Lighting Supplier Insights – Wave 2 (Study RLPNC 16-2)

TASK 8A: FINAL REPORT 2017 SUPPLIER INTERVIEWS

February 24, 2018

SUBMITTED TO:
Massachusetts Electric Program Administrators and Energy Efficiency Advisory Council Consultants

SUBMITTED BY:
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ES Executive Summary

This report summarizes findings from 2017 in-depth interviews with lighting manufacturers and high-level lighting buyers[1] (referred to as "lighting suppliers" in this report). This research supports the continued assessment and monitoring of the Massachusetts lighting market and the Massachusetts ENERGY STAR® Lighting Program ("the program").

This research forms part of a larger study, Lighting Supplier Interviews and Store Manager Surveys (RLPNC 16-2). DNV GL completed this research under subcontract with NMR Group Inc. ("the evaluation team") on behalf of Massachusetts Electric Program Administrators (PAs) and the Energy Efficiency Advisory Council (EEAC) Consultants. The results will also inform the RLPNC 17-6 Market Adoption Model and 17-11 LED NTG Consensus Efforts.

Under this study, DNV GL conducted two waves of lighting supplier in-depth interviews: Wave 1 (September-October 2016) and Wave 2 (October 2017). This report summarizes Wave 2 interview findings and represents the final study deliverable. A separate report[2] summarized results from three other study tasks: (1) in-depth interviews with lighting suppliers – Wave 1, (2) CATI surveys with Massachusetts store managers, and (3) Discussions at the ENERGY STAR Partners Meeting.

During Wave 2 in-depth interviews, lighting suppliers offered market share predictions and shared their perspectives on current lighting market trends. Key findings appear in the Executive Summary and complete interview findings appear, by research topic, in the main body of this report.

The study does not offer any specific recommendations, as the research is meant to inform other studies that will result in actionable recommendations.

METHODOLOGY

DNV GL conducted in-depth interviews with 19 manufacturers and four high-level retail lighting buyers (referred to as "lighting suppliers" in the report) in October 2017. These companies manufactured, supplied, or purchased lighting products that received upstream incentives from the program from June 2016 to June 2017. Collectively, these lighting suppliers accounted for 99% of total program sales during this period.

Prior to the interviews, DNV GL staff sent each supplier their predictions (or those from a colleague, when the original supplier was not available) made during Fall 2016 interviews. DNV GL staff conducted all interviews and developed the analysis for this report.

[1] A *high-level retail lighting buyer* refers to a purchaser of lighting products for a large chain retailer which participated in the Massachusetts program.
[2] NMR Group Inc., DNV GL, and Tetra Tech. *Lighting Supplier, Store Manager, and ENERGY STAR Partner Insights (Study RLPNC 16-2)*, June 30, 2017.

During telephone interviews, DNV GL staff asked lighting suppliers questions on the following topics: market share predictions, federal lighting standards, market transformation, LED price predictions, non-ENERGY STAR LED quality issues, incandescent lamp trends, California's early implementation of EISA Phase 2 standards, and international sales trends.

All in-depth interview data presented are unweighted (e.g., all responses are counted equally with no sales weights applied), at the request of the PAs and EEAC Consultants.[3] The sample size reported per question varies as not all suppliers provided answers to every question (either they refused to answer the question or they were skipped out of the question based on earlier responses).

FINDINGS

This subsection presents key findings from the in-depth interviews with lighting suppliers. Complete results appear in Section 1 through Section 6 of this report.

Market Share and Price Predictions

- **Lighting suppliers predicted that LED market shares will still dominate without program incentives through 2022, but these LED shares will be much lower. The suppliers predicted that halogen market shares for standard, reflector, and specialty lamps will primarily make up the difference between program and no program scenarios.**

Lighting suppliers predicted market shares for LED, CFL, halogen, and incandescent lamps for 2018, 2020, and 2022 under two different scenarios: *program continues* and *program ends*.[4] For Massachusetts, suppliers predicted market share for standard (A-line/standard spiral), reflector, and specialty lamps. Figure 1 shows the results. Their forecasts showed strong similarities for these three lamp types:

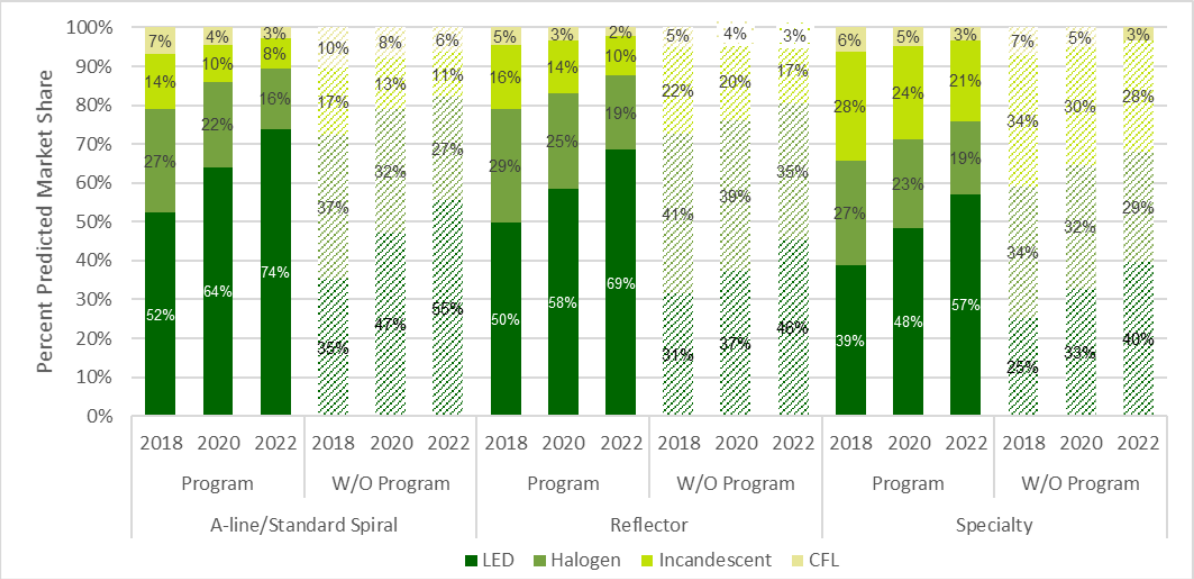
- LED market shares will rise from 2018 to 2022 – from 52% to 74% in the *program continues* scenario and from 35% to 55% in the *program ends* scenario.
- The halogen, CFL, and incandescent market shares will decline over the same period under both the *program continues* and the *program ends* scenarios.
- Without program incentives, LED market shares will still increase but not to the same level, and halogen lamp market share will primarily benefit.
- Among LED lamps, A-line will hold the highest market share by 2022 under *program continues* and *program ends* scenarios (74% vs. 55%, respectively), followed by reflectors (69% vs. 46%), and specialty (57% vs. 40%).

[3] This was primarily due to concerns that program sales might not be a representative proxy for market sales (the projections were done at the market level). However, there were other concerns (discussed in Appendix A.4).

[4] The *program continues* scenario assumed that the program continued to offer LED incentives through 2021 but dropped CFL incentives in 2017. The *program ends* scenario assumed the program ceased to offer all incentives after 2017. Lighting suppliers provided separate predictions for A-line and reflector lamps for each scenario.

The interviewers asked the suppliers to choose the most likely trend for LED prices over the next two years (the supplier interviews took place in Fall 2017). The most common prediction (43% of respondents) was that LED prices would continue to increase but at a reduced rate compared to the previous two years. About one quarter of the respondents (22%) either said that LED prices would stabilize in general or that standard LED prices would stabilize while prices for reflector and specialty LEDs would continue to decline. Only 9% of the respondents said that LED prices would increase and only 4% said that LED prices would decline at the same rate as they had during the previous two years.

Figure 1: Average Predicted Massachusetts Retail Market Shares: Standard, Reflector and Specialty Lamps, 2018-2022 Under *Program Continues* and *Program Ends* Scenarios* (n=20)



* Solid-colored bars indicate *program continues* scenario; dashed line bars indicate *program ends* scenario.

Federal Standards

- **Suppliers were fairly evenly divided as to the future of federal standards (GSL and backstop). When asked whether the U.S. Department of Energy's expanded definition of general service lamps[5] will be adopted, suppliers' median likelihood score was 6.0 and their mean score was 5.3 (using a 10-point scale, where 10 indicated "very likely" to be adopted and 0 indicated "very unlikely"). When the interviewers asked the suppliers to predict the likelihood of the backstop being enforced, their median likelihood score was 5.0 and their mean likelihood score was 4.5. As we discuss in the body of this report, some of the suppliers were uncertain about their predictions.**

[5] In two rules published January 18, 2017, the U.S. Department of Energy (DOE) expanded the definition of general service lamps to include most lamps (regardless of shape, brightness, and function) and kept the *backstop* in place that would bar the manufacturing and import of non-compliant bulbs starting in January 2020.

Figure 2 and Figure 3 show the full spread of their responses. Lighting suppliers primarily mentioned politics (i.e., changing political climate or presidential administration) when asked what political, economic, or other factors they thought will impact federal lighting standards in the next three years.

Figure 2: Supplier Likelihood Predictions for GSL Definition Adoption (n=20)

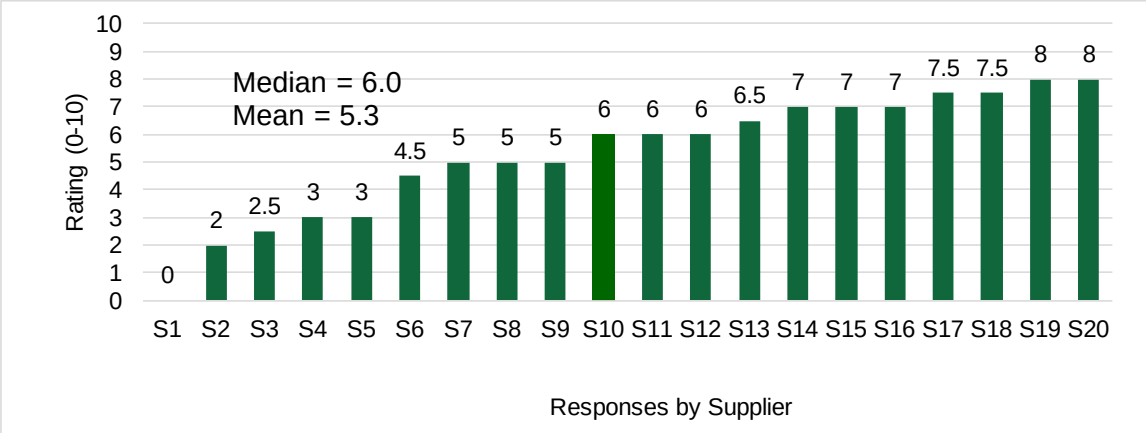
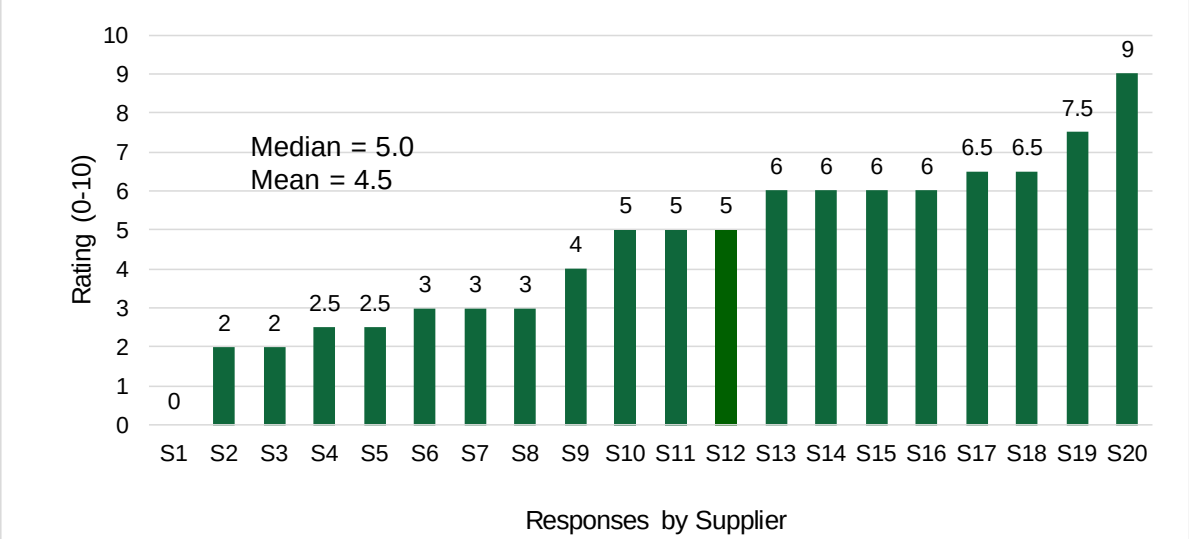


Figure 3: Supplier Likelihood Predictions for Backstop Enforcement (n=20)



Market Transformation

- **Suppliers primarily defined residential lighting market transformation in terms of customers' buying habits or retail shelf saturation of LEDs; however, they thought that an LED market share of greater than 50% signaled that program incentives were no longer necessary.[6]**

Interviewers asked lighting suppliers to define market transformation in the context of residential lighting, and for the indicators they believe would indicate when the program should stop offering incentives. Key findings include the following:

- The indicators of market transformation that the suppliers mentioned most frequently included customer education/purchasing habits (where most customers are aware of the benefits of and choose LEDs over less efficient alternatives), customer lamp acceptance (where customers replace all incandescent lamps or only select LED lamps), and shelf saturation (where store shelves contain mostly LED lamps).
- About one-half suggested using LED market share indicators – either 50%-75% (six suppliers) or 75%-99% (three suppliers) – as evidence that program incentives were no longer needed. Fewer reported socket penetration or shelf saturation as indicators.

Non-ENERGY STAR LEDs

- **Suppliers continued to report concerns about non-ENERGY STAR LED lamp quality, although a large majority said product quality had either improved or stayed the same over the past few years.**

Interviewers asked lighting suppliers about any quality concerns for non-ENERGY STAR LED lamps. Key findings include the following:

- Nearly three-fourths (71%; 15 suppliers) reported being aware of the poor quality of non-ENERGY STAR LEDs; they most frequently mentioned early lamp failure.
- Nearly one-half (45%; nine suppliers) said LED lamp quality had improved in the past few years, while a slightly smaller proportion (40%; eight suppliers) reported that quality had stayed the same. A minority (15%; three suppliers) said LED quality had decreased over the past few years.

Incandescent Lamp Trends

- **Suppliers estimated that nearly one-half of low lumen (<310) lamp shapes on Massachusetts store shelves use incandescent technology and that manufacturers will primarily transition these lamps to LEDs in the next five years.**

[6] As context, the November 2017 Massachusetts RLPNC 16-5 and 17-10 Sales Data Analysis and Modeling report estimated the 2016 Massachusetts market share for LEDs to be 26%.

