
35%
+11%
9%
55%
31%
6%
37%
5%
23%
41%
30%
5%
35%
-2%
None
A few
Most
All
Incandescent (n=78)
CFL (n=78)
LED (n=75)
Light Bulb Purchase Locations (In the Past Year)
DIY
75%
71%
Big Box
37%
30%
Club
30%
24%
Hardware
14%
12%
Grocery
20%
15%
Dollar/Discount
1%
6%
Drug
5%
4%
Other
11%
27%
Segment (n=68)
Eligible Population (n=220)
LED QUALITY KNOWLEDGE INDEX**
0.61
(n=77)
VS AVERAGE 0.60
AWARE OF LEDS BEING ES CERTIFIED
73%
(n=77)
VS AVERAGE 72%
IMPORTANCE OF LED ES CERTIFICATION***
7.5
(n=55)
VS AVERAGE 7.6
SEEK ES LEDS WHEN SHOPPING FOR BULBS
72%
(n=55)
VS AVERAGE 72%
AWARE OF TITLE 20
25%
(n=78)
VS AVERAGE 29%
SUPPORT TITLE 20
57%
(n=78)
VS AVERAGE 49%
WOULD SEEK INCANDESCENTS ONLINE /OTHER STATES
16%
VS AVERAGE 12%
(n=79)
*Eligible households are households with reflector light bulbs
**Average of correct answers across three questions that measure knowledge of LED life, dimmability, and quality.
*** On a scale from 0 to 10, where 0 is not at all important and 10 is very important


Frugal Consumers
Segment Profile
SEGMENT SIZE (HOUSEHOLDS)
1,814,512
PERCENT OF ELIGIBLE HOUSEHOLDS*
38%
HOME OWNERSHIP
30%
70%
(n=85)
Own Rent
HOME TYPE
23%
0%
77%
(n=85)
SF Non-SF Other
EDUCATION
34%
66%
(n=83)
No college degree
College degree +
INCOME
27%
45%
28%
(n=80)
<$50K $50K-$100K $100K+
Segment Summary
Price is the key purchase driver
More likely to prefer incandescents than other segments, but market share is dominated by LEDs (71%)
Much less likely to have sockets saturated with LEDs
Less likely to support Title 20
Lighting Preferences
Relative Attribute Importance Scores
50
9
14
9
4
6
3
4
(n=88)
Price Technology Expected Life Annual Cost Light Color CRI ENERGY STAR Certification Utility Endorsement
Reflector Bulb Market Shares by Technology
LED Market Share: 71%
9%
20%
39%
32%
(n=88)
ENERGY STAR LED
Non-ENERGY STAR LED
CFL
Incandescent
Lighting Knowledge and Behaviors
Percent of Sockets with Bulbs by Technology
11%
59%
27%
3%
+6%
30%
7%
57%
29%
8%
+5%
37%
27%
55%
17%
1%
-20%
18%
Incandescent (n=88)
CFL (n=88)
LED (n=84)
None
A few
Most
All
Light Bulb Purchase Locations (In the Past Year)
DIY 75% 71%
Big Box 33% 30%
Club 17% 24%
Hardware 8% 12%
Grocery 16% 15%
Dollar/Discount 5% 6%
Drug 5% 4%
Other 19% 27%
Segment (n=79)
Eligible Population (n=220)
LED QUALITY KNOWLEDGE INDEX** 0.53 (n=84) VS AVERAGE 0.60
AWARE OF LEDS BEING ES CERTIFIED 77% (n=88) VS AVERAGE 72%
IMPORTANCE OF LED ES CERTIFICATION*** 7.6 (n=52) VS AVERAGE 7.6
SEEK ES LEDS WHEN SHOPPING FOR BULBS 72% (n=52) VS AVERAGE 72%
AWARE OF TITLE 20 27% (n=85) VS AVERAGE 29%
SUPPORT TITLE 20 39% (n=85) VS AVERAGE 49%
WOULD SEEK INCANDESCENTS ONLINE /OTHER STATES 10% (n=88) VS AVERAGE 12%
*Eligible households are households with reflector light bulbs
**Average of correct answers across three questions that measure knowledge of LED life, dimmability, and quality.
*** On a scale from 0 to 10, where 0 is not at all important and 10 is very important

Appendix B. Data Collection Instruments

Online Data Collection Instrument

California Statewide Residential Lighting Customer Decision Study Survey

Final

September 6, 2017

Survey Background

The main purpose of this survey is to measure customer preferences and the effect of various lamp attributes on consumer purchase decisions using a discrete choice survey design. The survey also includes questions about customer awareness and usage of lighting technologies; preferred shopping venues; awareness of quality markers and new lighting efficiency standards; and anticipated behavior changes considering the new standards (Title 20). We will use the survey results to isolate the lamp attributes that drive purchases, identify customer segments and develop diffusion of LED technology innovation curves.

Table B-1 provides an overview of the survey topic areas and research objectives associated with each.

Table B-1. Survey Topic Areas and Research Objectives

Topic Area	Research Objectives
Lighting Awareness	These questions measure customer awareness and experience with different lighting technologies.
Discrete Choice	These questions assess the relative value respondents put on each of the tested lighting attributes.
Perceptions of Energy Use	These questions provide information about customer perceptions of different lighting products.
Quality Markers	These questions assess customer awareness of lighting quality markers, such as ENERGY STAR and utility endorsement. We assess the importance of such markers in the discrete choice experiment.
Preferred Shopping Venues	These questions assess customer preferred lighting shopping venues, including online. This section also assesses awareness of the new lighting regulations called for in Title 20 and anticipated shopping behavior after 2018.
Demographics	We will use these questions to assess the representativeness of the sample. Additionally, we will compare the lighting preferences of different demographic groups.

