Final Report

HBL Market Effects Study

Project 1A New Construction Market Characterization

Massachusetts Energy Efficiency Programs'
Large Commercial & Industrial Evaluation

Prepared for: Massachusetts Energy Efficiency Program Administrators
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1. Executive Summary

This Executive Summary provides a high level review of the results for *Project 1A New Construction Market Characterization's High Bay Lighting (HBL) Market Effects Study*[1] for the evaluation of the large commercial and industrial (C&I) programs operated by the Massachusetts program administrators (PA). In this section, we provide a brief introduction to market effects research, the study objectives, summarize the evaluation approach, and present key findings and recommendations.

1.1 Introduction to Market Effects Research

A market effect is "a change in the structure of a market or the behavior of participants in a market that is reflective of an increase in the adoption of energy efficient products, services, or practices and is causally related to market intervention(s)."[2] Examples of changes to markets or behaviors of participants include increased levels of end user adoption of energy efficient equipment, contractor changes in design and installation practices, distributor changes in stocking practices and manufacturer changes in production. **The purpose of market effects research is to estimate the energy savings associated with the changes to a targeted market and assess the attribution of these market effects to the PAs' energy efficiency programs.**

The measurement of net market effects, or *Untracked Spillover*, excludes naturally occurring energy efficient sales and all energy efficient sales that are currently accounted for by program tracking or other evaluation activities. It is important that the market effects research avoid double counting by making appropriate adjustments to untracked spillover or program tracked sales if necessary. For example, if a PA applies a non-participant spillover rate to the entire C&I portfolio then the resulting non-participant spillover energy savings must be removed for the

[1] Massachusetts Large Commercial & Industrial Evaluation Contractor (LCIEC). *Final Work Plan Project 1A New Construction Market Characterization.* Prepared for the Massachusetts Energy Efficiency Program Administrators. August 6, 2010. Two additional Project 1A studies were conducted in parallel to this study. They are the *Supply Chain Profile* and the *Commercial New Construction Customer Quantitative Profile*.

[2] Eto, Joe, Ralph Prahl and Jeff Schlegal. *A Scoping Study on Energy-Efficiency Market Transformation by California Utility DMS Programs*. Lawrence Berkeley National Laboratory, 1996.

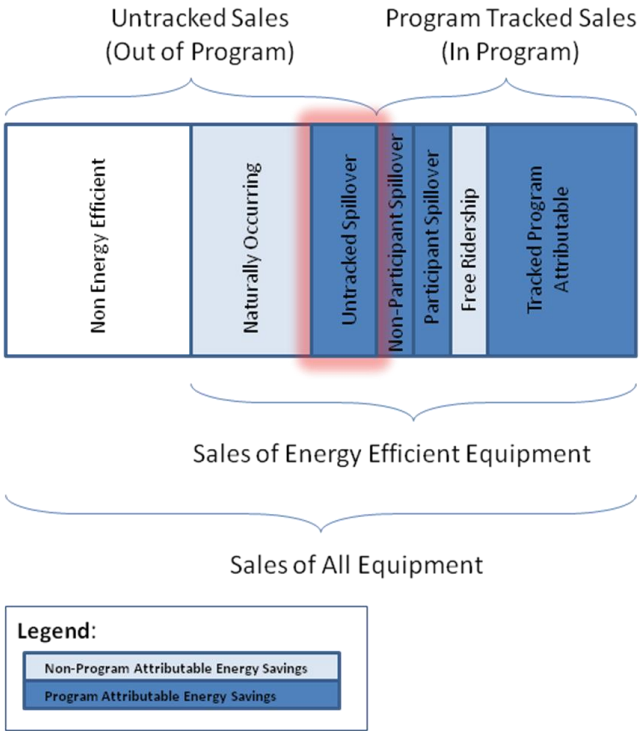
market effect study's targeted market (e.g. HBL). It will be replaced with a more robust estimate based on the targeted market study.

Figure 1-1 provides an overview of the relationship between Program Tracked Sales (in program) and Untracked Sales (out of program). These terms and definitions are used throughout this report.

Program Tracked Sales: Sales of energy efficient equipment that are currently accounted for by program tracking systems and existing evaluation activities. This includes program tracked sales that would not have occurred in the absence of the program ("Tracked Program Attributable"), naturally occurring sales that received program rebates or assistance ("free riders"), and may include participant spillover and non-participant spillover estimated from existing studies.