Interviewers asked suppliers about incandescent lamp trends, including low lumen (<310) lamps. Key findings include the following:

- They reported that about one-half (54% average estimate across all suppliers) of standard incandescent lamps remaining on Massachusetts shelves are lamps that are covered by the EISA phase-out or so-called *loophole lamps*, such as rough service or vibration resistant ones.
- They also estimated that nearly one-half (47%) of all low lumen (<310) lamp shapes on Massachusetts store shelves in Fall 2017 use incandescent technology.
- The large majority (86%, 19 suppliers) said manufacturers will transition their remaining incandescent low lumen lamps (all shapes) to either LED (15 suppliers) or both LED and halogen (four suppliers). Suppliers said the transition would occur in the next five years, primarily in the 2020-2022 timeframe, while a sizeable minority (six suppliers) stated that they did not know when the transition would occur.

California / International Markets

- **Suppliers were split about whether California's early implementation of EISA Phase 2 standards would impact Massachusetts markets, but said unequivocally that LEDs will still dominate the U.S. market, even when taking national/international market trends into consideration.**

Interviewers asked for manufacturers'[7] thoughts on California's early implementation of EISA Phase 2 standards[8] and on international sales trends that may impact U.S. sales.

Key findings include the following:

- Manufacturers were evenly split over whether California's early EISA Phase 2 implementation schedule will impact the manufacturing and sales of lamps for markets outside California, or for Massachusetts specifically.
- Only three of the ten manufacturers agreed that manufacturing for international markets affects manufacturing decisions for the U.S. market.
- Ten manufacturers selling LEDs abroad indicated that LEDs will dominate the U.S. market, even when taking national and international market trends into consideration.

REPORT CONTENTS

The remainder of this report contains the following sections:

- Market Share Predictions (Section 1)
- Federal Standards (Section 2)

[7] Interviewers only posed these questions to manufacturers because high-level retail buyers are less likely to be aware of California-specific and international trends.
[8] See Section 6 for details.

- Market Transformation (Section 3)
- Non-ENERGY STAR LEDs (Section 4)
- Incandescent Lamp Trends (Section 5)
- International Trends (Section 6)

1 Section 1 Market Share and Price Predictions

This section presents lighting suppliers' average Massachusetts market share predictions for three lamp types: (1) A-line/standard spiral (standard lamps), (2) Reflector, and (3) Specialty. Lighting suppliers predicted shares for LED, CFL, halogen, incandescent, and other lamp technologies in 2018, 2020, and 2022 under two different hypothetical scenarios. In the first scenario, the Massachusetts ENERGY STAR lighting program continues to offer incentives for ENERGY STAR LED lamps through 2022.[9] In the second scenario, the Massachusetts ENERGY STAR lighting program discontinues incentives for all LED lamps after 2017. Lighting suppliers also shared reasons for their predictions. Twenty of the 23 lighting suppliers interviewed offered Massachusetts retail market share predictions for all bulb shapes and lamp technologies, regardless of whether their company manufactured or sold them.

1.1 Standard Lamp Market Share

Figure 4 presents suppliers' market share predictions for standard lamps under the *program continues* scenario, represented by solid lines, and under the *program ends* scenario, represented by a dashed line (LED, CFL, and halogen only).

Lighting suppliers predicted the following:

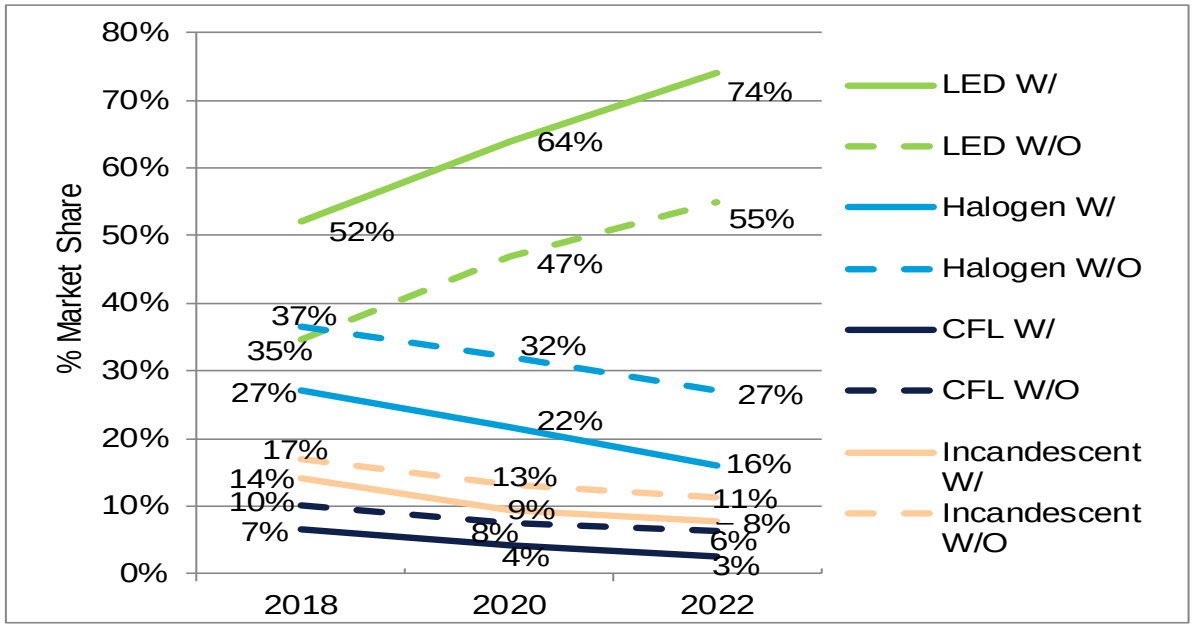
- Standard LED market share will rise from 2018 to 2022, while halogen, CFL, and incandescent market shares will decline over the same period under both *program continues* and *program ends* scenarios.
- Standard LED market shares will rise much higher in the *program continues* scenario (to 73% by 2022; solid green line) compared to *program ends* (to 54% by 2022; dashed green line). Standard halogen lamps (+11% absolute) would claim most of the lost LED market share under the *program ends* scenario, followed by CFLs (+4% absolute) and incandescents (+4% absolute).
- The decline in standard incandescent market shares slows by 2022, from 5% absolute decline (14% to 9%) from 2018 to 2020 to 1% absolute decline (9% to 8%) from 2020 to 2022.
- Standard LEDs showed the largest spread between program and non-program scenarios (19% absolute), followed by halogens (11% absolute) and standard spiral CFLs (3% absolute).

Table 5 contains average Massachusetts market share predictions for standard lamps from the 2016 and 2017 interviews conducted with lighting suppliers. Included are predictions for CFL, halogen, LED, incandescent, and other lamps under the *program continues* and *program ends* scenarios.

[9] The Massachusetts ENERGY STAR lighting program discontinued incentives for CFLs in 2016.

Table 5, in Appendix A, contains lighting suppliers' standard lamp predictions from the 2016 and 2017 interviews. Although the 2016 and 2017 interviewees were predicting for different years, there are two notable changes in their predictions. First, the 2017 interviewees were more likely than their 2016 predecessors to predict a larger share for LED lamps, regardless of the lamp type or scenario. Second, the 2017 interviewees were more likely than the 2016 interviewees to predict smaller shares of CFLs for the various scenarios.

Figure 4: Suppliers' 2017 Massachusetts Market Share Predictions (with and without Program Support*): Standard Lamps, 2018-2022 (n=20))



*W/ = with program support; W/O = without program support

Lighting suppliers also shared reasons for their predicted standard lamps market shares. Figure 5 and Figure 6 show the top three reasons given for LED, CFL, and halogen lamp predictions under the *program continues* and *program ends* scenarios, respectively.

Appendix A contains further details on reasons lighting suppliers gave for their market share predictions, by lamp technology.

Figure 5: Suppliers' Top Three Reasons for Market Share Predictions: Standard LED, CFL, and Halogen Lamps, *Program Continues* Scenario (n=20)

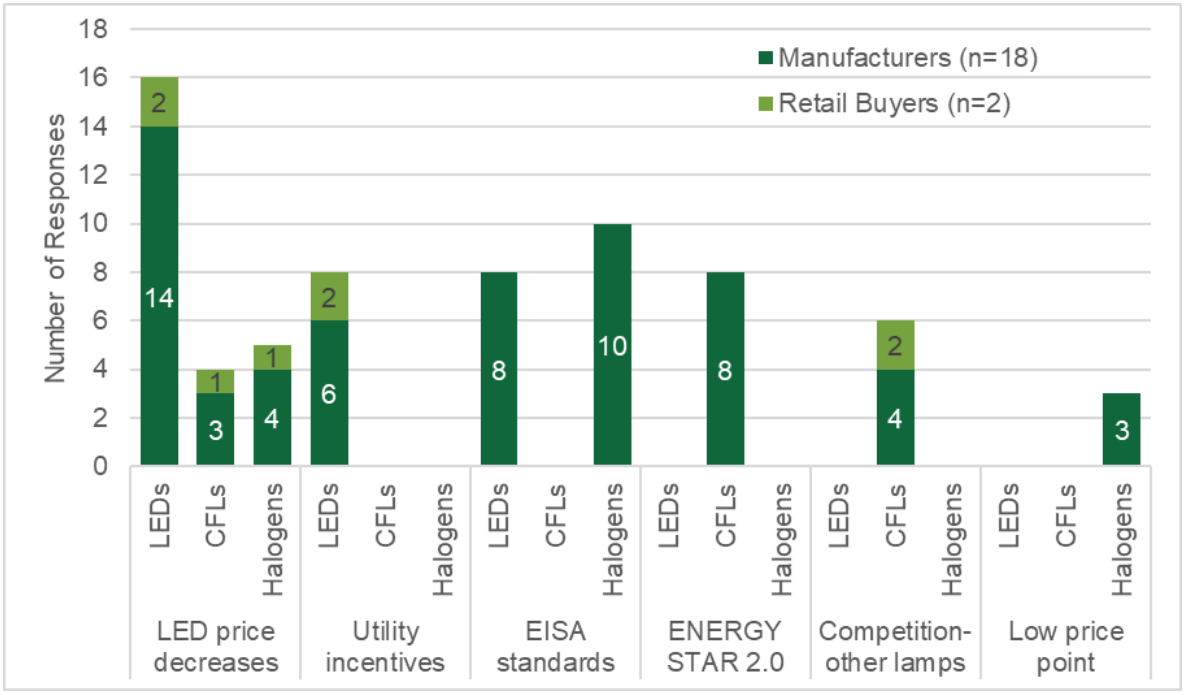
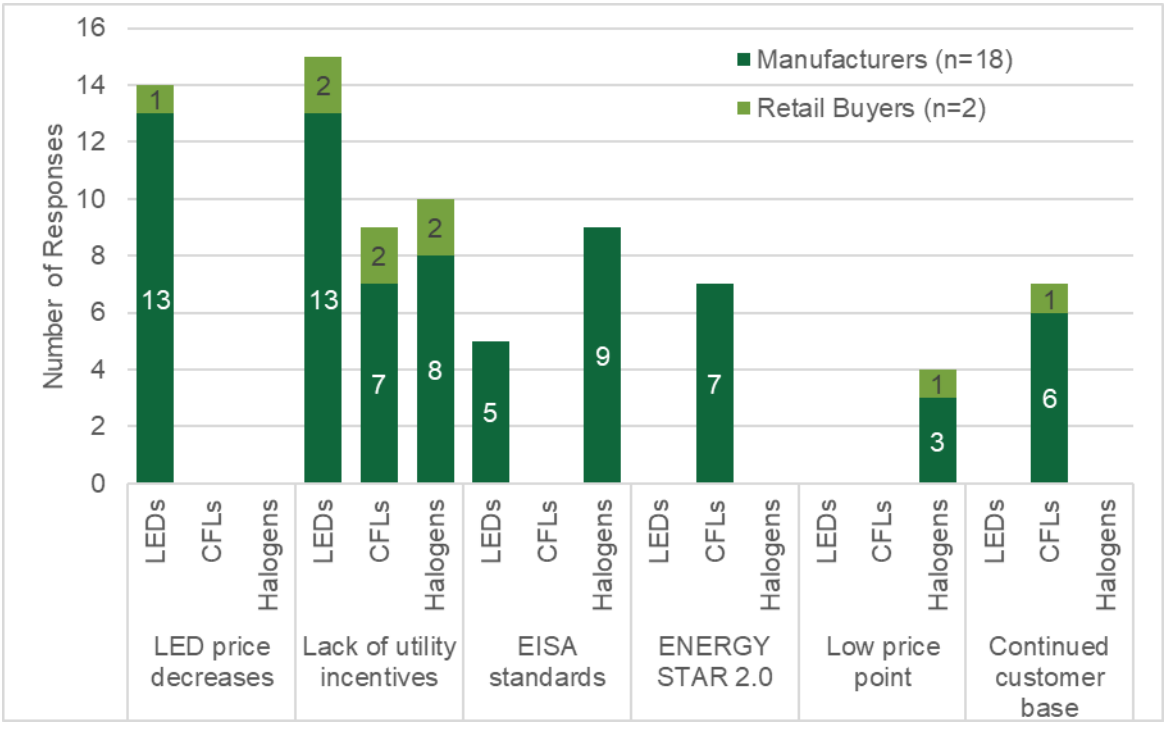


Figure 6: Suppliers' Top Three Reasons for Market Share Predictions: Standard LED, CFL, and Halogen Lamps, *Program Ends* Scenario (n=20)



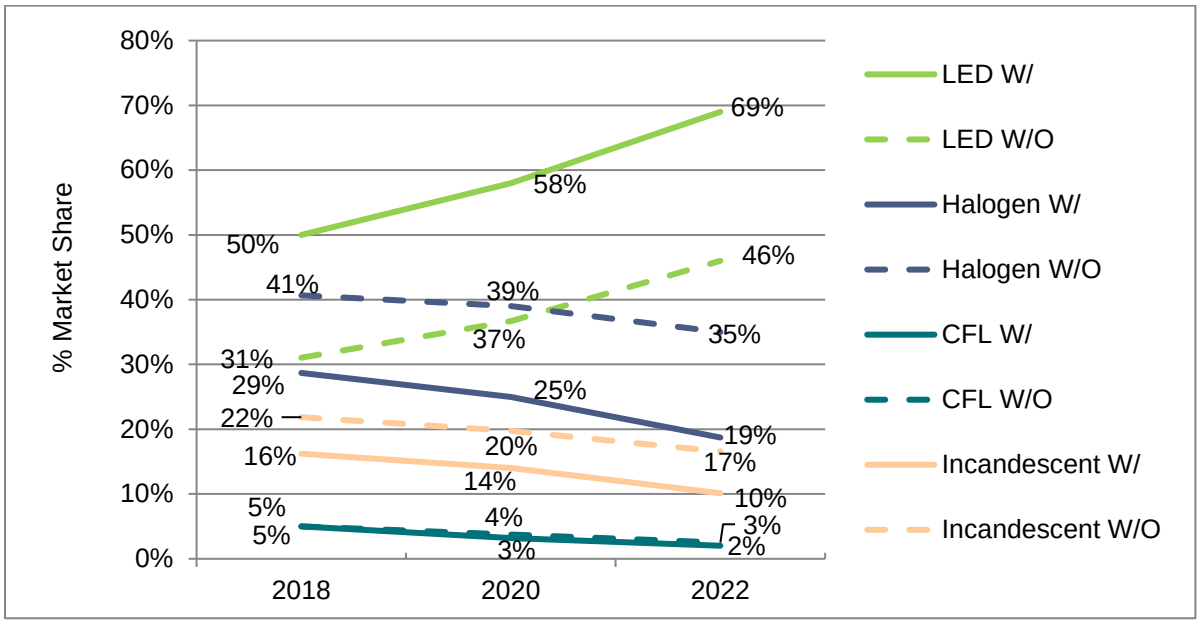
1.2 REFLECTOR LAMP MARKET SHARE

Figure 7 shows suppliers' market share predictions for reflector lamps under the *program continues* scenario, represented by solid lines, and under the *program ends* scenario, represented by a dashed line (for LED, CFL, and halogen only). Reflector prediction trends are like those for standard lamp market shares.