Landing Page

Web address: www.CAlightingsurvey.com

Welcome to the California Statewide Lighting Survey and thank you for participating in this important study! If you complete this survey, you will receive a $5 Amazon gift card as our thank you for participation.

The next screen will ask you for the 5-digit personal identification number (PIN) provided in the survey invitation. Please click on the link below to enter your PIN and start the survey.

Start Survey

Introduction

[SHOW IOU AND OPINION DYNAMICS LOGOS ON EVERY PAGE OF THE SURVEY]

Please enter the 5-digit personal identification number (PIN) from the survey invitation letter that you received.

00. [NUMERIC OPEN END, 10000 – 49999]

We have just a few questions about your energy providers.

S1. Who is your electric service provider?
1. Pacific Gas and Electric Company (PG&E)
2. San Diego Gas & Electric (SDG&E)
3. Southern California Edison (SCE)
0. Other (Please Specify)

S2. Does your home have natural gas connection?
1. Yes
2. No

[ASK IF S2=1]
S3. Who is your gas services provider?
1. Pacific Gas and Electric Company (PG&E)
2. San Diego Gas & Electric (SDG&E)
0. Other (Please Specify)

This survey is about lighting. We would like to learn what lighting products you use in your home and how you shop for lighting. There are no right or wrong answers, as each person has different needs and preferences.

Lighting Awareness and Use (I)

We would first like to learn about your experience with the various lighting technologies you can find in-store and online.

I1. Please indicate your level of experience with each type of light bulb. For each product, please think about a bulb with a screw base like the bulbs in the pictures.

Bulb Type	Your Response
A. Incandescent  An incandescent bulb is a traditional light bulb that has been available for 100 years.	1. Have used this type of light bulb 2. Have heard of this type of light bulb but have never used it 3. Have not heard of this type of light bulb before today
B. CFL (otherwise known as compact fluorescent lamp)  A CFL bulb sometimes has a "twisty" spiral shape which makes them easy to identify. However, the "twisty" part can be covered by an opaque glass bulb. CFLs can also be identified because of their short plastic base.	1. Have used this type of light bulb 2. Have heard of this type of light bulb but have never used it 3. Have not heard of this type of light bulb before today
C. LED (otherwise known as light emitting diode)  An LED is the newest type of light bulb on the market. LEDs come in a variety of shapes and forms. They often have a large plastic base, sometimes with ridges.	1. Have used this type of light bulb 2. Have heard of this type of light bulb but have never used it 3. Have not heard of this type of light bulb before today

I2. Do you have any of these products currently installed either inside or outside of your home?

Bulb Type	Your Response
A. Incandescent 	1. Yes 2. No 8. Not sure
B. CFL (otherwise known as compact fluorescent lamp) 	1. Yes 2. No 8. Not sure

Bulb Type	Your Response
C. LED (otherwise known as light emitting diode) 	1. Yes 2. No 8. Not sure

I3. Thinking about ALL of the light sockets in your home, how many of them contain each of the following bulb types?

Bulb Type	Your Response				
	All light sockets contain this type of bulb 1	Most light sockets contain this type of bulb 2	A few light sockets contain this type of bulb 3	No light sockets contain this type of bulb 4	Not sure 8
[ASK IF I2A=1] A. Incandescents 	○	○	○	○	○
[ASK IF I2B=1] B. CFLs 	○	○	○	○	○
[ASK IF I2C=1] C. LEDs 	○	○	○	○	○

I4. Do you have any recessed can lighting fixtures in the ceilings of your home? The fixture typically looks like this:

1. Yes
2. No

Discrete Choice Module

[IF I4 = 1 and BATTERY=STANDARD, ASK STANDARD DISCRETE CHOICE MODULE. IF I4=1 AND BATTERY=REFLECTOR, ASK REFLECTOR DISCRETE CHOICE MODULE. IF I4=2, ASK STANDARD DISCRETE CHOICE BATTERY]

Standard Products

With our next set of questions, we would like to send you on a shopping trip for lighting. Assume that a light in your house that is used frequently has burned out, and you need to replace the bulb. The light is not dimmable or three-way and takes a standard screw-in bulb of 60 watts or equivalent. You don't have a replacement bulb at home, so you need to purchase one. Finally, imagine that you need to install the bulb in a table lamp that looks something like this:

For the next series of questions, we will show you some different light bulbs and ask which one you would purchase, if any. We will show you 5 light bulbs at a time that have different characteristics.

Click NEXT to see an example of the screen.

After making your purchase selection, we will show you another screen with 5 different light bulbs and again ask you to select which one you would purchase. We will ask you to make a total of 12 separate purchase decisions.

When making your selections, please use the following instructions:

- Do not "comparison shop" between screens. Try to "start over" on each screen and make selections only based on the bulb options presented on that screen.
- Do not feel you have to buy anything if you don't want to or don't see the right product. Simply select the "None" option.
- Assume that you are spending your own money. While you are not asked to purchase light bulbs, it is extremely important that you select products as if you were actually buying them.
- Some of the bulb options presented to you may not be realistic or seem different than what you see at your local retailer. Please imagine that all products you see are available for purchase.
- Assume that all of the bulb choices that you will see come as single-bulb packs.

Finally, remember, **THERE ARE NO RIGHT OR WRONG ANSWERS**. We are looking to best understand how **YOU** purchase light bulbs.

Discrete Choice Experiment Setup for Standard Products

Attributes is a list of characteristics that respondents will see for each product option. Attribute levels are the values that will experimentally be assigned to each attribute.