Untracked Sales: Includes sales of non energy efficient equipment, naturally occurring sales that did not receive a program rebate or assistance, and untracked spillover. Untracked spillover is the additional program attributable energy efficient sales that are currently not accounted for by the programs. This study quantifies the attributable energy savings for those untracked sales.

Figure 1-1: Accounting for Energy Efficient Sales



The California Market Effects Protocol[3] (Protocol) is the leading market effects methodological document. The Protocol provides a clear framework for market effects evaluation. It is designed to measure untracked spillover for a target market at the market level rather than focusing on individual program influences and interventions. KEMA used the framework as the basis of the MA research and three other recent C&I market effects studies conducted for California[4] and Wisconsin[5, 6] that focused on high bay lighting. Each of these previous studies found significant market effects attributable to the effort of the long standing programs in California and Wisconsin. This is the foundation of the LCIEC Team's initial belief that significant market effects exist in Massachusetts.

The Protocol acknowledges the field of market effects research continues to evolve and there is no agreed upon best method. Therefore it is important for the research to clearly describe the approach and state all known uncertainties around the estimates and limitations to the methods. The value of market effects research should not be dismissed based on the perceived accuracy of the point estimate of savings. For this reason the Protocol recommends the presentation of a range of probable effects rather than a point estimate of savings. This allows regulators to assess the complete body of evidence presented and weigh it against the known limitations of the approach to decide the level of untracked spillover credit to be awarded to the program.

1.2 Approach

The Massachusetts electric PAs have been promoting energy efficient lighting in the commercial and industrial market via technical assistance and financial incentives for more than twenty years. The LCIEC Team believes the PA's on-going efforts have caused changes to the Massachusetts C&I lighting market that result in energy savings that are not accounted for by program tracking systems or existing evaluation activities. The LCIEC Team estimated

[3] The TecMarket Works Team. California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals. Prepared for California Public Utilities Commission. April 2006.

[4] California Public Utilities Commission Energy Division. High Bay Lighting Market Effects Study. Final Report June 18, 2010.

[5] Public Service Commission of Wisconsin. Focus on Energy Evaluation. Business Programs: Supply-side Evaluation. Final Report April 22, 2010.

[6] Public Service Commission of Wisconsin. Focus on Energy Evaluation. Business Programs: Channel Studies - Fiscal Year 2008. Final Report January 17, 2009.

untracked spillover and assessed the attribution of these savings to the PA's energy efficiency programs based on a comparison of the level of adoption of energy efficient high bay lighting in Massachusetts versus a comparison area lacking programs promoting energy efficient high bay lighting. The primary analytic steps include:

1. Estimate the volume of high bay lighting installed in Massachusetts and the comparison area.

2. Estimate the market share of energy efficient high bay lighting installed in Massachusetts and the comparison area.

3. Assess attribution of untracked spillover to the PA's energy efficiency programs.

According to the California Protocols, the "key considerations for the rigor of market effects estimates are the accuracy of the estimates of energy impacts and the accuracy of the attribution of market effects."[7] The LCIEC Team approach achieved the Protocols' highest level of rigor via data collected using representative samples from multiple sources and comparison markets.

Information collected from interviews with key market actors were used to estimate the level of adoption of specific HBL technologies in Massachusetts. The rationale for the selection of each market actor is provided in Table 1-1.

The MA study used that same comparison area (Mississippi, Alabama, Georgia, and South Carolina) and data collected for the CA study in 2009. To ensure comparability of the results the MA instruments mirrored those of the CA study with minor modifications. We also compared the Massachusetts market actors' responses to a number of survey responses that were examined in Illinois, serving as the comparison area for the two Wisconsin studies. These additional triangulation points provide further credibility to the modeled results.

[7] The TecMarket Works Team. California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals. Prepared for California Public Utilities Commission. April 2006, page 152.