Lighting suppliers predicted the following:

- LED reflector market share will increase from 2018 to 2022, while halogen, CFL, and incandescent reflector market shares will decline over the same period, under both *program continues* and *program ends* scenarios.
- LED reflector market shares will rise more steeply in the *program continues* scenario (to 67% by 2022; solid green line) compared to *program ends* scenario (to 45% by 2022; dashed green line). Like standard LEDs, halogen reflectors (+16% absolute) will claim most of the lost LED market share, followed by incandescent reflectors (+6% absolute). CFL reflector market share would not change.
- CFL reflector market shares show little difference between *program continues* and *program ends* scenarios, with low single digit market shares over the next five years.
- A-line LEDs will have the largest spread between program and non-program scenarios (22% absolute), followed by halogens (15% absolute), incandescents (7% absolute) and standard spiral CFLs (1% absolute).

Figure 7: Suppliers' 2017 Massachusetts Market Share Predictions[10] (with and without Program Support*): Reflector Lamps, for the 2018-2022 Period (n=20)



*W/ = with program support; W/O = without program support

As reference, Table 6 in Appendix A contains lighting suppliers' reflector market share predictions from the 2016 and 2017 interviews.

Table 1 and Table 2 show the reasons given for reflector LED, CFL, halogen, and incandescent lamp predictions under the *program continues* and *program ends* scenarios, respectively. Reasons in common with standard lamp predictions are marked with an asterisk.

To minimize respondent fatigue, interviewers asked respondents to discuss any reflector prediction reasons that differed from those for standard lamps. While some reasons overlapped, three-quarters (15 suppliers) cited additional different reasons.

Appendix A contains further details on reasons lighting suppliers gave for their reflector market share predictions, by lamp technology.

[10] Predictions made during Fall 2017 in-depth interviews with lighting manufacturers and high-level retail buyers.

Table 1: Suppliers' Reasons for Market Share Predictions: Reflector LED, CFL, Halogen, and Incandescent Lamps, *Program Continues* Scenario (n=20)

Reasons	LED Reflector	CFL Reflector	Halogen Reflector	Incandescent Reflector
LED Price Decrease*	✓	✓	✓	✓
Utility Incentives*	✓			
EISA Standards*			✓	✓
ENERGY STAR 2.0*		✓		
Market Momentum	✓			
Lower Price Point			✓	✓
Technology Limitations		✓		
Substitute Competition			✓	
Shelf Saturation				✓

*Reasons in common with standard lamps.

Table 2: Suppliers' Reasons for Market Share Predictions: Reflector LED, CFL, Halogen, and Incandescent Lamps, *Program Ends* Scenario (n=20)

Reasons	LED Reflector	CFL Reflector	Halogen Reflector	Incandescent Reflector
LED Price Decrease*	✓			✓
(Lack of) Utility Incentives*	✓	✓	✓	
EISA Standards*			✓	✓
ENERGY STAR 2.0*		✓		
Market Momentum	✓			
Lower Price Point			✓	✓
Technology Limitations		✓		
Substitute Competition		✓		
Shelf Saturation				✓
Longer Rated Life	✓			
Possible EISA Exemption		✓		

*Reasons in common with standard lamps.

1.3 Specialty Lamp Market Share

Figure 8 shows suppliers' market share predictions for specialty lamps under the *program continues* scenario, represented by solid lines, and LED specialty predictions only under the *program ends* scenario, represented by a dashed line.

Lighting suppliers predicted the following:

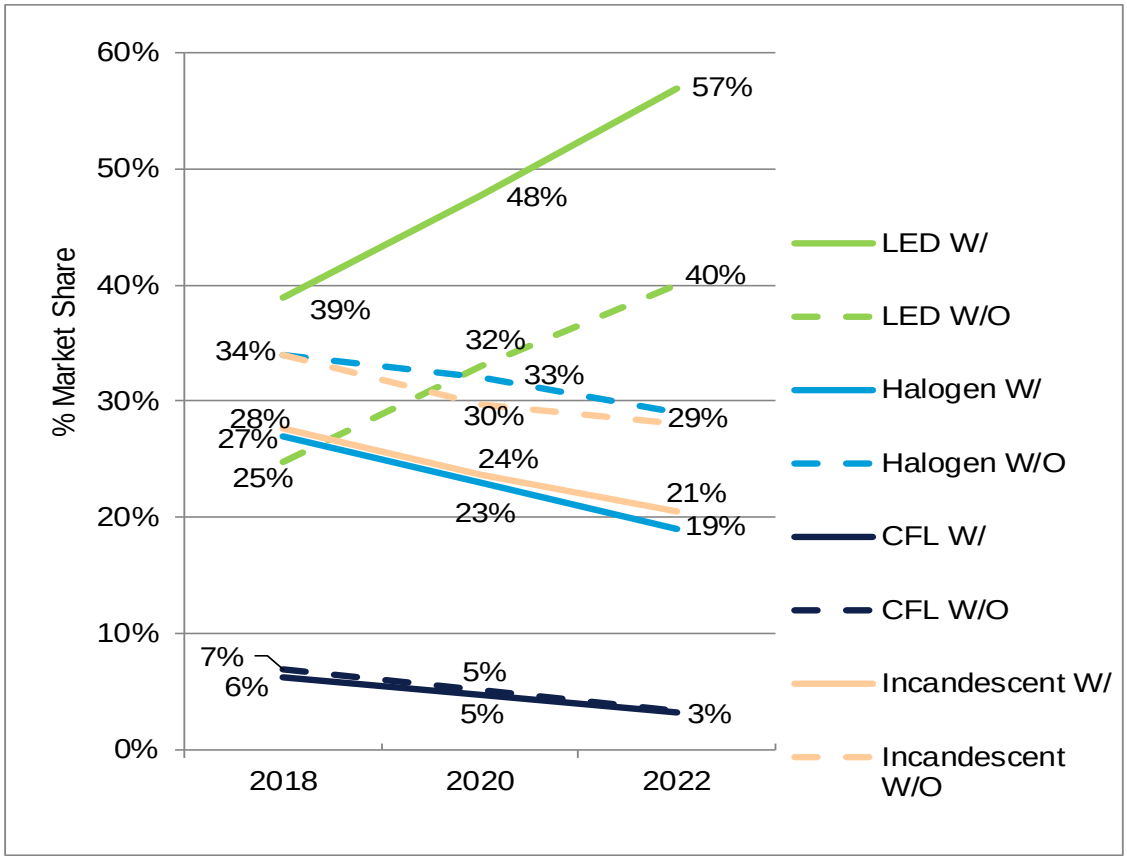
- Even with program support, LED specialty lamps will only command about one-half (56%) of the total specialty market share by 2022.
- LED specialty lamp market share will increase from 2018 to 2022, while halogen, CFL, and incandescent specialty market shares will decline over the same period,

under both *program continues* and *program ends* scenarios (like LED standard and reflector lamp market shares).

- LED specialty market shares will rise more steeply in the *program continues* scenario (to 56% by 2022; solid green line) compared to *program ends* scenario (to 39% by 2022; dashed green line). Halogen specialty (+10% absolute) will claim most of the lost LED market share, followed by incandescent specialty (+7% absolute). CFL specialty market share would not change.
- By 2022, LED specialty lamps will have the largest spread between program and non-program scenarios (17% absolute), followed by halogens (10% absolute), incandescents (7% absolute), and CFLs (1% absolute).

Table 7, in Appendix A, contains lighting suppliers' specialty market share predictions from the 2017 interviews.

Figure 8: Suppliers' 2017 Massachusetts Market Share Predictions[11] (with and without Program Support*): Specialty Lamps, for the 2018-2022 Period (n=20)



*W/ = with program support; W/O = without program support

Table 3 and Table 4 show the reasons given for specialty LED, CFL, halogen, and incandescent lamp predictions under the *program continues* and *program ends* scenarios,

[11] Predictions made during Fall 2017 in-depth interviews with lighting manufacturers and high-level retail buyers.

respectively. Reasons in common with standard lamp predictions are marked with an asterisk.

Like reflectors, to minimize respondent fatigue, interviewers asked respondents if their reasons for specialty market share predictions differed from those for standard lamps. While some reasons overlapped, the majority of lighting suppliers[12] cited additional different reasons for their specialty predictions.

Appendix A contains further details on reasons lighting suppliers gave for their specialty market share predictions, by lamp technology.

Table 3: Suppliers' Reasons for Market Share Predictions: Specialty LED, CFL, Halogen, and Incandescent Lamps, *Program Continues* Scenario (n=20)

Reasons	LED Specialty	CFL Specialty	Halogen Specialty	Incandescent Specialty
LED Price Decrease*	✓	✓	✓	✓
Utility Incentives*	✓			
EISA Standards*		✓	✓	✓
Superior Product	✓			
Lower Price Point			✓	✓
Technology Limitations		✓		
Substitute Competition		✓		
Shelf Saturation				✓
Continued Customer Base			✓	
Development of Filament Style	✓			

*Reasons in common with standard lamps.

[12] Sixteen suppliers cited differences in the program continues scenario, and 17 cited differences in the program ends scenario.

Table 4: Suppliers' Reasons for Market Share Predictions: Specialty LED, CFL, Halogen, and Incandescent Lamps, *Program Ends* Scenario (n=20)

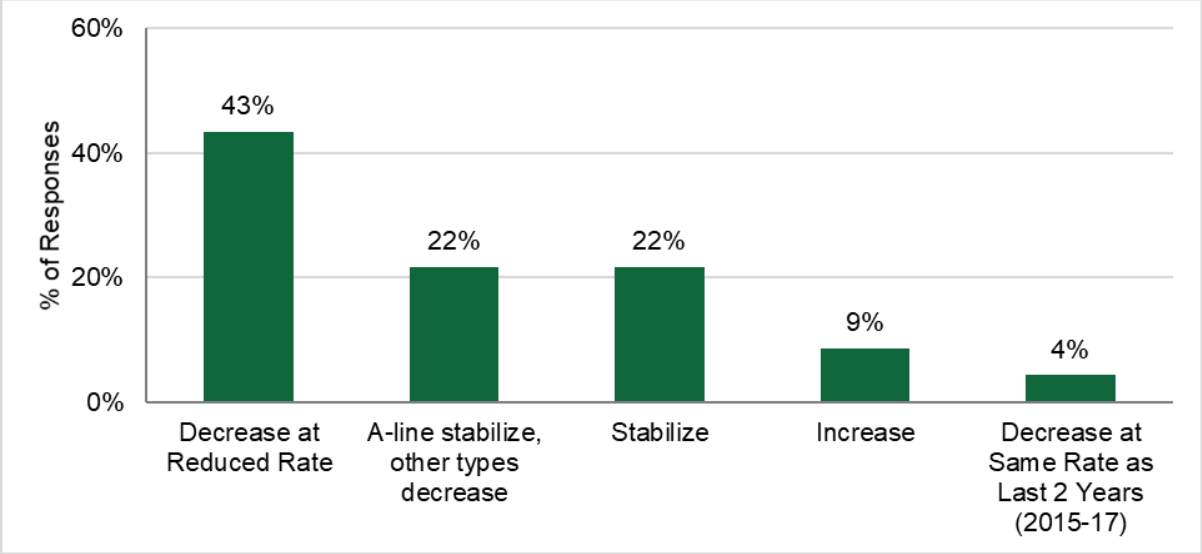
Reasons	LED Specialty	CFL Specialty	Halogen Specialty	Incandescent Specialty
LED Price Decrease*	✓			✓
(Lack of) Utility Incentives*	✓	✓	✓	
EISA Standards*			✓	✓
ENERGY STAR 2.0*		✓		
Superior Product	✓			
Lower Price Point			✓	✓
Substitute Competition		✓		
Shelf Saturation				✓
Continued Customer Base			✓	
Development of Filament Style	✓			
Poor Product Performance		✓		

*Reasons in common with standard lamps.

1.4 LED Price Predictions

Almost one-half (43%) of lighting suppliers predicted that LED retail prices will decrease in the next two years (Fall 2017 to Fall 2019), but at a reduced rate compared to the previous two years. According to suppliers, this was the most likely scenario (Figure 9). About one-fifth (22%) made a distinction between standard and other types of LEDs (such as reflectors, other specialty bulbs, and high-wattage LEDs), making the case that standard LED prices will stabilize, while prices for other LEDs will likely continue to decrease. Another 22% said that LED retail prices will stabilize over this period.