Attributes	Attribute Levels	
Price	$0.50, $2.10, $3.80, $5.40, $7.10, $8.70, $10.40, $12.00	None
Technology	Incandescent, CFL, LED	
Bulb life	1, 7, 15 and 25 years	
Annual energy cost	$1.00, $1.75, $5.00, and $7.25	
Light color	Warm White, Bright White, Daylight	
Color Accuracy (CRI)	62, 80, 95, 100	
ENERGY STAR rating	"ENERGY STAR rated" or "Not ENERGY STAR rated"	
Utility endorsement	Utility Logo or no Logo	

Reflector Products

With our next set of questions, we would like to send you on a shopping trip for lighting. Assume that a frequently used light in your house has burned out, and you need to replace the bulb. The light is not dimmable or three-way and takes a standard screw-in reflector bulb of 65 watts or equivalent. You don't have a replacement bulb at home, so you need to purchase one. Finally, imagine that you need to install the bulb in a fixture that looks something like this:

For the next series of questions, we will show you some different light bulbs and ask which one you would purchase, if any. We will show you 5 light bulbs at a time that have different characteristics.

Click NEXT to see an example of the screen.

After making your purchase selection, we will show you another screen with 5 different light bulbs and again ask you to select which one you would purchase. We will ask you to make a total of 12 separate purchase decisions.

When making your selections, please use the following instructions:

- Do not "comparison shop" between screens. Try to "start over" on each screen and make selections only based on the bulb options presented on that screen.
- Do not feel you have to buy anything if you don't want to or don't see the right product. Simply select the "None" option.
- Assume that you are spending your own money. While you are not asked to purchase light bulbs, it is extremely important that you select products as if you were actually buying them.
- Some of the bulb options presented to you may not be realistic or seem different than what you see at your local retailer. Please imagine that all products you see are available for purchase.
- Assume that all of the bulb choices that you will see come as single-bulb packs.

Finally, remember, **THERE ARE NO RIGHT OR WRONG ANSWERS**. We are looking to best understand how **YOU** purchase light bulbs.

Discrete Choice Experiment Setup for Reflector Products

Attributes is a list of characteristics that respondents will see for each product option. Attribute levels are the values that will experimentally be assigned to each attribute.

Attributes	Attribute Levels	
Price	$1.00, $3.70, $6.40, $9.10, $11.90, $14.60, $17.30, $20.00	None
Technology	Incandescent, CFL, LED	
Bulb life	1, 7, 15 and 25 years	
Annual energy cost	$1.00, $1.75, $5.00, and $7.25	
Light color	Warm White, Bright White, Daylight	
Color Accuracy (CRI)	62, 80, 95, 100	
ENERGY STAR rating	"ENERGY STAR rated" or "Not ENERGY STAR rated"	
Utility endorsement	Utility Logo or no Logo	

Lighting Product Perceptions (P)

[RANDOMIZE P1 – P3]
[SKIP IF I1A = 3]

P1. Which of the following words do you associate with **incandescent light bulbs**? For each set of words please indicate the place on the scale that best represents the degree to which you associate the given words with incandescent light bulbs. [RANDOMIZE WORD ORDER] [SCALE 1-5] [PROGRAM AS RADIO BUTTONS]

#	1=	2	3	4	5=
A.	Expensive				Inexpensive
B.	Dangerous				Safe
C.	Outdated				Cutting edge
D.	Energy intensive				Energy efficient
E.	Bad				Good
F.	Overpriced				Bargain
G.	Poor choice				Smart choice
H.	Bad for environment				Good for environment

[SKIP IF I1B=3]

P2. Which of the following words do you associate with **CFL light bulbs**? For each set of words please indicate the place on the scale that best represents the degree to which you associate the given words with CFL light bulbs. [RANDOMIZE WORD ORDER] [SLIDING SCALE 1-5] [PROGRAM AS RADIO BUTTONS]

#	1=	2	3	4	5=
A.	Expensive				Inexpensive
B.	Dangerous				Safe
C.	Outdated				Cutting edge
D.	Energy intensive				Energy efficient
E.	Bad				Good
F.	Overpriced				Bargain
G.	Poor choice				Smart choice
H.	Bad for environment				Good for environment

[SKIP IF I1C=3]

P3. Which of the following words do you associate with **LED light bulbs**? For each set of words please indicate the place on the scale that best represents the degree to which you associate the given words with LED light bulbs. RANDOMIZE WORD ORDER] [SLIDING SCALE 1-5] [PROGRAM AS RADIO BUTTONS]

#	1=	2	3	4	5=
A.	Expensive				Inexpensive
B.	Dangerous				Safe
C.	Outdated				Cutting edge
D.	Energy intensive				Energy efficient
E.	Bad				Good
F.	Overpriced				Bargain
G.	Poor choice				Smart choice
H.	Bad for environment				Good for environment

[SKIP IF I1C=3]

Please select what you believe is the correct answer. [RANDOMIZE RESPONSE OPTIONS, ANCHOR NOT SURE LAST]

P4a. Quality of LEDs

1. All LED products are of the same quality
2. The quality of LEDs varies from product to product
8. Not sure

P4b. Life Span of LEDs

1. All LEDs have a similar life span
2. LED life span varies from product to product
8. Not sure

P4c. LED Dimmability

1. All LEDs work on dimmable switches
2. Some LEDs don't work on dimmable switches
8. Not sure

P4d. LEDs compared to other technologies

1. LED quality is better than other lighting technologies
2. LED quality is the same as other technologies
3. LED quality is worse than other lighting technologies
8. Not sure

[SKIP IF I1C=3]

P5. What characteristics do you look at to determine that the LED is high quality? Please select all that apply. [MULTIPLE RESPONSE; RANDOMIZE]

01. Light color
02. Dimmability
03. Color rendering index (CRI)
04. Wattage
05. ENERGY STAR logo
06. Price
07. Bulb life
08. Beam spread
09. Brightness (lumens)
10. Warranty

11. Utility endorsement

P5a. How familiar are you with the term CRI, also known as color rendering index?
1. Very familiar
2. Somewhat familiar
3. Not very familiar
4. Have not heard this term before today

[ASK IF P5A=1 OR 2]
P5b. To the best of your knowledge, what does CRI represent? [OPEN END]

P6. Have you ever seen or heard of the ENERGY STAR® label?
1. Yes
2. No

[ASK IF P6=2]
P7. Please look at the ENERGY STAR® label below. Before today, had you ever seen or heard of this label?