Table 1-1: Market Actors Interviewed

Market Actor	Rationale for Selected Market Actor
End User	Represents population of C&F firms who made high bay lighting purchases. Provide model with estimated total size of the HBL market.
Lighting Contractors	Electrical and lighting contractors that specify and install high bay lighting fixtures and controls provide a broad understanding for the technology shares and specification trends.
Distributors	Sellers of HBL products to contractors and end users represent a valuable source of information concerning changes in the regional demand for HBL products, as well as trends in the promotion and competitive position of HBL products.
Manufacturers	Producers of HBL products are aware of inter-regional differences in the promotion and distribution of energy efficient technologies, and provide evidence of the production cost changes that may result from increased sales.
Program Staff	Program staff provides information on program design and logic, motivations and barriers to program acceptance, and identify observed market effects.

In addition to the interview data the analysis utilized:

PAs Program Tracking Data. Program tracked gross and net energy savings for HBL measures identified by the PAs.

Other Secondary Data. Engineering data from various engineering databases regarding the average lumens per square foot, and information concerning the average number of lumens per watt for different technologies.

The various data sources were used to calculate untracked spillover. A high level summary of the modeling process is as follows:

1. Combine data from the Massachusetts end user and contractor surveys with engineering data to estimate total gross demand and energy savings associated with HBL measures (*Sales of All Equipment & Sales of Energy Efficient Equipment* in Figure 1-1).

2. Compare gross savings estimates in Massachusetts to the comparison area savings estimates to identify total program attributable demand and energy savings in Massachusetts (*Program Attributable Energy Savings {dark blue}* in Figure 1-1).

3. Use program tracking data to remove program attributable saving that are currently accounted for by the program (*Program Tracked Sales {In Program}* in Figure 1-1).

4. Assess attribution of untracked energy efficient sales to the PA's energy efficiency programs (*Untracked Spillover* in Figure 1-1).

As previously stated, we analyzed survey results from a broad range of market actors to provide supplemental evidence of market effects. In contrast to the modeled approach outlined above, this portion of the analysis relies on a *preponderance of evidence* obtained from primary research to determine the extent of program related changes to market share, availability, design specification, marketing practices, production costs, awareness, and perceptions of energy efficient HBL products. As stated in the Protocols:

"In this approach the analyst relies on triangulation from multiple data sources to draw conclusions about the presence and attribution of market effects. This approach is accomplished by interviewing and surveying knowledgeable market actors. Program staff, utility staff and trade allies provide useful information for understanding the context of sales and counts of behavior. Over time, these views provide much of the information needed to draw conclusions about attribution and sustainability."[8]

1.2.1 Limitations to the Approach

The LCIEC Team acknowledges several limitations to the approach.

1.2.1.1 Compatibility of Comparison Area

The loss of the comparison market is an increasingly problematic limitation for using quasi-experimental techniques to estimate market effects attributable to C&I and residential energy efficiency programs. Due to the limited number of remaining states without energy efficient lighting programs, the LCIEC Team determined that the four state region used for the 2010 California HBL Study was the best available region to use a comparison group. Similar to the

[8] Ibid. page 156.

CA study team, the LCIEC team concluded it was more important to select a comparison area without prior or existing HBL programs than one with closely linked socio-economic factors. The choice of this region does, however, represent a limitation to the analysis due to key differences among the regions. KEMA analyzed a number of these differences to provide insight into their impact on the estimated market effects. Important findings from this analysis include:

- The inventory of Massachusetts end user facilities is older, smaller, and has lower ceilings than in both the comparison region and California, partially explaining the higher proportion of lighting projects over the past few years.

- A greater share of firms in the comparison area are used for warehousing and process manufacturing, while Massachusetts has a slightly greater proportion of food sales stores. This difference may result in greater savings as warehouse and manufacturing facilities are likely to have multiple shifts requiring continual usage of HBL.

- Electric prices in Massachusetts are 1.7 to 2 times higher than in the southern states, while incomes are only 1.2 to 1.6 times higher. These higher rates are likely to result in greater attention to efficiency measures, thereby potentially reducing the amount of savings attributable to the electric PAs programs.

- The level of education in Massachusetts is also higher than in the south. While it is very difficult to quantify, increased education is often believed to correlate to a higher level of social awareness. This effect can be seen by Massachusetts ACEEE 2010 Efficiency scorecard, which indicates Massachusetts ranks second in the US, while the southern region ranks between 37th and 49th.

1.2.1.2 Temporal Issues

The comparison area from the 2010 California HBL Study provided analysis of market effects based self-reported data from market actors for 2006 through 2008, while the Massachusetts study used 2007 through 2010 as the study period.