Figure 9: LED Price Predictions, Fall 2017 to Fall 2019 (n=23)



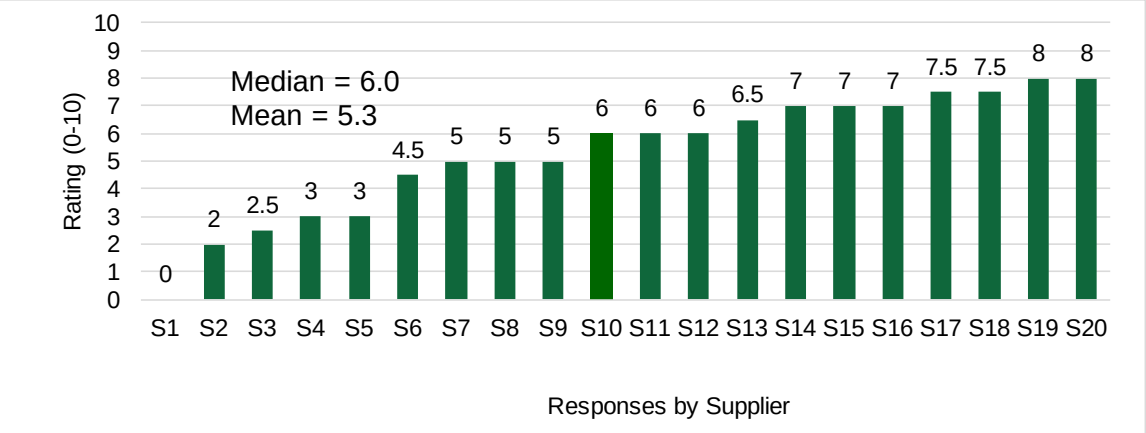
2 Section 2 Federal Lighting Standards

This section presents lighting suppliers' opinions about federal standards, EISA Phase 2 enforcement, and the likely effects on the lighting market over the next three years.

2.1 EISA Phase 2: Likelihood of DOE Rule Adoption and Backstop Enforcement

Suppliers were fairly evenly divided as to whether the U.S. Department of Energy's expanded definition of general service lamps[13] will be adopted. Using a 10-point scale, where 10 indicated "very likely" to be adopted and 0 indicated "very unlikely" to be adopted, their median likelihood score was 6.0 and their mean score was 5.3. Figure 10 shows the full range of their responses.

Figure 10: Suppliers Rated Likelihood of Expanded General Service Lamp Definition Adoption in January 2020 (n=20)



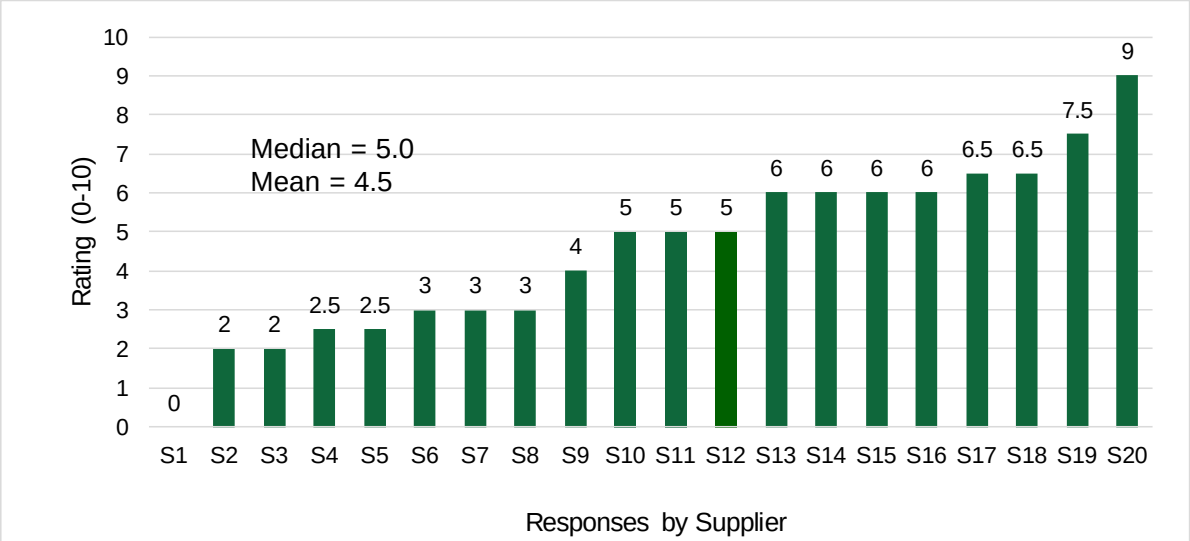
When asked to explain their likelihood rating, suppliers most commonly mentioned general uncertainty about whether or when the expanded definition may be adopted (45%; eight suppliers, likelihood rating 6.4 average and 6.75 median[14]). One supplier (rating: 8) commented, "The case has been made to add that provision. Of course, that's a few years down the road and who knows what's going to take place in the next three years." Another (rating: 8) stated, "They might extend the deadline which is why I don't think it's a 10."

[13] In two rules published January 18, 2017, the U.S. Department of Energy (DOE) expanded the definition of general service lamps to include most lamps (regardless of shape, brightness, and function) and kept the *backstop* in place that would bar the manufacturing and import of non-compliant bulbs starting in January 2020.
[14] One gave a score of 2.5 and the others gave scores of 6 or higher.

Other suppliers said the expanded definition will not be adopted by January 2020 due to legal challenges (three manufacturers; average likelihood score 1.7), but may occur instead in the 2022-2024 timeframe. Some suppliers thought that the definition adoption by January 2020 would depend on the California Title 20 standards (three manufacturers; average likelihood score 6.8). One supplier admitted having insufficient information to explain their rating (rating: 5).

When the interviewers asked the suppliers to predict the likelihood of the backstop being enforced, their median likelihood score was 5.0 and their mean likelihood score was 4.5. Figure 11 shows the full range of their responses.

Figure 11: Suppliers Rated Likelihood of Enforcement Backstop on Non-Compliant Lamps Starting January 2020 (n=20)



When asked to explain their likelihood rating, suppliers most frequently expressed pessimism about the likelihood of backstop enforcement starting in 2020, either because they thought it was impractical (25%; average rating 3.2) or because of inadequate enforcement funding (15%; average rating 3.0). One lighting supplier echoed many of those giving likelihood scores under 4: “There was no enforcement of EISA Phase 1. Because the timeline was established for products currently on the shelf, it’s not cost-effective to enforce it when customers are trying to buy efficient products anyway.” (likelihood score 2).

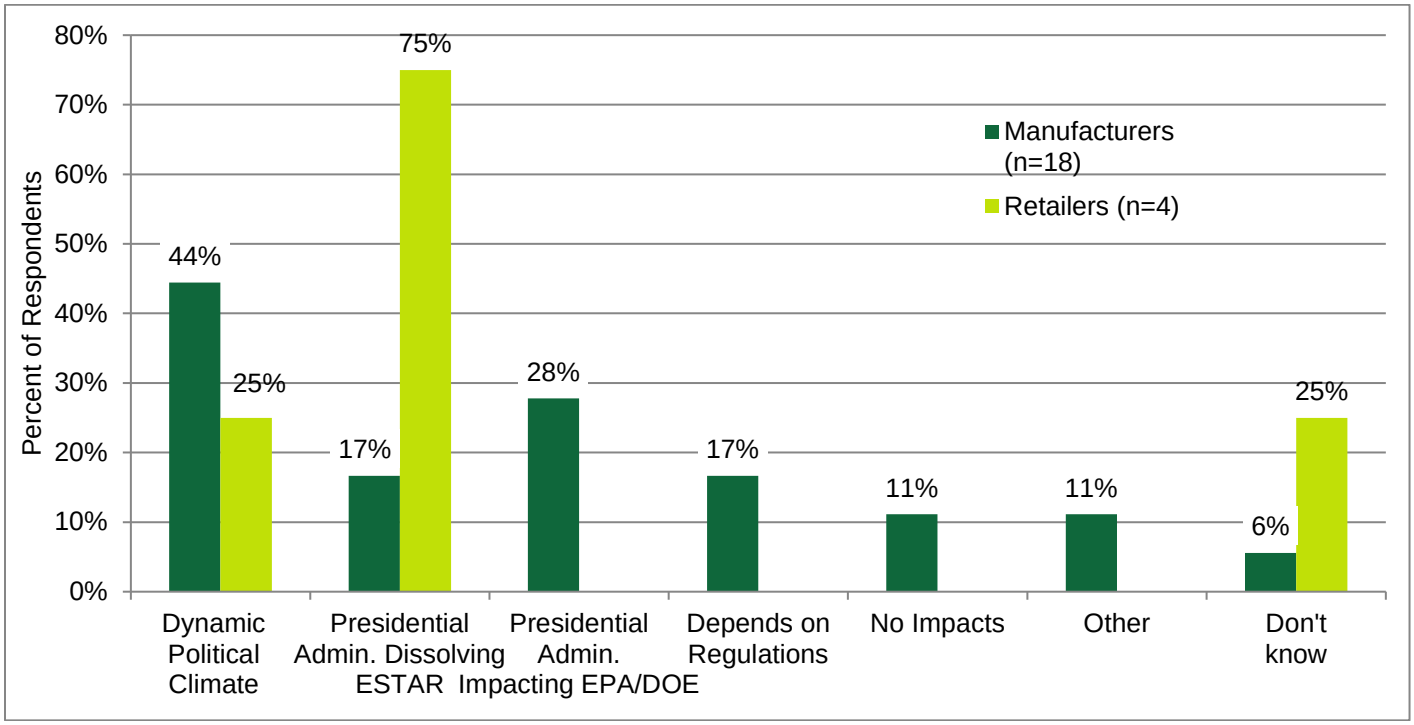
A sizeable minority said they lacked in-depth knowledge to back up their likelihood rating (20%; average rating 4.4). Another 15% (three suppliers; average score 6.8) expressed a great deal of uncertainty about enforcement likelihood, even while giving higher-than-average likelihood scores.

2.2 Factors Affecting Federal Lighting Standards

Lighting suppliers primarily mentioned politics (i.e., changing climate or presidential administration) when asked what political, economic, or other factors they thought will impact federal lighting standards from 2017 to 2020. As shown in Figure 12, nearly one-half

of the manufacturers mentioned the changing/dynamic political climate (31%; nine responses) or the current presidential administration, including the potential dissolution of the ENERGY STAR program (21%; six responses) or the presidential administration's general impact on federal agencies such as DOE and EPA (17%; five responses).

Figure 12: Suppliers' Reported Factors Impacting Federal Lighting Standards, 2017-2020 (n=22)



Note: Multiple responses were accepted. 'Other' responses included limited state budgets and the potential for a trade war.

No consensus emerged as to how the 2016 election, in which Republicans took control of both the Executive and Legislative branches of government, would impact federal lighting standards. Among the ten suppliers responding to the question, four said it will depend on the regulations that come out of the federal agencies and three said they were uncertain. An additional four said that the 2016 election results would not impact federal lighting standards at all.

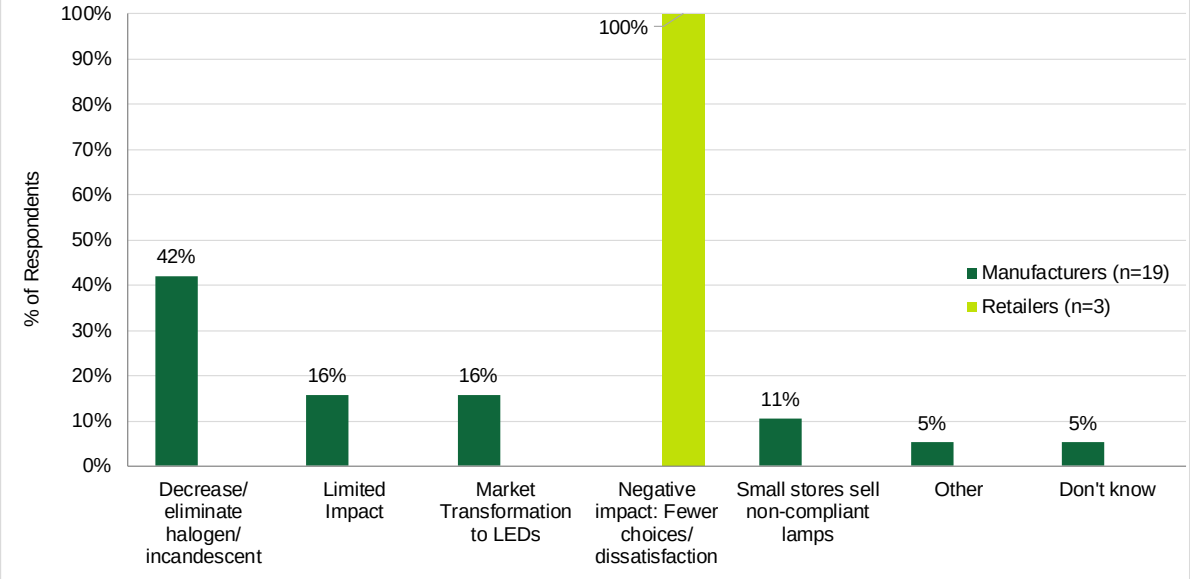
2.3 Impacts of Federal Standards on Lighting Markets

Figure 13 shows that most suppliers predicted that EISA legislation Phase 2, as currently written,[15] will have at least some impact on lighting markets. Key findings included the following:

[15] As of October 2017, when DNV GL conducted the interviews.

- Nearly one-half (42%) of the manufacturers said that halogen and/or incandescent lamps will decrease in market share or be eliminated from the marketplace. Two suppliers specifically mentioned GSL lamps and their verbatim responses are as follows:
  - o "[EISA Phase 2] will likely start to push halogens and remaining general service lamps off the shelves for most large manufacturers."
  - o "If it does go through, it should wipe a lot of the remaining general service lamps off the shelves and replace them with LEDs and some halogens."
- All three retail buyers who responded said that the EISA Phase 2 would have negative impacts on lighting markets, such as fewer lamp choices and resulting customer dissatisfaction.
- Fourteen percent (3 suppliers) said that EISA Phase 2 would have a limited impact because EISA Phase 2 legislation will be delayed/stopped (two suppliers), manufacturers will find ways around EISA Phase 2 standards and/or develop compliant halogen lamps (one supplier), and that CA's Title 20 will be the main driver of lighting markets (one supplier).
- Nine percent (two suppliers) said that large stores will comply with EISA Phase 2, but that smaller stores will continue to sell non-compliant lamps.