1. Yes
2. No

[ASK IF I1B=1,2 OR I1C=1,2]
P8. Before today, were you aware that CFL and LED light bulbs can be ENERGY STAR® certified?
1. Yes
2. No

[ASK IF P8=1]
P9. How important is it to you that the CFLs and LEDs are ENERGY STAR® certified?

Not at all important										Very important
0	1	2	3	4	5	6	7	8	9	10

[ASK IF P8=1]
P10. Do you look for the ENERGY STAR® label when shopping for light bulbs?
1. Yes
2. No

P13. Have you heard of light bulbs that you can control remotely, such as from your smart phone or home assistant (Alexa, Google, etc.)?
1. Yes
2. No

Preferred Shopping Venues (V)

V1. Have you or anyone in your household purchased light bulbs in the past year?
1. Yes
2. No

[ASK IF V1=1]
V2. What types of bulbs have you purchased? Select all that apply. [MULTIPLE RESPONSE. RANDOMIZE RESPONSES]
1. Incandescents
2. CFLs
3. LEDs
8. Not sure

[ASK IF V1=1]
V3. Where did you purchase light bulbs in the past year? Select all that apply. [RANDOMIZED RESPONSE OPTIONS]
01 99 Cent Only Store
03 Ace Hardware
02 Albertsons
04 Amazon.com
05 Costco
06 CVS
07 Dixieline Lumber Co.
08 Food 4 Less
09 HD Supply
10 Home Depot
11 Longs Drugs
12 Lowes
13 Orchard Supply
14 Ralphs
15 Rite Aid
16 Sam's Club
17 Stater Brothers
18 Target
19 True Value Hardware
20 Walgreens
21 Wal-Mart
22. Online [SPECIFY]
00 Other [SPECIFY]
98 Not sure

[ASK IF V1=1 AND V2=3]

V4. Thinking specifically about LEDs that you purchased, did you install all, some, or none of the LED bulbs that you purchased?

1. All
2. Some
3. None
8. Cannot recall

[ASK IF V4=1 OR 2]

V5. Did you replace working light bulbs or burnt out light bulbs with the LEDs that you purchased?

1. All bulbs were working
2. All bulbs were burnt out
3. Some bulbs were working and some burnt out
0. Other (specify)
8. Cannot recall

[ASK IF V1=1]

V6. Customers have a variety of lighting options. When last shopping for light bulbs, how easy or difficult was it to find and select a light bulb that suited your needs?

0	1	2	3	4	5	6	7	8	9	10
Very Difficult										Very Easy

[ASK IF V1=1 AND V3<>4 OR 22]

V7. When last shopping for light bulbs, did you ask a store representative for assistance in selecting a bulb that suited your needs?

1. Yes
2. No

V8. Have you ever purchased light bulbs online?

1. Yes
2. No

[ASK IF V8=1]

V9. Which of the following best describes the frequency of shopping for light bulbs online as opposed to in-store?

1. I almost always purchase light bulbs **online** and rarely **at the store**
2. I sometimes purchase light bulbs **online** and sometimes **at the store**
3. I almost always purchase light bulbs **at the store** and rarely **online**
8. Not sure

New lighting regulations will soon be taking effect in California. As of January 2018, retailers in California will not be able to sell incandescent light bulbs. CFLs and LEDs will be the only light bulbs available for sale. These regulations will only affect the state of California – retailers in other parts of the country will be able to continue selling incandescent products along with CFLs and LEDs until 2020.

V10. Before today, have you heard of these regulations?
1. Yes
2. No

V11. How do feel about these regulations?
1. Strongly support
2. Somewhat support
3. Feel neutral
4. Somewhat oppose
5. Strongly oppose
8. Have no opinion

V12. How likely are you to stock up on incandescent light bulbs before the regulations go into effect in January 2018?
1. Very likely
2. Somewhat likely
3. Not very likely
4. Not at all likely

V13. Once the regulations go into effect and you can no longer purchase incandescent light bulbs in California, which of the following will you be likely to do? [MULTIPLE RESPONSE]
1. Buy CFL or LED bulbs that are available at your local retailer
2. Go online so you can purchase incandescent bulbs
3. Purchase incandescent bulbs when you are in another state and/or Mexico
0. (Other, specify)

Demographics (D)

D1. Which of the following best describes your home?
01. Detached single family
02. Townhouse
03. Manufactured home/Mobile home
04. Duplex/2-family home
05. Apartment/Condominium/Multi-family (3 or more units)
00. Other, specify

[ASK IF D1 = 5]
D1b. How many apartments/housing units are in your building?
1. 3-5
2. 6-9
3. 10 or more
8. Not Sure

D1c. Do you own or rent your home?
1. Own
2. Rent

D2. Including yourself, how many people currently live in your residence year-round?
00. [NUMERIC OPEN END, 1-20]

D3. How many people under the age of 18 live in your residence?
00. [NUMERIC OPEN END]

D4. Approximately when was your house built?
1. Before 1947
2. 1947-1966
3. 1967-1986
4. 1987-1996
5. 1997-2012
6. 2013 or later
8. Not sure

D5. Approximately, how many square feet is your residence?
00. [NUMERIC OPEN END]
99999. Not sure

[ASK IF D5=99999]
D6. What would you estimate the square footage of your residence to be?
1. Less than 1,000 sqft
2. 1,000 to just under 2,000 sqft
3. 2,000 to just under 3,000 sqft
4. 3,000 to just under 4,000 sqft
5. 4,000 to just under 5,000 sqft
6. 5,000 sqft or more
8. Not sure

D7. In what year were you born? [NUMERIC OPEN END 1900-2015] [RESPONSE NOT REQUIRED]

D8. What is your highest level of education? [RESPONSE NOT REQUIRED]
1. Less than a high school degree
2. High school degree
3. Technical/trade school program
4. Associates degree or some college
5. Bachelor's degree
6. Graduate / professional degree, e.g., J.D., MBA, MD, etc.