The periods being examined in the Massachusetts and California HBL studies were also different lengths. This difference in length presents another limitation to the analysis; therefore, KEMA reviewed a range of data to suggest the magnitude and direction of effect these differences impose on the analysis. Our findings in this regard include:

- Program tracked sales and estimated savings in Massachusetts increased sharply from 2007 to 2008, but then leveled off between 2008 and 2010.
- Falling energy prices in Massachusetts should lead to less exogenous pressure to adopt energy efficient technologies, thereby supporting the evidence of relatively high program-attributable market effects.
- Economic indicators suggest that while Massachusetts' economy is clearly much different than the comparison area, it has not experienced trends that are dissimilar to those experienced by the comparison area.

1.3 Key findings

1.3.1 Modeled market effects results

In Table 1-2, we summarize the results of our modeled approach used to estimate the overall magnitude of market effects resulting from the electric PAs HBL programs in Massachusetts. The table shows the results from three separate scenarios. Scenario 1 represents the model results using the data collected directly from Massachusetts end users and contractors.

Table 1-2: Estimated market effects from the electric PA's HBL programs

Savings measure	Scenario 1: MA high bay space and purchase parameters	Scenario 2: Average MA and CA high bay space and purchase parameters	Scenario 3: CA high bay space and purchase parameters
Total savings resulting from energy efficient HBL	90.7	45.4	15.5
2010 Program tracked net savings*	27.6	27.6	27.6
Exogenous savings	10.6	5.3	0
Untracked spillover savings	**52.4**	**12.4**	**(12.17)**
2010 Program tracked gross savings	31.4	31.4	31.4
Spillover as a % of program tracked gross savings	167%	39%	-39%

* The electric PAs report 3.8 GWh per year attributable to free ridership

As is discussed in Section 4.1.6, we identified two key inputs that the Massachusetts survey results provided larger estimates than the results from the two previous studies. These key inputs are the percent of firms with high bay space and the percent of those firms that

purchased high bay lighting during the study period. After examination of key differences between the Massachusetts and California HBL studies,[9] we created two additional scenarios that incorporate data from the 2010 California HBL study to estimate these parameters. **The LCIEC Team recommends the level of savings provided by Scenario 2, which uses the average of the Massachusetts and California values for the percent of firms with high bay space and the percent that made HBL purchases.**

Based Scenario 2, the LCIEC Team estimates over 45 GWh per year in savings is attributable to the electric PAs HBL programs. The PA's program tracking data reports that program tracked net savings accounts for 28 GWh of this 45 GWh. **This provides an additional 12 GWh of 2010 savings attributable to the program that did not receive rebates, and therefore occurs outside the program.** These program-attributable savings represent our measured estimate of market effects. In addition to these program attributable savings, we identified 5 GWh per year in savings that result from naturally occurring sales of energy efficient HBL in the state. These additional savings would occur in the absence of the program and include roughly 4 GWh per in savings that the PAs identified as savings resulting from free riders. Our estimate of untracked spillover savings amounts to 39 percent of the 2010 program gross tracked savings, which the PAs report at 31 GWh in 2010.

These modeled estimates are driven by differences in the technology shares between Massachusetts and the comparison area. Specifically, the model reflects differences in the percent of high bay space illuminated using fixtures with high efficiency (lumens per watt) in Massachusetts relative to those found in the comparison area. These differences in lighting specifications translate into a higher overall wattage in the comparison area relative to Massachusetts in order to provide the amount of light necessary to illuminate space served by recent Massachusetts HBL purchases.

The following research results serve as key inputs to our modeled approach and provide supporting evidence of the untracked spillover savings estimates presented above.

[9] See Section 5.3.2 and 5.3.3.

Comparison of technology shares

- As see in Table 1-3, Massachusetts lighting contractors report a much higher percentage of HBL projects use high efficiency T-5 HBL than the comparison area. With nearly the same percentage of T-5's as California, one of the most aggressive states in terms of energy efficient lighting programs, Massachusetts is a leader in the adoption of energy efficient HBL. This point is further supported by findings from manufacturer interviews. Conversely, Massachusetts contractors report much lower shares of T-12 fixtures which are less efficient. In terms of the modeled results, the higher market share of these less efficient fixtures in the comparison area relative to T-5 fluorescents results in greater energy consumption in the comparison area to light the same amount of space, and therefore, greater energy savings for Massachusetts.