Figure 13: Suppliers Reported Impacts of EISA Legislation Phase 2 as Currently Written on Lighting Markets (n=22)



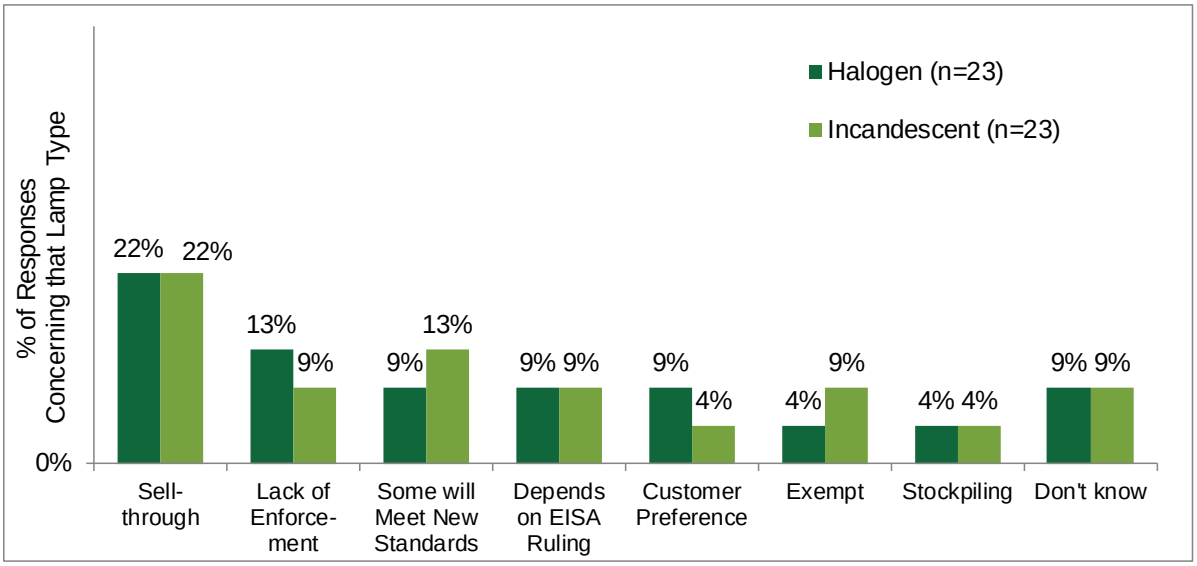
Note: Multiple responses were accepted. Other responses, cited by one supplier each, included higher-quality LEDs in the market, market consolidation, market players adhere to EISA 2 standards, and new energy-efficient technologies emerge.

The large majority (86%) of suppliers said that LEDs would still be the dominant technology in the market under a hypothetical scenario in which the United States either overturns or fails to enforce EISA Phase 2, allowing the continued sales and import of halogen and many incandescent bulbs. Three reasons were overwhelmingly cited for this belief: market momentum towards LEDs (13 suppliers), LEDs are a superior product compared to

alternatives (nine suppliers), and the recent rise of value-line or non-ENERGY STAR LEDs (seven suppliers).

Most suppliers thought that both halogen (86%) and incandescent lamps (65%) would remain on store shelves after EISA Phase 2 implementation in January 2020. Figure 14 shows that they cited a diverse set of reasons for these beliefs, primarily sell-through of remaining stock, lack of DOE enforcement, and that some of these lamps will meet the new standards.

Figure 14: Reasons Why Suppliers Predicted that Halogens and Incandescents Will Still Be on the Shelves in 2020 (n=23)



Suppliers mostly agreed that retailers will not stockpile phased-out bulbs (halogens and incandescents) in preparation for EISA Phase 2. A sizeable minority (33%) expected stores to stockpile halogen lamps. Among those 33%, suppliers agreed that halogens would most likely be stockpiled at Big Box stores, although just one supplier said they had seen evidence of halogen stockpiling so far. In addition, 28% of all suppliers expected stores to stockpile incandescent lamps. As with halogens, these suppliers agreed that incandescents would most likely be stockpiled at Big Box stores. However, unlike with halogens, four of the five suppliers who had expected stockpiling of incandescents said they had already seen evidence of stockpiling. One supplier commented, “There are rumors that Menards had a football field-sized warehouse where they stockpiled incandescents. I still see them when I visit Menards on weekends many years later.”

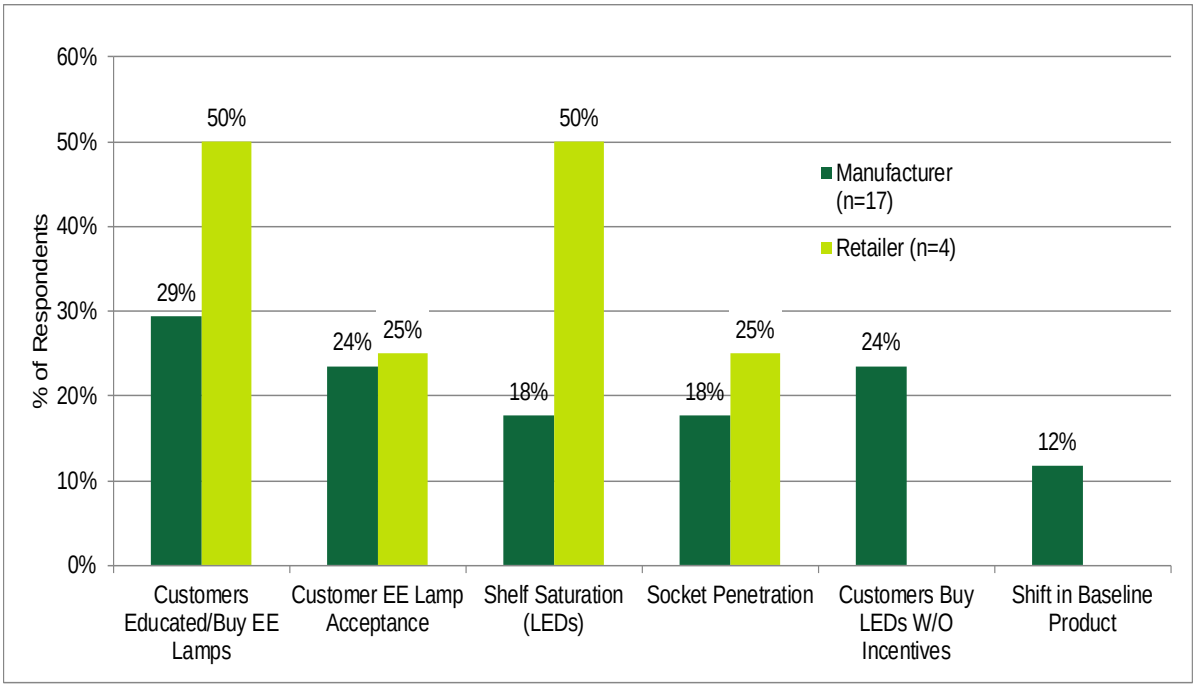
3 Section 3 Market Transformation

This section presents suppliers' opinions about market transformation of the Massachusetts retail lighting market. The program's long-term goal is to discontinue incentives when the lighting market has been transformed. Interviewers sought lighting suppliers' opinions about market transformation and related indicators of when the program should discontinue incentives.

3.1 Market Transformation: Definitions and Indicators

When asked to define market transformation in the context of residential lighting, the most frequently mentioned definition was *when most customers are aware of the benefits of and choose energy-efficient lamps (primarily LEDs) over less efficient alternatives*. However, Figure 15 shows that they had a wide variety of other definitions.

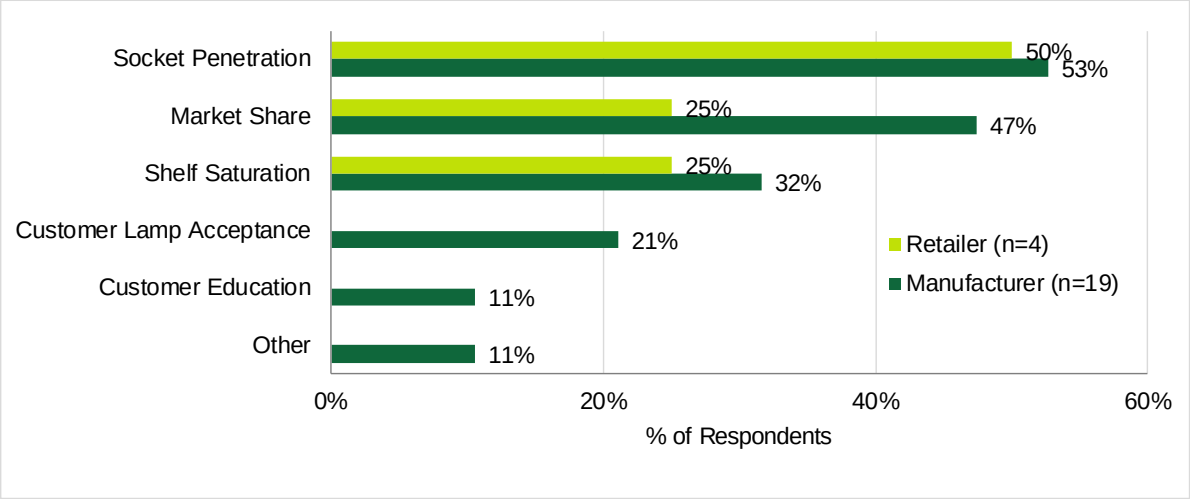
Figure 15: Suppliers' Definitions of Market Transformation (n=23)



Note: Multiple responses were accepted.

The interviewers asked the suppliers what signs or indicators the program should consider in determining whether the residential lighting market can stand on its own and continue to gain market share. About one-half of the suppliers thought the Massachusetts ENERGY STAR Lighting program should consider socket penetration. Other popular metrics included market share and shelf saturation. Indicators such as customer education and customer lamp acceptance, which most suppliers defined when speaking generally about market transformation, were less frequently mentioned. This is likely due to the relative difficulty in measuring these indicators compared to socket penetration, market share, or shelf saturation.

Figure 16: Suppliers' Reported Indicators Signaling Residential Lighting Market Transformation (n=23)



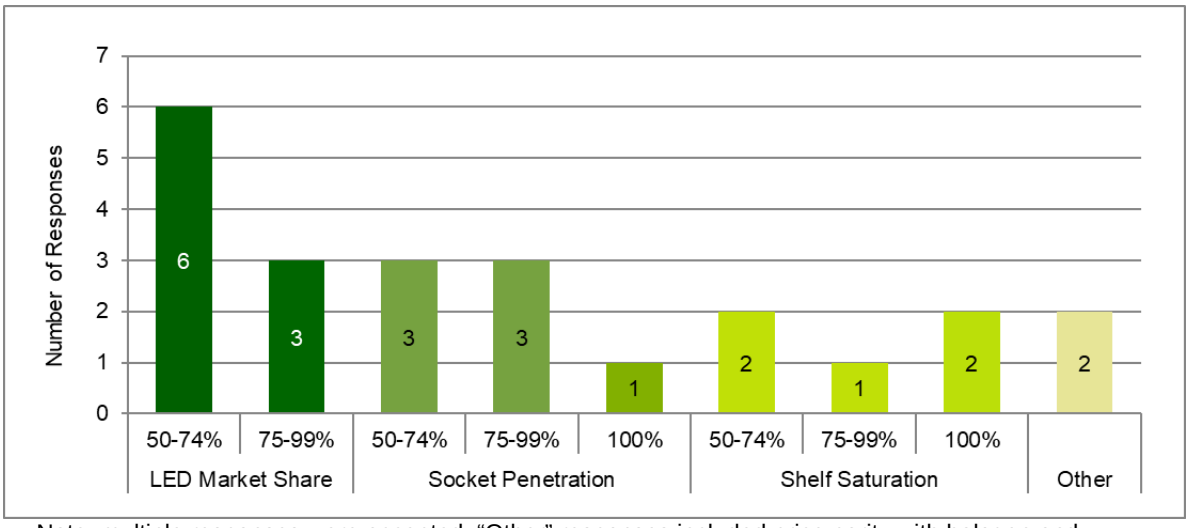
Note: Multiple responses were accepted. "Other" responses included manufacturers no longer producing older lamp technology and likelihood of customer purchasing LEDs with and without a rebate.

Nearly all suppliers said that they have seen evidence indicating progress towards market transformation (figure not shown).[16] Increased LED market share in recent years was the most frequently-cited reason (45%; ten suppliers), followed by shelf saturation (32%; seven suppliers) and LEDs dominating certain markets, such as California and Massachusetts (14%; three suppliers). Only one supplier mentioned seeing evidence of socket penetration, suggesting that the others are not aware of the evaluation studies from Massachusetts and elsewhere that have documented changes in socket saturation over time.

Suppliers provided various lighting market benchmarks to indicate when the Massachusetts ENERGY STAR lighting program should be discontinued. They most frequently (although only six of 23 suppliers) stated that LED market shares between 50% and 75% was evidence that the program was no longer needed, with another three suppliers citing LED market shares between 75% and 99%.

[16] Some suppliers said they had seen progress on other market transformation indicators in addition to those they cited for the program to consider. This explains why some percentages in Figure 16 are larger than their counterparts in Figure 17.

Figure 17: Suppliers' Suggested Indicators to Determine When Massachusetts Should Discontinue the Lighting Program (n=20)



Note: multiple responses were accepted. "Other" responses included price parity with halogen and incandescent lamps, and 40% LED market share.

When asked how long the program should continue education and advertising about lighting efficiency (figure not shown), they provided the following insights:

- Thirty-nine percent (nine of 23 suppliers) indicated a continued need but gave no specific timeframe. They cited evidence such as "nine of ten customers still bring in picture or actual bulb to match," customers still referring to light bulbs with old wattages instead of lumens, older populations needing education because they tend to distrust energy efficient lighting after experiences with CFLs, and many customers who remain unaware of LEDs.
- Seventeen percent (four suppliers) reported no need to continue education and advertising. Their comments touched on lack of effectiveness ("Educating customers doesn't change their behavior, it's all about cost"), difficulty ("shelf transformation will get harder to convince customers to switch over and younger folks are already adopting specialty LEDS") and lack of customer interest ("People don't want to be educated about lighting").
- Thirteen percent (three suppliers) mentioned specific time periods: two to three years (one manufacturer), five years (one retail buyer), and eight+ years (one manufacturer).

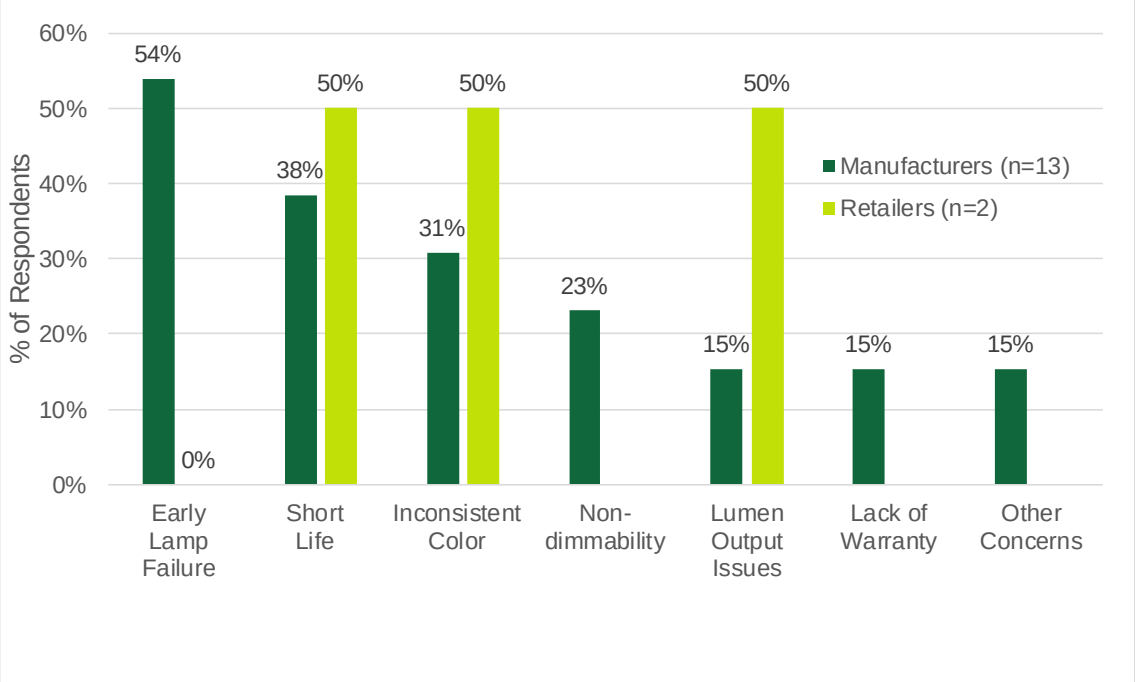
4 Section 4 Non-ENERGY STAR LEDs

Interviewers asked lighting suppliers about non-ENERGY STAR LEDs. Specifically, they asked whether they were aware of and could name any evidence of quality concerns; and whether lamp quality had improved, stayed the same, or decreased over the past few years.