D9. Which of the following best describes your current employment status? [RESPONSE NOT REQUIRED]
1. Employed full-time
2. Employed part-time
3. Retired
4. Not employed, but actively looking
5. Not employed, and not looking

D10. Which category best describes your annual household income in 2016? [RESPONSE NOT REQUIRED]
1. Less than $25,000
2. $25,000 to just under $50,000
3. $50,000 to just under $75,000
4. $75,000 to just under $100,000
5. $100,000 to just under $150,000
6. $150,000 or more

D11. What is your gender? [RESPONSE NOT REQUIRED]
1. Male
2. Female

D12. In politics, as of today, do you consider yourself a…? [RESPONSE NOT REQUIRED]
1. Democrat
2. Republican
3. Independent
0. Other, specify
5. None

FIN. This completes the survey. Thank you very much for your time and participation in this important study. Please include your name, email address, and the best number to reach you at so that we can send your $5 Amazon gift card to you.

Include text boxes for Name, email address, and phone number (Include area code
Include box that says "I do not have an email address" then provide box for Mailing address
Include box that says "I do not wish to receive the gift card"

Thank you so much for completing our survey. Have a great day!

Telephone Data Collection Instrument

California Statewide Residential Lighting Customer Decision Study Survey

Inbound Phone Survey

Final

September 6, 2017

The main purpose of this survey is to gather key data on customer lighting awareness, usage, preferences, as well as customer demographic and household characteristics to assess the coverage bias due to the online only mode of the discrete choice survey.

Introduction

Thank you very much for calling to participate in the California Statewide Lighting Survey. We are interested in learning more about what lighting products you use in your home and how you shop for lighting. There are no right or wrong answers, as each person has different needs and preferences.

The questions should take just a couple of minutes of your time. You will receive a $5 Amazon gift card as our thank you for completing this survey.

A1. Do you have Internet access?
1. Yes
2. No
8. (Don't know)
9. (Refused)

[ASK IF A1=1]
A2. We would love if you could take this survey online. The online version has questions about lighting that we are unable to successfully explore over the phone. The survey is easy to find and you can take at any time that is convenient for you. Will you be able to complete this survey online?
1. Yes
2. No
8. (Don't know)
9. (Refused)

[READ IF A2=1] The invitation letter should have the address of the website where you can find the survey. I can also share it with you now. [IF NEEDED, PROVIDE WEB ADDRESS www.CAlightingSurvey.com] You will need to enter your personal identification number once you get to the survey website. Your pin should be listed in your letter as well.

[READ IF A2=1, TERMINATE AFTER READING THIS] Thank you for agreeing to participate in this important study. Have a nice day.

My first few questions are about your energy providers.

S1. Who is your electric service provider?
- 4. Pacific Gas and Electric Company (PG&E)
- 5. San Diego Gas and Electric (SDG&E)
- 6. Southern California Edison (SCE)
- 0. Other (Please Specify)

S2. Does your home have natural gas connection?
- 1. Yes
- 2. No

[ASK IF S2=1]
S3. Who is your gas services provider?
- 3. Pacific Gas and Electric Company (PG&E)
- 4. San Diego Gas and Electric (SDG&E)
- 0. Other (Please Specify)

I1. We would first like to learn about your experience with the various lighting technologies you can find in-store and online. Please indicate your level of experience with the following types of light bulbs.

A. An incandescent bulb is a traditional light bulb that has been available for 100 years. Would you say you…? (READ ANSWER CHOICES)
- 1. Have used this type of light bulb
- 2. Have heard of this type of light bulb but have never used it
- 3. Have not heard of this type of light bulb before today
- 8. (Don't know)
- 9. (Refused)

B. A CFL bulb sometimes has a "twisty" spiral shape which makes them easy to identify. However, the "twisty" part can be covered by an opaque glass bulb. CFLs can also be identified because of their short plastic base. Would you say you…? (READ ANSWER CHOICES)
- 1. Have used this type of light bulb
- 2. Have heard of this type of light bulb but have never used it
- 3. Have not heard of this type of light bulb before today
- 8. (Don't know)
- 9. (Refused)

C. An LED is the newest type of light bulb on the market. LEDs come in a variety of shapes and forms. They often have a large plastic base, sometimes with ridges. Would you say you…? (READ ANSWER CHOICES)
   1. Have used this type of light bulb
   2. Have heard of this type of light bulb but have never used it
   3. Have not heard of this type of light bulb before today
   8. (Don't know)
   9. (Refused)

I2. Do you have any of the following products currently installed either inside or outside of your home? [1=YES, 2=NO, 8=DON'T KNOW, 9= REFUSED]
   A. Incandescent
   B. CFL
   C. LED

V1. Have you or anyone in your household purchased light bulbs in the past year?
   1. Yes
   2. No
   8. (Don't know)
   9. (Refused)

[ASK IF V1=1]

V2. What types of bulbs have you purchased? [READ RESPONSE OPTIONS. MULTIPLE RESPONSE. RANDOMIZE RESPONSES]
   1. Incandescents
   2. CFLs
   3. LEDs
   8. (Don't know)
   9. (Refused)

V8. Have you ever purchased light bulbs online?
   1. Yes
   2. No
   8. (Don't know)
   9. (Refused)

New lighting regulations will soon be taking effect in California. As of January 2018, retailers in California will not be able to sell incandescent light bulbs. CFLs and LEDs will be the only light bulbs available for sale. These regulations will only affect the state of California – retailers in other parts of the country will be able to continue selling incandescent products along with CFLs and LEDs until 2020.