Table 1-3: Contractor-reported Technology Shares of High Bay Lighting Installations

2007-2010 for MA	Massachusetts	Comparison Area	California
Fluorescent Tube: T-5/ Electronic Ballast T-5	64%	29%	65%
Fluorescent Tube: T-8 /Electronic Ballast T-8	13%	16%	14%
Fluorescent Tube: All other, including T12/Magnetic Ballast	1%	11%	1%
HID: Pulse-start metal halide	3%	31%	14%
HID: High-pressure sodium	1%	8%	3%
HID: Other HID such as mercury vapor or probe-start metal halide	1%	3%	1%
Other: technologies such as Induction or LED	17%	2%	2%

- We found that contractors representing only 3 percent of Massachusetts HBL projects install pulse-start metal halide fixtures compared to 31 percent in the comparison area. Although these fixtures are program supported, evidence provided by each group of market actors indicates that pulse-start metal halides are recognized as an out-dated technology due to their lower efficiency and product attributes. As discussed in greater detail below, this finding suggests that the pulse-start metal halide fixtures no longer represent an effective technology for achieving energy savings goals. Consequently, the PAs should consider discontinuing their sponsorship through the energy efficiency programs.

- The table shows that contractors representing a substantial share of projects report installing LED fixtures in Massachusetts. While these fixtures are not sponsored by the

existing programs, this finding is supportive of greater market effects because it suggests that the programs result in changes to market actor behavior supportive of energy efficient technologies. We attribute the relatively high adoption of LEDs in Massachusetts to the electric PAs programs' ability to educate contractors and end users about the benefits of energy efficient HBL. Specifically, firms in Massachusetts appear to be more interested in energy and life cycle cost savings associated with fixtures than their acquisition cost. However, we also find a number of important limitations concerning the extent of savings resulting from LEDs in high bay applications. Specifically, numerous market actors report that LEDs face considerable barriers to entry in the high bay sector due to issues associated with light dispersion at greater heights. Further, LED fixtures face considerable acquisition cost constraint essentially pricing them out of most applications.

Program tracked savings

Each of the electric PAs provided program tracking records reporting their estimated gross and net energy and demand savings associated with various lighting measures, including HBL. Our analysis of these data revealed the following values for program tracked savings from measures target towards HBL applications:

- Total gross savings –31.4 GWh in 2010;
- Total net savings – 27.6 GWh / year;
- Estimated free ridership – 3.8 GWh / year;

Untracked Spillover

As shown in Table 1-2, in the recommended Scenario 2 we estimated 17.7 GWh/year (12.4 + 5.3 GWh) in savings results from untracked adoptions of increased energy efficient lighting in Massachusetts. However, a portion of this savings, 5.3 GWh/year, cannot be attributed to the program because it results from exogenous influences rather than being program induced. We identified and analyzed the following three sources of this exogenous savings:

1. **Savings from chain & franchise corporate policies** – We estimate that design and construction policies of national chain & franchises account for 3.73 GWh/year (8.2 percent) of the 45.3 GWh/year total savings resulting from greater efficacy in HBL in Massachusetts.

2. **Savings from other corporate policies** – We estimate that design and construction policies of non-chain & franchise firms account for 3.53 GWh/year (7.8 percent) of the 45.3GWh/year total savings resulting from greater efficacy in HBL in Massachusetts.

3. **Savings from building codes** – We estimate building codes account for 3.35 GWh (7.4 percent) of the 45.3 GWh/year total savings resulting from greater efficacy in HBL in Massachusetts.

Total savings from exogenous factors – In combining savings attributable to these exogenous factors, we assume that 50 percent of the estimated savings from each source are independent of the other two sources, and therefore additive. This provides our estimated savings estimate for these three exogenous sources of 5.3 GWh/year. As shown in Table 1-2, we reduce the amount of out of program savings by this amount to provide our estimate of untracked spillover savings of 12.4 GWh/year.