Interview results indicate the following about non-ENERGY STAR LEDs:

- Nearly three-fourths (71%; 15 suppliers) reported being aware of quality issues for non-ENERGY STAR LEDs. The most frequently-mentioned concerns included early lamp failure, short life expectancy, and inconsistent color quality. Figure 18 shows the full range of concerns.
- Nearly one-half (45%; nine suppliers) said LED lamp quality had improved in the past few years, while a slightly smaller proportion (40%; eight suppliers) reported that LED quality had stayed the same. A minority (15%, three suppliers) said that LED quality had decreased over the past few years.
- Lighting suppliers primarily attributed increased quality to decreased cost of parts and materials (38%; three suppliers) or advances in LED technologies (25%; two suppliers).

Figure 18: Suppliers' Reported Reasons for Concerns About Non-ENERGY STAR LED Lamp Quality (n=15)



Note: multiple responses were accepted.

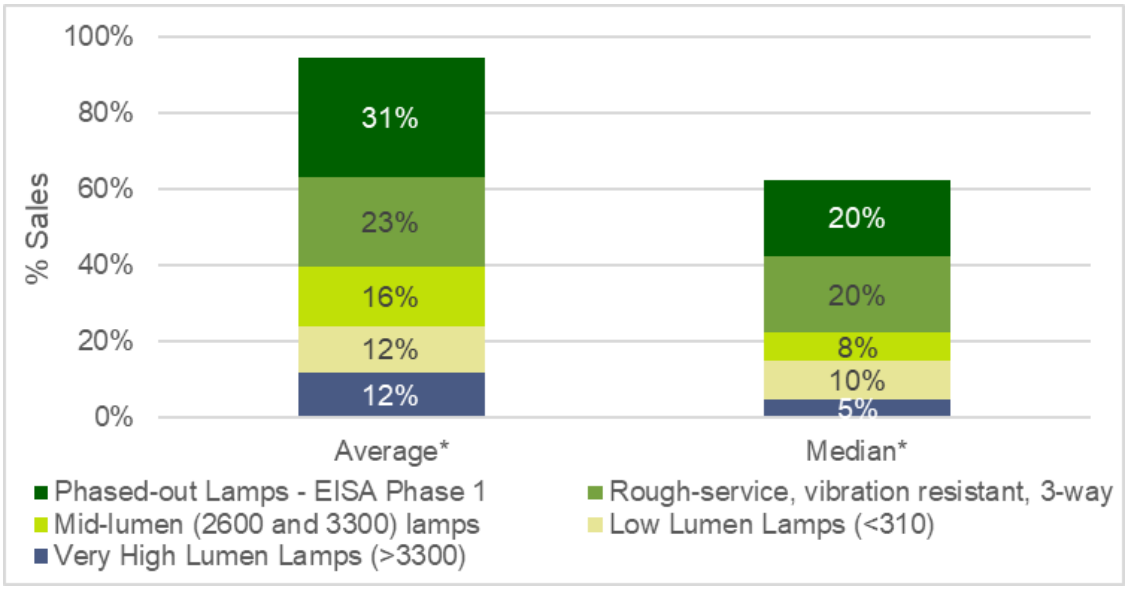
5 Section 5 Incandescent Lamp Trends

This section presents lighting suppliers' assessment of incandescent lamp types sold in 2017, including information on whether manufacturers will transition incandescent low lumen lamps (<310) to other lamp technologies.

Interviewers asked suppliers to estimate the percentage of Massachusetts standard incandescent lamp types sold in 2017. Figure 19 displays the average and median percentages reported. The evaluation team urges caution when interpreting these results because the interview guide did not force the responses to sum to 100%. Some suppliers' responses totaled roughly 100% (four suppliers had totals of 120%), but others gave responses that fell below (four suppliers) or above 100% (three suppliers). Estimated percentages likely did not sum to 100% because suppliers refused responses to some questions; the categories did not cover all lamp types in their estimation; or, conversely, the lamp types overlapped.

On average, suppliers gave the highest percentage of sales to the incandescent lamps that were phased out in EISA Phase 1 (31%). For median estimates, two lamp types tied for the highest percentage of sales (20% each): phased-out lamps and *loophole lamps* (rough service, vibration resistant, 3-way). Low lumen lamps (<310) accounted for 12% (average) or 10% (median) of Massachusetts standard incandescent sales in 2017, according to suppliers.[17]

Figure 19: Suppliers' Estimated Percent 2017 Massachusetts Sales for Standard Incandescent Lamp Types (n=12)

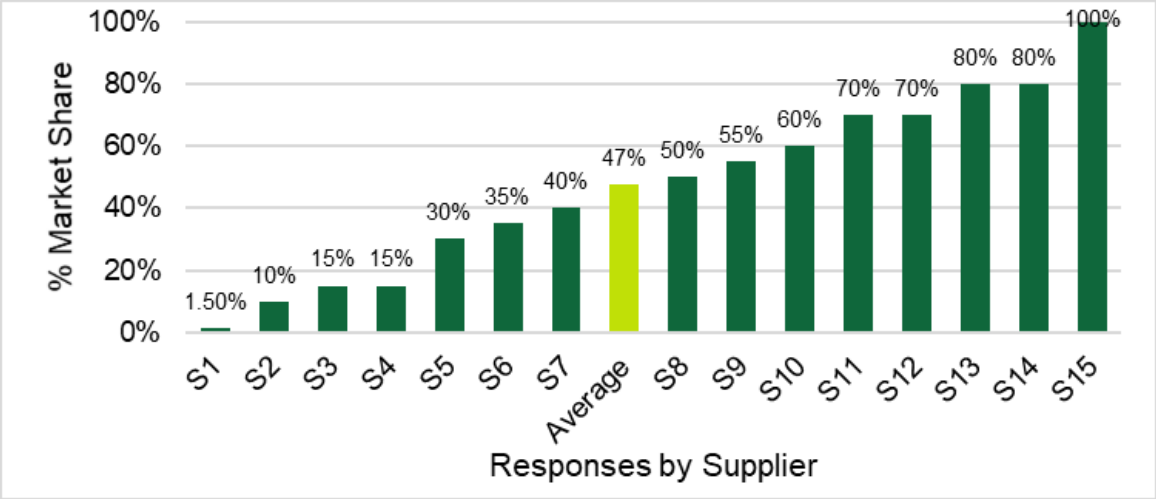


*Five types of standard incandescent market shares sum to 95% (average) and 63% (median).

[17] The mid-lumen (2600-3300) lamp category was part of the high lumen lamp category in EISA Phase 1 and remains exempt; however, they are included in the definition of General Service Lamps for EISA Phase 2.

Suppliers estimated that an average of 47% of all low lumen (<310) lamps (all shapes) for sale on Massachusetts retail store shelves as of October 2017 use incandescent technology, as shown in Figure 20. The figure also shows individual replies from the 20 suppliers who responded to the question. The November 2017 Massachusetts RLPNC 16-5 and 17-10 Sales Data Analysis and Modeling report estimated the 2016 Massachusetts market share to be 43% for halogens and 15% for traditional incandescents. In 2017, Massachusetts also conducted a shelf inventory study, but the data from that study is not yet available.

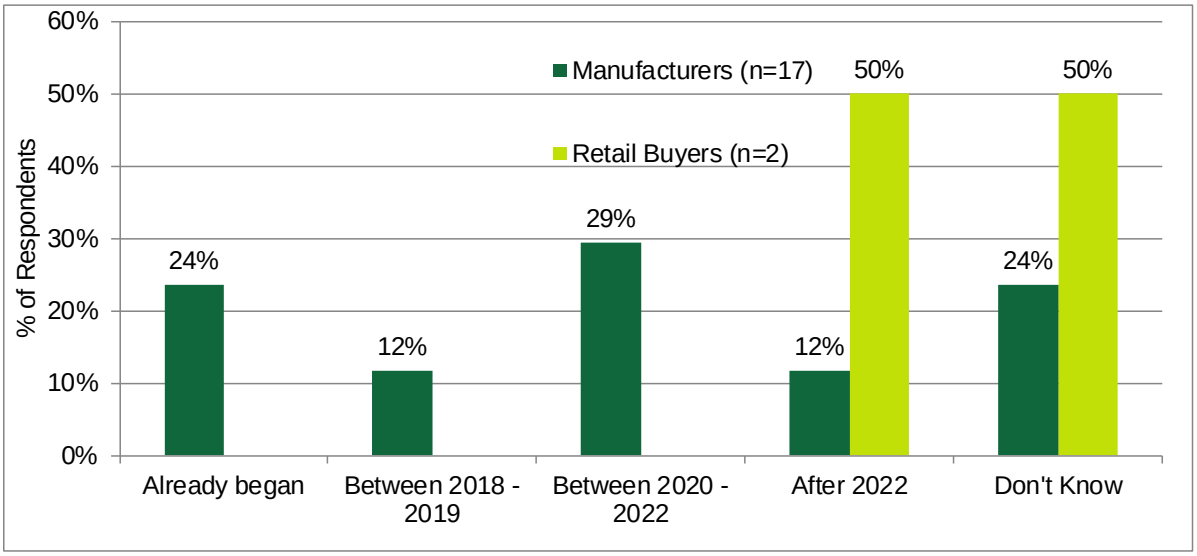
Figure 20: Suppliers' Estimated Percent of All Low Lumen (<310) Lamp Shapes Using Incandescent Technology (n=15)



Key findings include the following:

- Suppliers who indicated that greater than 50% of low lumen lamps use would be incandescent technologies suggested that the main reason for this was the low price point (four of nine suppliers), followed by size limitations (two suppliers). One supplier each mentioned the high cost of LEDs, the limited application/low demand for these lamps, and incandescent light quality. Verbatim comments included the following:
  - [On low price point] "There are a lot of incandescent candelabras that are low lumen [and] they are the majority because they are much cheaper [than LED technology]."
  - [On size limitations] "You can't make an LED in certain shapes and sizes for that light output that would fit in the fixture."
- A clear majority (86%; 19 suppliers) said manufacturers will transition their remaining incandescent low lumen lamps to another lighting technology, either LED (15 of 19 suppliers) or both LED and halogen (four suppliers). Figure 21 shows that the predicted timeframes for this transition varied a lot among the suppliers.

Figure 21: Suppliers Reported Timeframe for When Manufacturers Will Transition Remaining Incandescent Lamps to Another Lighting Technology (n=19)



6 Section 6 California and International Markets

This section presents manufacturers' thoughts on early implementation of EISA Phase 2 standards in California, as well as international sales trends and any impacts on U.S. sales. Interviewers did not ask high-level retail buyers this series of questions on international trends because they primarily focus on national trends.

6.1 Early EISA Phase 2 Implementation in California

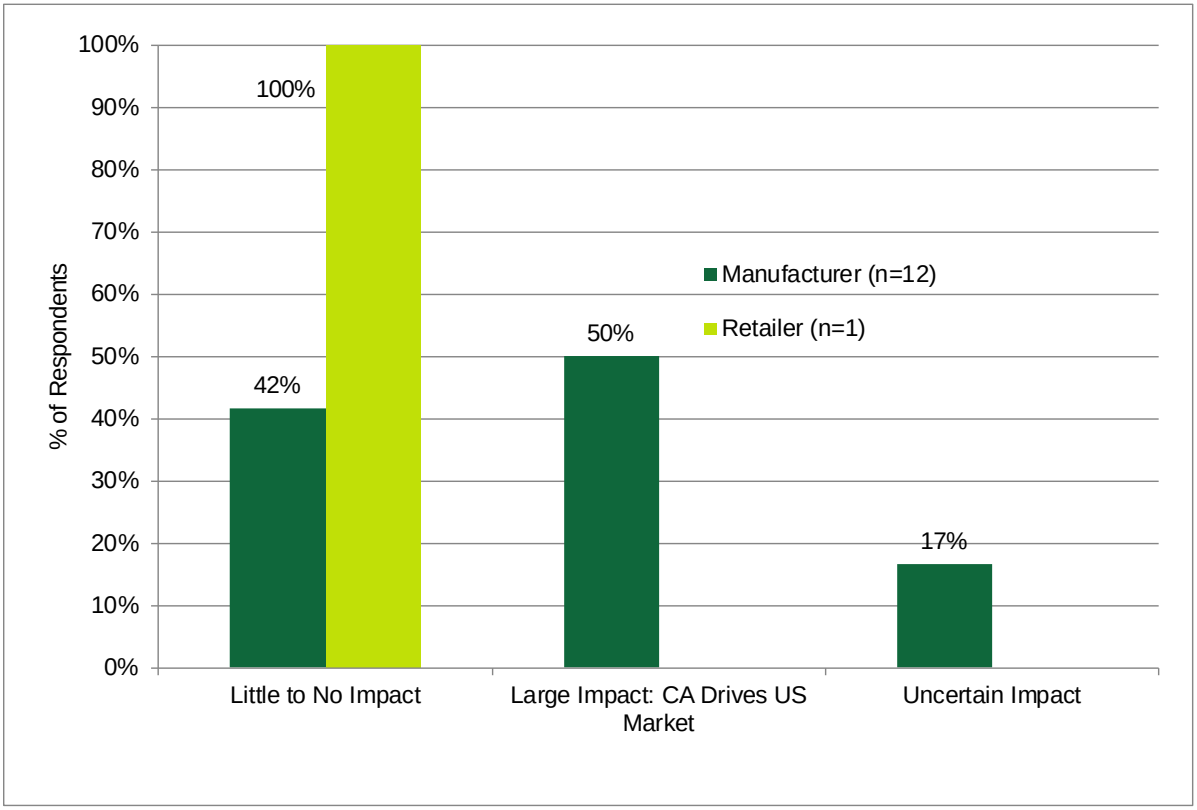
A provision in the 2007 EISA legislation allowed California to expedite the effective date of the Phase 2 standards to January 1, 2018 – two years before the federal standards take effect. Interviews first asked the manufacturers (and one retailer) whether they were aware of alternative EISA implementation schedules or efficiency standards planned for California, and then asked what they had heard about it.[18] Finally, interviewers asked about the impacts of the California schedule and standards on manufacturing and sales elsewhere (generally) and in Massachusetts (specifically).