V10. Before today, have you heard of these regulations?
1. Yes
2. No
8. (Don't know)
9. (Refused)

V11. How do feel about these regulations?
1. Strongly support
2. Somewhat support
3. Feel neutral
4. Somewhat oppose
5. Strongly oppose
6. Have no opinion
8. (Don't know)
9. (Refused)

V12. How likely are you to stock up on incandescent light bulbs before the regulations go into effect in January 2018?
1. Very likely
2. Somewhat likely
3. Not very likely
4. Not at all likely
8. (Don't know)
9. (Refused)

V13. Once the regulations go into effect and you can no longer purchase incandescent light bulbs in California, which of the following will you be likely to do? [MULTIPLE RESPONSE]
1. Buy CFL or LED bulbs that are available at your local retailer
2. Go online so you can purchase incandescent bulbs
3. Purchase incandescent bulbs when you are in another state and/or Mexico
0. (Other, specify)
8. (Don't know)
9. (Refused)

Demographics

Now I'd like to ask you a few questions about your home and then we will be done.

D1. Which of the following best describes your home?
- 01. Detached single family
- 02. Townhouse
- 03. Manufactured home/Mobile home
- 04. Duplex/2-family home
- 05. Apartment/Condominium/Multi-family (3 or more units)
- 00. Other, specify
- 98. (Don't know)
- 99. (Refused)

[ASK IF D1 = 05]

D1b. How many apartments/housing units are in your building?
- 1. 3-5
- 2. 6-9
- 3. 10 or more
- 8. Not Sure
- 9. (Refused)

D1c. Do you own or rent your home?
- 1. Own
- 2. Rent
- 8. (Don't know)
- 9. (Refused)

D2. Including yourself, how many people currently live in your residence year-round?
- 00. [NUMERIC OPEN END]
- 98. (Don't know)
- 99. (Refused)

D3. How many people under the age of 18 live in your residence?
- 00. [NUMERIC OPEN END]
- 98. (Don't know)
- 99. (Refused)

D4. Approximately when was your house built?
- 1. Before 1947
- 2. 1947-1966
- 3. 1967-1986
- 4. 1987-1996
- 5. 1997-2012
- 6. 2013 or later
- 8. (Not sure)
- 9. (Refused)

D5. Approximately, how many square feet is your residence? [NUMERIC OPEN END]
9998. (Not sure)
9999. (Refused)

[ASK IF D5=9998]
D6. What would you estimate the square footage of your residence to be?
1. Less than 1,000 sqft
2. 1,000 to just under 2,000 sqft
3. 2,000 to just under 3,000 sqft
4. 3,000 to just under 4,000 sqft
5. 4,000 to just under 5,000 sqft
6. 5,000 sqft or more
8. (Not sure)
9. (Refused)

D7. In what year were you born? [NUMERIC OPEN END 1900-2015, 99998 = DON'T KNOW, 99999 = REFUSED] [RESPONSE NOT REQUIRED]

D8. What is your highest level of education? [RESPONSE NOT REQUIRED]
1. Less than a high school degree
2. High school degree
3. Technical/trade school program
4. Associates degree or some college
5. Bachelor's degree
6. Graduate / professional degree, e.g., J.D., MBA, MD, etc.
8. (Don't know)
9. (Refused)

D9. Which of the following best describes your current employment status? [RESPONSE NOT REQUIRED]
1. Employed full-time
2. Employed part-time
3. Retired
4. Not employed, but actively looking
5. Not employed, and not looking
8. (Don't know)
9. (Refused)

D10. Which category best describes your annual household income in 2016? [RESPONSE NOT REQUIRED]
1. Less than $25,000
2. $25,000 to just under $50,000
3. $50,000 to just under $75,000
4. $75,000 to just under $100,000
5. $100,000 to just under $150,000
6. $150,000 or more
8. (Don't know)
9. (Refused)

D11. What is your gender? [RESPONSE NOT REQUIRED]
1. Male
2. Female
8. (Don't know)
9. (Refused)

D12. In politics, as of today, do you consider yourself a…?
01. Democrat
02. Republican
03. Independent
00. Other, specify
96. None
98. (Rather not say)
99. (Refused)

FIN. This completes the survey. Thank you very much for your time and participation in this important study. May I have your name, email address, and the best number to reach you at so that we can ship your $5 Amazon gift card to you? (IF RESPONDENT SAYS THEY DO NOT HAVE AN EMAIL ADDRESS, ASK FOR THEIR MAILING ADDRESS)

00. Name, address, and phone number (Include area code): [OPEN RESPONSE]

Thank you so much for completing our survey. Have a great day!

Appendix C. Standardized Recommendations

To facilitate the response to recommendations process, this Appendix catalogs recommendations resulting from this research study.

Table C-1. Standard Design Attributes and Possible Values

Study ID	Study Type	Study Title	Study Manager
PGE0419.01	Market Research	Statewide Residential Lighting Customer Decision Study	Pacific Gas and Electric Company (PG&E)

Table C-2. Standard Design Attributes and Possible Values

#	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice/Recommendation	Recommendation Recipient	Affected Workpaper or DEER
1		The California lighting market is nearing transformation. The transformative effects are evidenced in the near universal awareness and penetration of energy efficient technologies, knowledge of their benefits, and a natural preference for the technologies.	Detailed research results are presented in Section 5 of the report	This study suggests diminishing effects from mass market incentive-based energy efficiency lighting programs, such as the current upstream residential lighting programs administered by the California IOUs. Many customers are using LEDs and are willing to pay more for them, which signals high free-ridership rates. The IOUs that have not yet done so should consider sun-setting their mass market programs and replacing them with 1) offerings that target customer segments that lag behind in their adoption of energy efficiency lighting products; and 2) offerings that focus on informational and educational interventions as opposed to incentives.	All IOUs	
2		While many Californians are knowledgeable about LEDs and prefer them over other bulb technologies,	Detailed research results are presented in Section 5 of the report	We recommend that the IOUs continue targeting underserved customer groups with incentives in the short-term until the effects	All IOUs	