1.3.2 Additional evidence of market effects results

We provide evidence of market effects based on a preponderance of evidence from primary research data obtained from each of the five groups of market actors. Where possible, we compare results from the Massachusetts market actors to those in the comparison area. These comparisons allow us to make conclusions regarding the extent of market effects relative to baseline conditions, which are represented by the comparison area. In addition the primary comparison area for this study, a limited number of results are compared to results for the comparison area from the Wisconsin market effects studies, Illinois. Table 1-4 and Table 1-5 summarize key findings from this portion of the analysis.

Table 1-4: Preponderance of evidence of market effects (part 1)

Topics Covered	Market Actor Group	Evidence	Summary
Sales of HBL by technology	Contractors	Contractors report T5 fluorescent tubes accounted for 64% percent of all fixtures used in high bay situations in Massachusetts relative to 29% in the four state comparison area, and 28% in IL. These differences are statistically significant at 90%.	Data from both contractors and end users indicate greater sales of energy efficient HBL products relative to the four state comparison area as well as Illinois. Fluorescent T-5 fixtures are clearly the preferred technology among MA contractors. End users also report a high concentration of T-5 fluorescent tubes, but an even greater number of T-8's. Information provided by the 5 manufacturers affirms the popularity of T5's and T8's in Massachusetts. Massachusetts contractors also report installing LEDs on a significantly greater number of projects than in the comparison area, providing a further indication of market effects as firms are willing to trade short term acquisition costs for long term savings from reduced energy costs. Finally, Massachusetts contractors and end users both report greater adoption of lighting controls than the comparison area and Illinois.
		17% of projects reported by contractors in Massachusetts installed "other" HBL types such as induction and LED indicating increased focus on energy efficient lighting.	
		Contractors representing 46% of Massachusetts HBL projects report installing occupancy sensors compared to 22% in IL. This difference is statistically significant at 95%.	
	End Users	End users report 78% of high bay space in MA served by fluorescent tube fixtures compared to 55% in the comparison area. This difference is statistically significant at 95%.	
		68% of end users who installed fluorescent tubes report installing T8's and 37% report T5's compared to 45% and 16% in the comparison area. This difference is statistically significant at 95%.	
		43% end users report installing occupancy or motion sensors and 26% installed daylight controls compared to 12% and 3%, respectively, in the comparison area. This difference is statistically significant at 95%.	
		23% of end users installed daylight controls compared to 14% in the comparison area. This difference is not statistically significant.	
	Manufacturers	Four of five manufacturers agree that fluorescent HBLs T-5s and T-8s are driving their MA HBL sales.	
Recommendations for energy efficient HBL	Contractors	Contractors that represent 74% of projects report talking directly to customers to promote energy efficient high bay lighting technologies.	The evidence suggests that contractors, distributors, and manufacturers actively promote energy efficient HBL in Massachusetts. However, contractors are more likely to recommend fixtures in the comparison region. Contrasting contractor results from Massachusetts with those from the WI study, illustrates that contractors in WI are also less likely to recommend energy efficient fixtures than IL. This finding, coupled with the relatively high proportion of projects in which energy efficient fixtures are installed suggest that end users in each of the program states are better informed about energy efficient options prior to undertaking projects than in non-program areas.
		Contractors representing 73% of Massachusetts HBL projects report recommending energy efficient HBL always or most of the time compared to 86% in the comparison area and 80% in CA. This difference is not statistically significant. By comparison, contractors representing 90% of IL projects report recommending T5 or T8 fluorescent fixtures, while only 80% of WI projects installing these technologies were recommended by contractors.	
		Contractors representing 66% of Massachusetts HBL projects report recommending occupancy sensors compared to 21% in IL. This difference is statistically significant at 95%.	
	Distributors	All five distributors recommend energy efficient option, and 4 of the 5 make such recommendations “always”, one does so “sometimes”.	
	End users	For 80% of end users in MA who installed fluorescent tubes, the contractor recommended using them compared to 67% in the comparison area. This difference is not statistically significant.	
		53% of end users in MA who installed fluorescent HBL heard of the technology through lighting vendors compared to 19% in the comparison area.	
Awareness of benefits of energy efficient HBL	Contractors	Contractors that represent 41% of Massachusetts projects indicate that concern/awareness about saving energy are main factors in determining the market share of high bay fluorescent lighting in the next two years relative to 22% in the comparison area. This difference is not statistically significant.	Massachusetts contractors and end users have a greater level of awareness of the cost, energy savings, and other benefits associated with HBL choices than firms in the comparison region and Illinois. This indicates that Massachusetts HBL programs have been effective in educating market actors on HBL choices and the implications those choices represent to their bottom line.
		Contractors that represent 63% of Massachusetts projects indicate that the majority of customers are aware of the full range of options for energy-efficient high bay lighting available to them before they provide recommendations about the lighting system compared to 17% in the comparison area.	
		Massachusetts contractors rate both the initial equipment costs and operation costs 9.7, and rate life cycle costs 8.4 out of 10. Contractors from Illinois rate each of these factors 7.3, 6.1 and 6.0, respectively.	
	End Users	44% of end users in MA who installed fluorescent HBL heard of the technology through previous projects compared to 38% in the comparison area. This difference is not statistically significant.	