Key interview findings include the following (Figure 22):

- Nearly two-thirds (65%; 13 suppliers) reported awareness of alternative EISA implementation schedules or efficiency standards planned for California. They most frequently mentioned hearing about the early adoption of EISA Phase 2 standards (45%; nine suppliers), having general knowledge that Title 20 lamps may meet EISA Phase 2 standards (20%; four suppliers), and hearing about the pending lawsuits against California's early Phase 2 implementation (15%; three suppliers). Another 15% (three suppliers) could not recall what they had heard about EISA alternative schedules.
- These aware respondents were evenly split over whether California's early implementation schedule will impact the manufacturing and sales of lamps affecting markets outside of California (specifically, in Massachusetts). Six reported little to no impact, while five reported large impacts (two were uncertain). One supplier summed up these responses: "We're getting to look through a time machine - what they do will apply at national level."

[18] The interviewers were supposed to skip the retail buyers past these California and International questions, but one interviewer did ask a retail buyer these CA questions; we have chosen to include that response in our results.

Figure 22: Reported Impacts of California Schedule and Standards on Lamp Markets Outside California (n=13)



6.2 INTERNATIONAL TRENDS

A large majority of manufacturers (79%) reported that their company sold LED products in countries outside the United States; they mentioned Canada (eight responses), Europe (six responses), Central America (five responses), and the Caribbean (four responses). Of the twelve manufacturers whose companies sold LEDs outside the U.S., six were completely familiar with their company's international sales trends, four were somewhat familiar, and five were not familiar.

International sales trends for LED products (as compared to the U.S.) varied by region, but manufacturers generally agreed for each region. For example, all manufacturers whose companies sold LED products into Europe said the sales breakdown there was similar to the U.S., whereas all those reporting sales in Central America said the share of LED sales there was lower. The only country or region in dispute was Canada, which received some responses saying their shares of LEDs were higher and some saying they were lower. Verbatim responses below summarize similarities and differences in each region.

- "I'm pretty sure Canada is a few years behind with regards to socket penetration and is still pushing more CFLs."
- "[As for] our international sales of LEDs, the percentage in Canada far exceeds the percent of sales in the US. LEDs in the U.S. are probably somewhere about 50-60% of revenue, while in Canada it's 75%."

- "Europe is moving to LEDs. China is also moving towards largely LED, and manufacturing there. CFLs are still a large focus in South America. There's not much energy efficiency adoption in Africa."
- "Asia and Europe are similar [to the U.S.], but less developed countries have decreased adoption."

Only three of the ten manufacturers agreed that manufacturing for international markets affects manufacturing decisions for the U.S. market. Verbatim responses from three manufacturers that summarized the views of the other seven included the following:

- "No, it's the reverse. U.S. manufacturing determines international market."
- "No, not at all. Other countries don't care about patents, [product safety certification] U.L., ENERGY STAR, etc., so they manufacture products differently and cheaper."
- "No. They are different markets with different consumers."

As previously reported, 86% of all suppliers said that LEDs would still be the dominant bulb in the market under a hypothetical scenario in which EISA Phase 2 is not enforced or implemented, allowing the continued sales and import of halogen and incandescent bulbs. None of the ten manufacturers that sold LEDs outside the U.S. changed their opinion when reconsidering with national and international market trends in mind.

A Appendix A Market Share Predictions

A.1 Standard Predictions and Reasons

Table 5 contains average Massachusetts market share predictions for standard lamps from the 2016 and 2017 interviews conducted with lighting suppliers. Included are predictions for CFL, halogen, LED, incandescent, and other lamps under the *program continues* and *program ends* scenarios.

Table 5: 2016 and 2017 Massachusetts Market Share Predictions* (with and without Program Support): Standard Lamps, for the Period 2017-2022

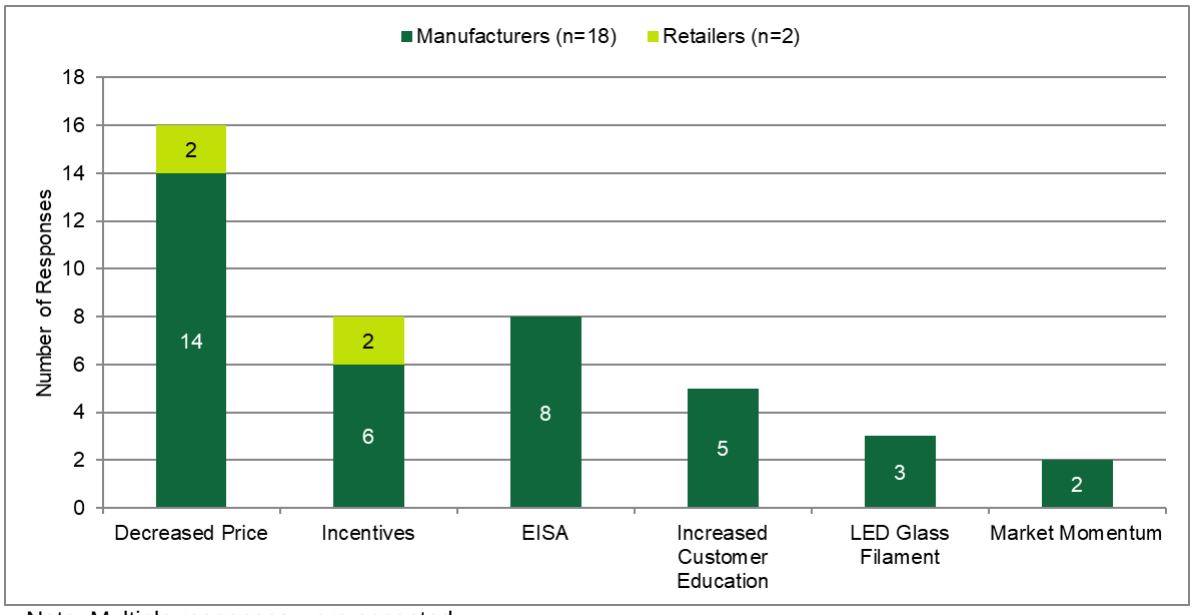
Lamp Type	2016 Interviews			2017 Interviews		
	2017	2019	2021	2018	2020	2022
***Program Continues* Scenario**						
Standard Spiral CFL	12%	6%	4%	7%	4%	3%
A-line halogen	33%	29%	21%	26%	22%	15%
A-line LED	41%	55%	66%	51%	63%	73%
A-line incandescent	12%	7%	5%	14%	9%	8%
Other	2%	3%	4%	2%	2%	1%
***Program Ends* Scenario**						
Standard Spiral CFL	17%	12%	10%	10%	8%	6%
A-line halogen	39%	37%	27%	37%	31%	26%
A-line LED	26%	38%	51%	35%	46%	54%
A-line incandescent	15%	9%	6%	17%	13%	11%
Other	3%	4%	6%	1%	2%	3%

*The 2016 interviews included market share predictions from 15 lighting suppliers for 2017, 2019, and 2021; the 2017 interviews included market share predictions from 20 lighting suppliers for 2018, 2020, and 2022.

The following figures show the factors suppliers considered when predicting Massachusetts market share for standard lamps, under the *program continues* scenario, for A-line LEDs (Figure 23), A-line halogens (Figure 24), CFL standard spiral (Figure 25), and A-line incandescent (Figure 26).

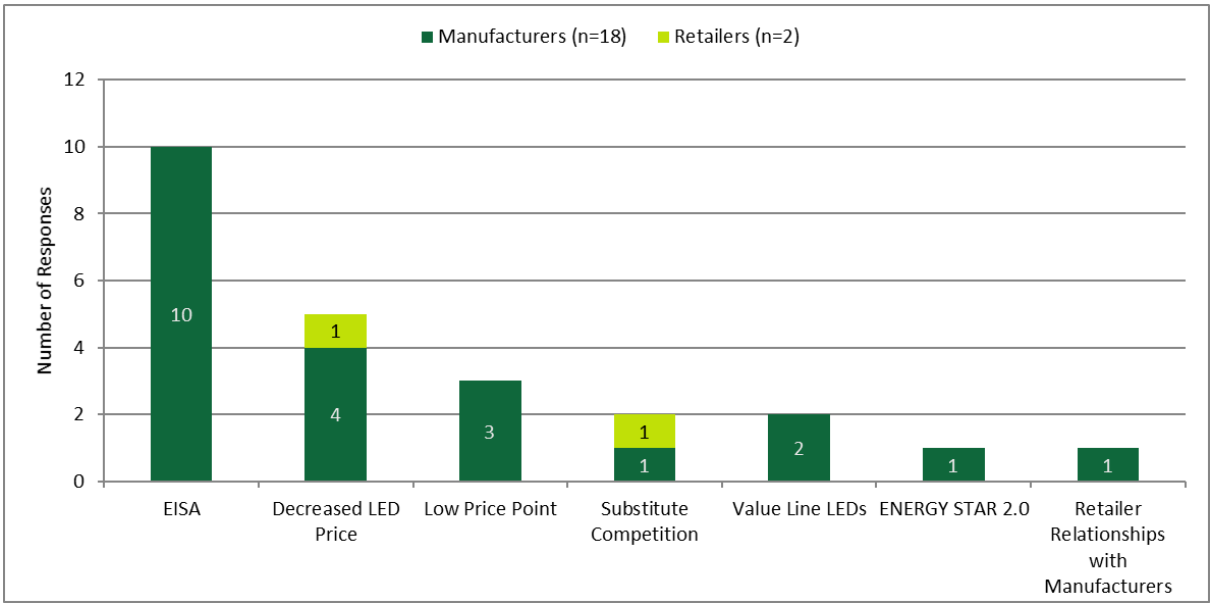
Subsequent figures show the prediction factors considered under the *program ends* scenario for A-line LEDs (Figure 27), A-line halogens (Figure 28), CFL standard spiral (Figure 29), and A-line incandescent (Figure 30).

Figure 23: Factors Considered When Predicting Massachusetts Market Share: A-line LED Lamps, *Program Continues* Scenario (n=20)



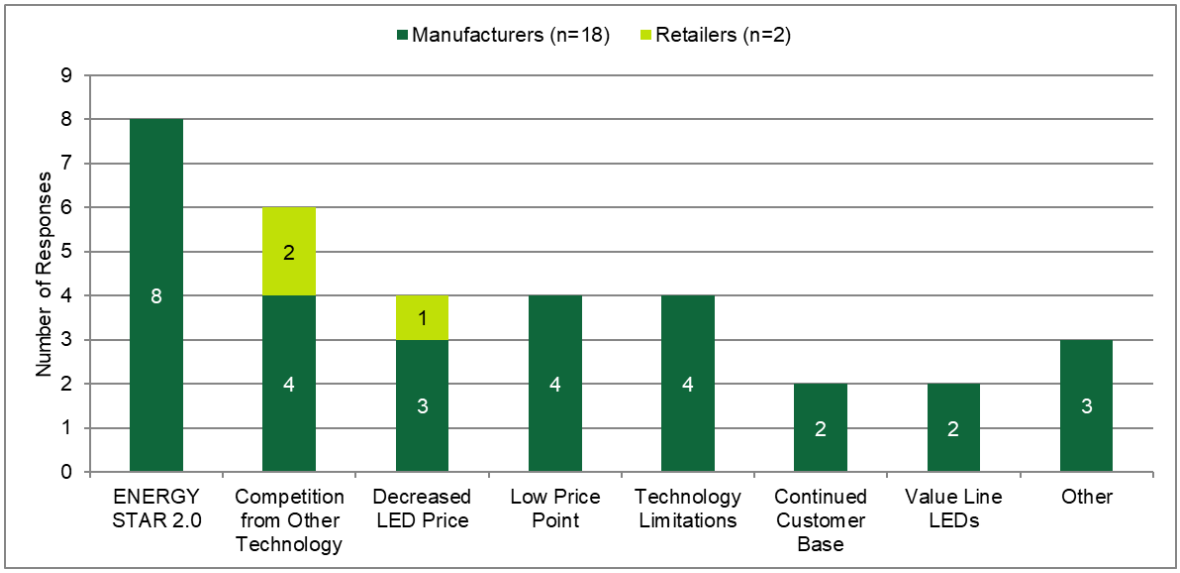
Note: Multiple responses were accepted.

Figure 24: Factors Considered When Predicting Massachusetts Market Share: A-line Halogen Lamps, *Program Continues* Scenario (n=20)



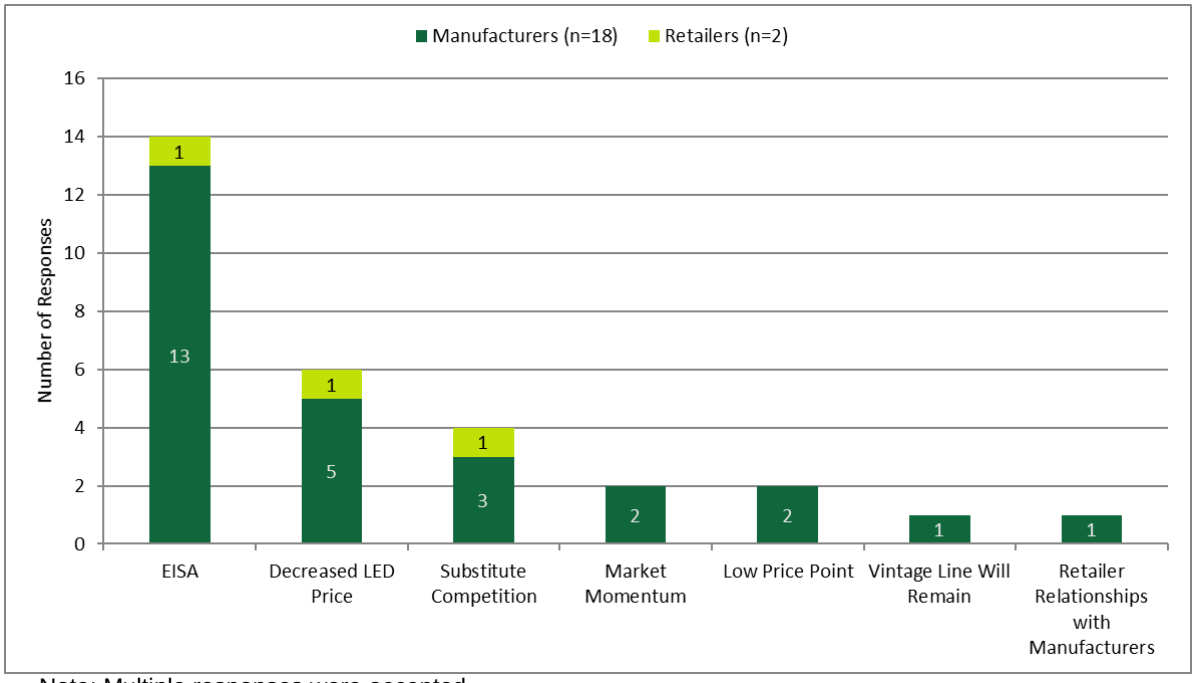
Note: Multiple responses were accepted.