#	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice/Recommendation	Recommendation Recipient	Affected Workpaper or DEER
		some customers lag behind in their knowledge and adoption of the energy efficient technologies.		of Title 20 standards are fully reflected in retailer stocking practices[37], because it will help accelerate the adoption of LEDs. To further improve targeting, the IOUs should consider using the results from the discrete choice modeling exercise and assign segments to each of its customers through a propensity scoring analysis and more precisely identify customers for targeting and outreach. Propensity scoring analysis involves regression modeling and allows to assign all IOU customers in one of the segments derived as part of this study. Reaching underserved customers through targeted retailer outreach can be an effective strategy as well, as these underserved customer segments are more likely to shop at Big Box and Dollar/Discount retailers such as Walmart, Dollar Tree, and Dollar General. It should be noted that a subset of customers from the underserved groups may qualify for the IOUs' Energy Savings Assistance (ESA) program. Findings ways to channel qualifying customers into the ESA program can be a beneficial targeting and outreach strategy that will help		

[37] Full transition to stocking of compliant products can take up to a few years, based on the market response to the first phase of EISA 2007 legislation, which was similar to Title 20 and prohibited the manufacturing of noncompliant products.

#	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice/Recommendation	Recommendation Recipient	Affected Workpaper or DEER
				the IOUs to further market transformation by capitalizing on the ESA program benefits.		
3		While customers demonstrate a good understanding of LEDs in general, their knowledge of LED quality markers is lacking. In fact, the indicators of LED quality vary considerably. Furthermore, the indicators of LED quality vary, with customers using multiple markers to define what a quality LED means to them. Finally, despite a general preference for LEDs, not all customers have an easy time finding the products that fit their needs.	Detailed research results are presented in Section 5 of the report	We recommend that the IOUs consider continuing educational outreach at point-of-sale to educate customers on the variability in LED technology quality as well as the range of product options in terms of brightness and light color.	All IOUs	
4		The study results indicate low resistance to Title 20 standards from the customer perspective. Our study has a limited insight into manufacturer and retailer compliance and the anticipated speed with which noncompliant products will disappear from the retailer shelves.	Detailed research results are presented in Section 5 of the report	The IOUs should consider conducting additional research into manufacturer, distributor, and retailer compliance, including compliance of online lighting retailers, and, based on the results of the research, encouraging compliance and ensuring code readiness for Tier 2 standards of Title 20. This will help ensure successful and more rapid market transition. We also recommend that the IOUs supplement this strategy with additional customer education about the rationale behind Tier 2 standards and	All IOUs	

#	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice/Recommendation	Recommendation Recipient	Affected Workpaper or DEER
				encourage compliance can further accelerate market transformation.		
5		CRI is one of the parameters used to set quality specifications for LED products by the CEC as well as part of Tier 2 Title 20 standards. Our research suggests that most customers are unaware of CRI. Our research, however, is limited in understanding the impact of the various CRI specifications on customer satisfaction with LED products and therefore whether educational efforts around CRI are an important and worthy endeavor.	Detailed research results are presented in Section 5 of the report	The IOUs should consider conducting additional research into the importance of light rendering accuracy to customer satisfaction with LEDs. Such research could be valuable when deciding on the scope and degree of educational efforts needed around CRI as well as the value of Tier 2 CRI specifications from the customer perspective.		

Appendix D. Discrete Choice Experiment Design

This appendix summarizes the design of the discrete choice survey experiment.

Standard Design

Design Summary

- 60 watt equivalent wattage assumption
- 5 options + "none" per choice set
- 12 total choice sets (including two fixed for quality assurance)

Table D-3. Standard Design Attributes and Possible Values

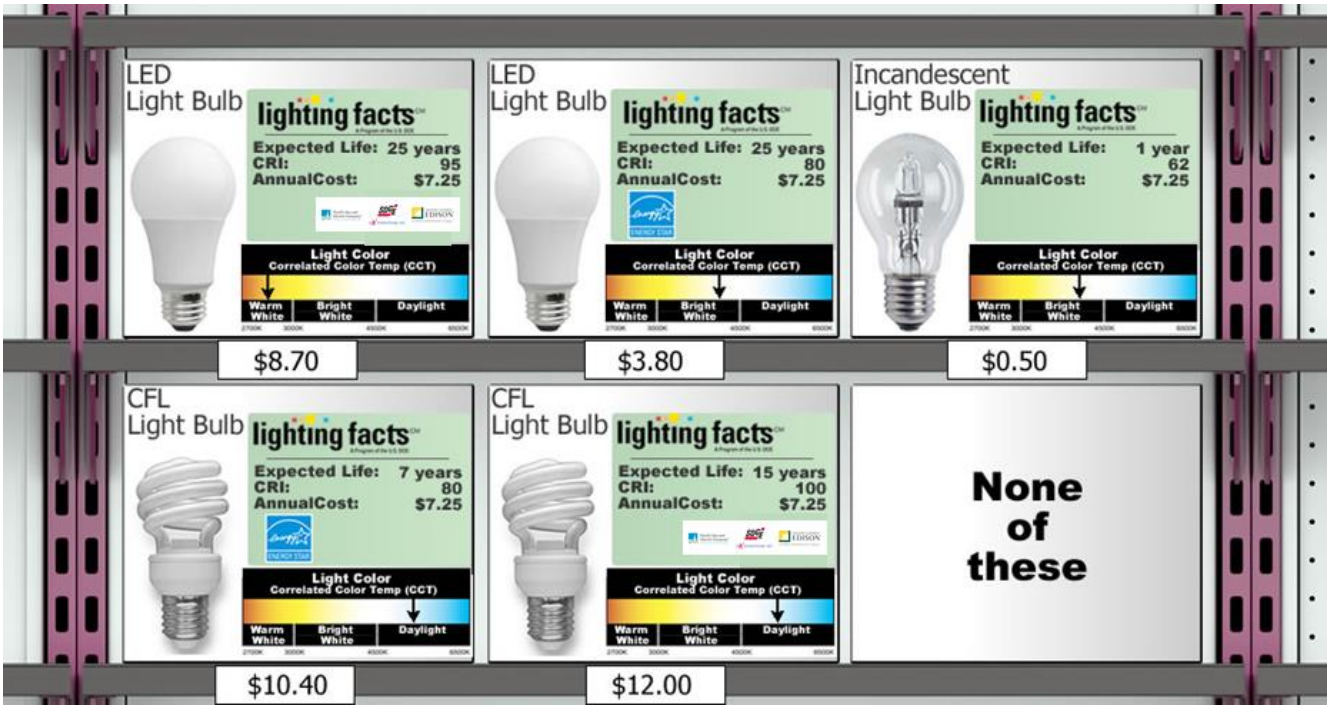
Attribute	Levels	
Technology	Incandescent, CFL, LED	None
Price	$0.50, $2.10, $3.80, $5.40, $7.10, $8.70, $10.40, $12.00	
Annual Energy Cost per Bulb	$1.00, $1.75, $5.00, $7.25	
Color Temperature	Warm White, Bright White, Daylight	
Color Rendering Index	62, 80, 95, 100	
Life Expectancy	1 year, 7 years, 15 years, 25 years	
ENERGY STAR Rating	ENERGY STAR rated, Not ENERGY STAR rated	
Smart Choice Endorsement	CA IOU Logos, No Logos	