Table 1-5 Preponderance of evidence of market effects (part 2)

Topics Covered	Market Actor Group	Evidence	Summary
Pulse Start Metal Halides	Contractors	Only 6% of projects reported by contractors in Massachusetts installed pulse start metal halide fixtures compared to 31% in the comparison area. This difference is statistically significant at 95%.	The survey results show that the program's promotion of pulse start metal halides have contributed to their success among HID fixtures, resulting in program attributable market effects. While contractors are aware that these fixtures are more energy efficient, the overwhelming evidence across market actors is that these fixtures are a lagging technology. Due to their lower efficacy, relative to T5's and T8's, as well as less desirable product attributes, pulse start metal halides are not promoted by contractors or manufacturers. we recommend the PA's consider allocating resources away from supporting these fixtures to those with greater energy savings potential and acceptability, such as LEDs.
		Contractors representing 94% of projects report that the cost of electricity influences customer choices regarding HID fixtures in Massachusetts compared to 21% in the comparison area.	
		Contractors that represent only 7% of projects report high bay pulse start metal halide lighting has increased over the last two years compared to 35% in the control region. This difference is statistically significant at 95%.	
	Manufacturers	Manufacturer comments suggested that none of the five consider this technology a major area of investment or emphasis going forward. Firms report that strike time is the major obstacle to this technology.	
	End users	80% end users who installed HID fixtures report installing pulse star metal halide compared to 14% in the comparison area. This difference is statistically significant at 95%.	
		For 9% of end users in MA who installed pulse-start metal the contractor recommended using them compared to 15% in the comparison area. These differences are not statistically significant.	
		13% of end users in MA who installed pulse-start metal heard of the technology through utility representatives compared to 0% in the comparison area.	
		26% of end users in MA who installed pulse-start metal heard of the technology through architects and engineers compared to 3% in the comparison area. This difference is statistically significant at 90%.	
Other factors influencing HBL choices	Contractors	Contractors representing 41% of projects report that saving energy influences customer choices in Massachusetts compared to 22% in the comparison area. This difference is statistically significant at 95%.	Market actors in Massachusetts are influenced by a range product attributes when selecting HBL fixtures. These include energy savings, purchase price, light quality, and other product features. Given the range of options facing end users and contractors, the fact that the majority of HBL purchases are energy efficient fixtures, suggests that HBL programs have been successfully in educating market actors of the implications of different lighting choices on their facility's operations and costs.
		Contractors representing 32% of projects report that the lower price of new equipment influences customer choices for fluorescent fixtures in Massachusetts compared to 24% in the comparison area. This difference is not statistically significant.	
	End Users	34% of Massachusetts end users report saving energy is their primary reason for choosing specific lighting technologies compared to 20% in the comparison area. This difference is not statistically significant.	
		28% of Massachusetts end users report improving the light quality is their primary reason for choosing specific lighting technologies compared to 20% in the comparison area. This difference is not statistically significant.	
	Distributors	Four of five distributors report that contractors cite many commercial advantages of the fluorescent high-bay products: “instant on” capability (no requirement for cooling between on-off operations); low maintenance costs; high energy savings; high lumen/Watt; and long life expectancy.	
Objections to EE HBL	Contractors	Contractors representing 66% of projects report no objections to installing in fluorescent HBL Massachusetts compared to 17% in the comparison area. This difference is statistically significant at 95%.	The electric PA's HBL programs have resulted in greater acceptance of energy efficient options for HBL.