Figure 25: Factors Considered When Predicting Massachusetts Market Share: CFL Standard Spiral Lamps, *Program Continues* Scenario (n=20)



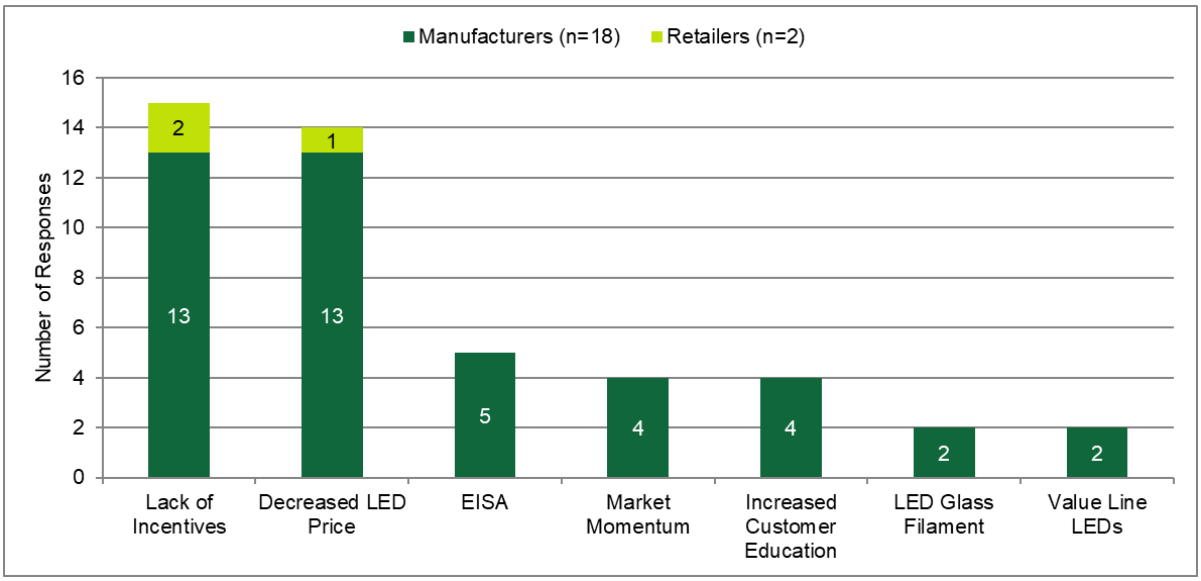
Note: Multiple responses were accepted.

Figure 26: Factors Considered When Predicting Massachusetts Market Share: A-line Incandescent Lamps, *Program Continues* Scenario (n=20)



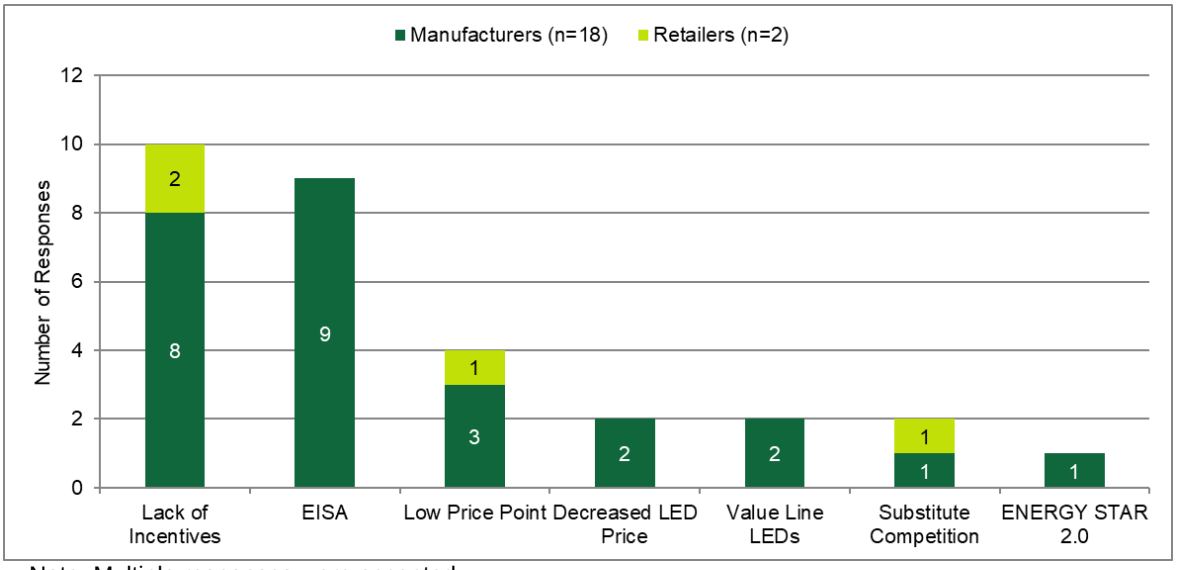
Note: Multiple responses were accepted.

Figure 27: Factors Considered When Predicting Massachusetts Market Share: LED A-line Lamps, *Program Ends* Scenario (n=20)



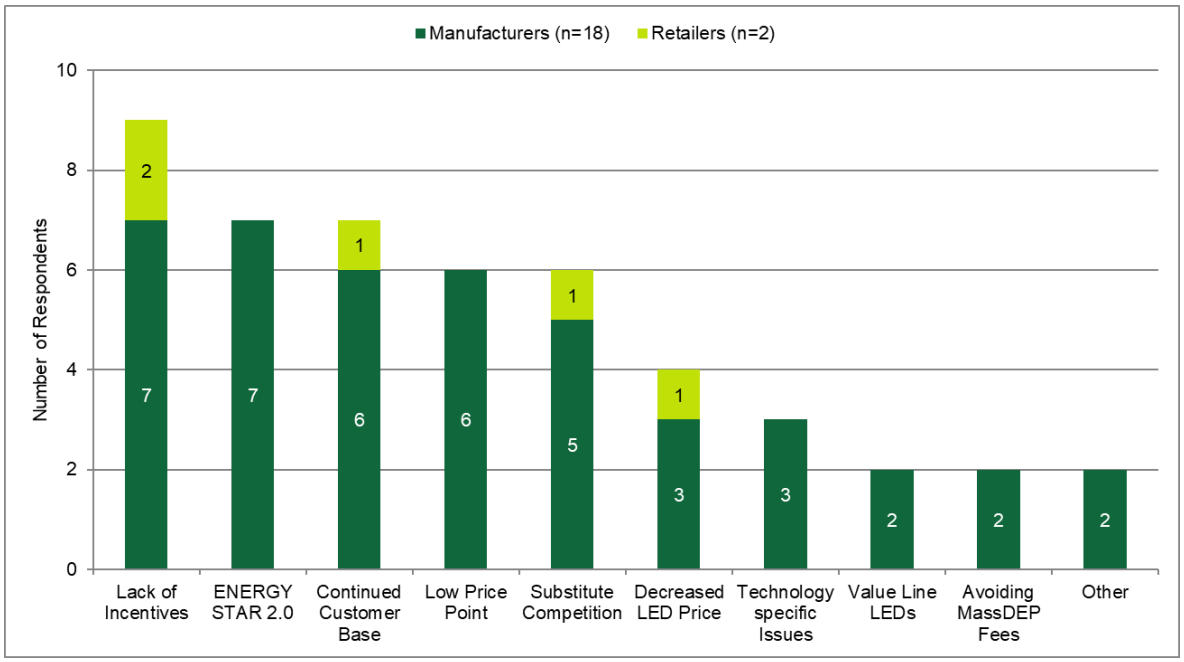
Note: Multiple responses were accepted.

Figure 28: Factors Considered When Predicting Massachusetts Market Share: Halogen A-line Lamps, *Program Ends* Scenario (n=20)



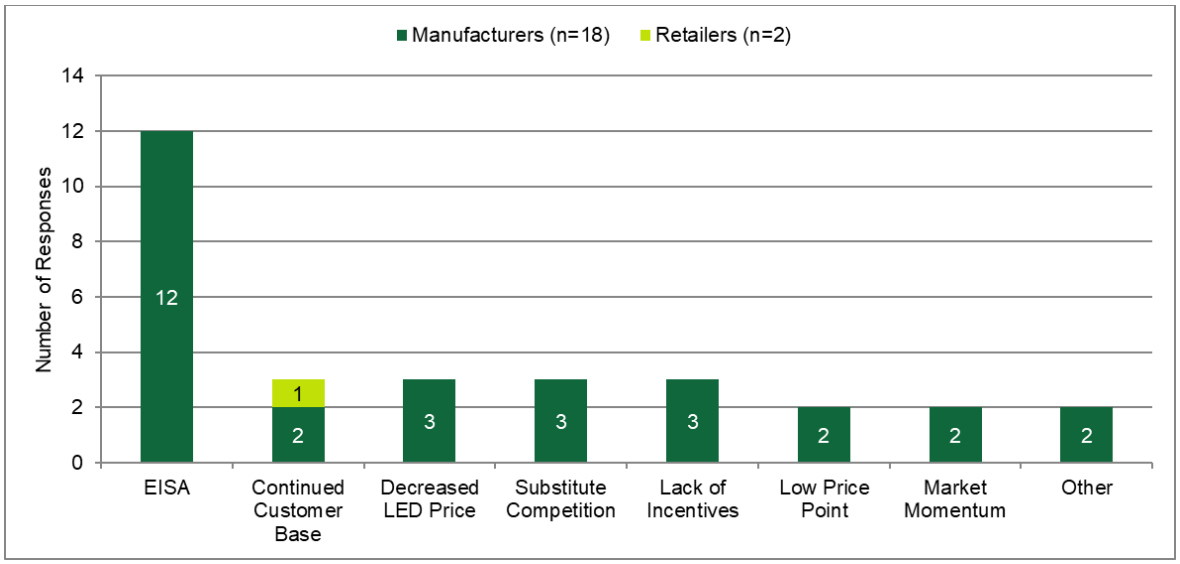
Note: Multiple responses were accepted.

Figure 29: Factors Considered When Predicting Massachusetts Market Share: CFL Standard Spirals, *Program Ends* Scenario (n=20)



Note: Multiple responses were accepted.

Figure 30: Factors Considered When Predicting Massachusetts Market Share: Incandescent A-line Lamps, *Program Ends* Scenario (n=20)



Note: Multiple responses were accepted.

A.2 REFLECTOR PREDICTIONS AND REASONS

Table 6 contains the average Massachusetts market share predictions for reflector lamps from the 2016 and 2017 interviews conducted with lighting suppliers. The table includes predictions for CFL, halogen, LED, incandescent, and other lamps under *program continues* and *program ends* scenarios.

Table 6: 2016 and 2017 Massachusetts Market Share Predictions (with and without Program Support): Reflector Lamps, for the Period 2017-2022

Lamp Type	2016 Interviews			2017 Interviews		
	2017	2019	2021	2018	2020	2022
***Program Continues* Scenario**						
CFL Reflectors	11%	7%	4%	4%	3%	2%
Halogen Reflectors	29%	26%	20%	29%	24%	19%
LED Reflectors	37%	49%	62%	49%	57%	67%
Incandescent Reflectors	21%	15%	11%	16%	13%	10%
Other Reflector Types	2%	3%	3%	2%	3%	2%
***Program Ends* Scenario**						
CFL Reflectors	12%	10%	7%	5%	4%	3%
Halogen Reflectors	36%	34%	28%	41%	38%	34%
LED Reflectors	25%	33%	47%	31%	37%	45%
Incandescent Reflectors	25%	20%	15%	22%	20%	17%
Other Reflector Types	2%	3%	3%	1%	1%	1%

*The 2016 interviews included market share predictions from 15 lighting suppliers for 2017, 2019, and 2021; the 2017 interviews included market share predictions from 20 lighting suppliers for 2018, 2020, and 2022.

A.3 SPECIALTY PREDICTIONS AND REASONS

Table 7 contains the average Massachusetts market share predictions for specialty lamps from the 2017 interviews conducted with lighting suppliers. The table includes predictions for CFL, halogen, LED, incandescent, and other lamps under *program continues* and *program ends* scenarios.

Table 7: 2017 Average Massachusetts Market Share Predictions* for Specialty Lamps, for the Period 2018-2022

Lamp Type	MA Retail Market Shares		
	2018	2020	2022
***Program Continues* Scenario**			
CFL Specialty	6%	5%	3%
Halogen Specialty	26%	22%	18%
LED Specialty	38%	48%	56%
Incandescent Specialty	28%	24%	21%
Other Types	2%	1%	2%
***Program Ends* Scenario**			
CFL Specialty	7%	5%	3%
Halogen Specialty	33%	31%	28%
LED Specialty	25%	32%	39%
Incandescent Specialty	33%	30%	28%
Other Types	2%	2%	2%

*The 2016 interviews did not ask for market predictions for specialty lamps; the 2017 interviews included market share predictions from lighting suppliers for 2018, 2020, and 2022.

A.4 THE RATIONALE FOR NOT USING SALES WEIGHTING

As mentioned in the main report, the evaluation team did not use sales weights to weight the market share predictions of the lighting suppliers; the EEAC and the PAs recommended using unweighted responses in calculating these market shares. This is primarily because the evaluators did not have weights for non-program sales and there were concerns about using just program sales weights as proxies for full market weights. The current Massachusetts program only promotes LEDs; therefore, using program sales as a proxy for total lamp sales would underrepresent suppliers who sell a wider variety of lamp technologies than just LEDs (and overrepresent those who only manufacture LEDs).

Another reason for not using the program sales weight is that the manufacturers are, in theory, making market share estimates for the full Massachusetts market and not just for their own sales.[19] This situation differs from the supplier self-report method for calculating retrospective NTG ratios (which we did not pursue in this study, given the focus on prospective NTG), for example, where suppliers are estimating what would have happened to their own sales in the absence of the program. In the case of retrospective NTG estimates, program sales weights are necessary because their assessment of the program's impacts on their own sales should be directly proportional to the size of their presence within the program.

[19] We say "in theory" because it is possible that some suppliers may make predictions for the broader Massachusetts market from the narrower perspective of what they think will happen to their own sales.