Survey Introduction

With our next set of questions, we would like to send you on a shopping trip for lighting. Assume that a light in your house that is used frequently has burned out, and you need to replace the bulb. The light is not dimmable or three-way and takes a standard screw-in bulb of 60 watts or equivalent. You don't have a replacement bulb at home, so you need to purchase one. Finally, imagine that you need to install the bulb in a table lamp that looks something like this:

For the next series of questions, we will show you some different light bulbs and ask which one you would purchase, if any. We will show you 5 light bulbs at a time that have different characteristics.

Click NEXT to see an example of the screen.



After making your purchase selection, we will show you another screen with 5 different light bulbs and again ask you to select which one you would purchase. We will ask you to make a total of 12 separate purchase decisions.

When making your selections, please use the following instructions:

- Do not "comparison shop" between screens. Try to "start over" on each screen and make selections only based on the bulb options presented on that screen.
- Do not feel you have to buy anything if you don't want to or don't see the right product. Simply select the "None" option.
- Assume that you are spending your own money. While you are not asked to purchase light bulbs, it is extremely important that you select products as if you were actually buying them.
- Some of the bulb options presented to you may not be realistic or seem different than what you see at your local retailer. Please imagine that all products you see are available for purchase.
- Assume that all of the bulb choices that you will see come as single-bulb packs.

Finally, remember, **THERE ARE NO RIGHT OR WRONG ANSWERS**. We are looking to best understand how **YOU** purchase light bulbs.

Reflector Design

Design Summary

- 65 watt equivalent wattage assumption
- 5 options + "none" per choice set
- 12 total choice sets (including two fixed for quality assurance)

Table D-4. Standard Design Attributes and Possible Values

Attribute	Levels	
Technology	Incandescent, CFL, LED	None
Price	$1.00, $3.70, $6.40, $9.10, $11.90, $14.60, $17.30, $20.00	
Annual Energy Cost per Bulb	$1.00, $1.75, $5.00, $7.25	
Color Temperature	Warm White, Bright White, Daylight	
Color Rendering Index	62, 80, 95, 100	
Life Expectancy	1 year, 7 years, 15 years, 25 years	
ENERGY STAR Rating	ENERGY STAR rated, Not ENERGY STAR rated	
Smart Choice Endorsement	CA IOU Logos, No Logos	

Survey Introduction

With our next set of questions, we would like to send you on a shopping trip for lighting. Assume that a frequently used light in your house has burned out, and you need to replace the bulb. The light is not dimmable or three-way and takes a standard screw-in reflector bulb of 65 watts or equivalent. You don't have a replacement bulb at home, so you need to purchase one. Finally, imagine that you need to install the bulb in a fixture that looks something like this:

For the next series of questions, we will show you some different light bulbs and ask which one you would purchase, if any. We will show you 5 light bulbs at a time that have different characteristics.

Click NEXT to see an example of the screen.

After making your purchase selection, we will show you another screen with 5 different light bulbs and again ask you to select which one you would purchase. We will ask you to make a total of 12 separate purchase decisions.

When making your selections, please use the following instructions:

- Do not "comparison shop" between screens. Try to "start over" on each screen and make selections only based on the bulb options presented on that screen.
- Do not feel you have to buy anything if you don't want to or don't see the right product. Simply select the "None" option.
- Assume that you are spending your own money. While you are not asked to purchase light bulbs, it is extremely important that you select products as if you were actually buying them.
- Some of the bulb options presented to you may not be realistic or seem different than what you see at your local retailer. Please imagine that all products you see are available for purchase.
- Assume that all of the bulb choices that you will see come as single-bulb packs.

Finally, remember, **THERE ARE NO RIGHT OR WRONG ANSWERS**. We are looking to best understand how **YOU** purchase light bulbs.

Appendix E. Visual Standard and Reflector Lamp Aid

Figure 8-1 below provides images of the most common standard lamps.

Figure 8-1. Most Common Standard Lamps

Figure 8-1 below provides images of the most common standard lamps.

Figure 8-2. Most Common Reflector Lamps

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