1.4 Recommendations

Based on the modeled approach and the preponderance of evidence presented in this market effects study, KEMA recommends the electric PAs claim untracked spillover energy savings associated with Massachusetts HBL measures. We recommend the Scenario 2 energy savings estimate of 12.4 GWh per year or 39 percent of 2010 program tracked gross savings. This value is consistent with the untracked spillover estimate of 34 percent of program tracked savings estimated for Wisconsin in the 2010 Wisconsin HBL study.

Several of the electric PAs are currently claiming low levels of participant and or non-participant energy savings for HBL measures. Prior to claiming the untracked spillover savings recommended by this report the PAs must remove participant and or non-participant spillover energy savings for HBL measures already being claimed to avoid double counting.

2. Introduction

This report presents the results of KEMA's study of the market effects associated with the Massachusetts Program Administrator's (PA's) electric energy efficiency programs that promote energy efficient high-bay lighting (HBL) and lighting control in Massachusetts. These programs are offered to Commercial and Industrial (C&I) customers by five electric PAs: Cape Light Compact, National Grid, NSTAR, Unitil, and WMECo. This market effects study is part of a multi-year C&I market characterization.[10]

KEMA conducted this Market Effects Study to determine the presence and extent of market effects resulting from high-bay lighting programs offered by the PAs over the past 4 years. The theory behind this investigation is that designers and equipment vendors learned about the customer and business benefits of specifying efficient equipment and design practices through their participation in the program. As a result of participating in the program, a portion of market participants realized the benefits of the energy efficient products and have become motivated to continue using them in projects regardless of whether or not they continue to receive any incentives. These behavioral changes represent market effects, which are defined by the California Protocols as follows[11]:

"A change in the structure of a market or behavior of participants in a market that is reflective of an increase in the adoption of energy-efficient products, services, or practices and is causally related to market intervention(s)."

2.1 Research objective and questions

The overall goal of the market effects study is to assess the extent to which the PA's recent HBL programs affected the adoption of energy efficient high-bay lighting equipment and controls. Specifically, we developed a quantitative model to estimate the effect of the PAs' programs on

[10] Final Work Plan Project 1A New Construction Market Characterization. Prepared for the Massachusetts Energy Efficiency Programs in Large Commercial & Industrial Evaluation Contractor (LCIEC). KEMA August 6, 2010.

[11] California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professional. San Francisco: California Public Utilities Commission. TecMarket Works Team. April 2006.

the rate of adoption of energy-efficient high bay lighting technologies among all customers, whether or not those customers participated in the promotional programs.

This modeled approach yields our estimated total "in-program" and "out-of-program" net demand (MW) and energy (MWh) savings associated with the HBL programs. The modeled results address the following three research questions:

1. What is the total (gross) demand and energy savings attributable to HBL measures implemented by the Massachusetts PA's over the past 4 years?

2. What is the total program tracked attributable savings?

3. What is the level of untracked spillover?

We supplement this quantitative assessment with additional evidence of market effects provided by interviews with a broad range of key market players. This additional information provides further evidence of behavioral changes among the various HBL market actors. These behavioral changes include changes to awareness, design specification, marketing practices, production practices, and market barriers associated with energy efficient HBL products. Based on market actor survey and interview results, we provide a preponderance of evidence of market effects that addresses the following four research questions:

1. Have HBL energy efficiency programs resulted in increased energy efficient HBL installations?

2. Have HBL energy efficiency programs resulted in increased knowledge and awareness of energy efficient HBL technologies?

3. Have HBL energy efficiency programs resulted in greater marketing and promotional activity of energy efficient HBL technologies by market actors?

4. Have market barriers either impeded the effectiveness of, or been reduced by energy efficient HBL programs?

2.2 Overview of study

2.2.1 Analytical framework

Our modeled approach is depicted in Figure 2-1 below in which the data inputs, represented by the purple rectangles, include end-user and contractor survey data, various engineering data elements from secondary data sources, and program tracking data. The final inputs to the model are data derived from the California HBL study, which provides energy consumption estimates for the control area, the four-state region that includes Alabama, Georgia, Mississippi, and South Carolina between 2006 and 2008. Data inputs are fed through the market effects model, depicted by the blue cylinder, to provide the model outputs, represented by the red circle. While a detailed description of the model is provided in Section 3, the general modeling process is as follows:

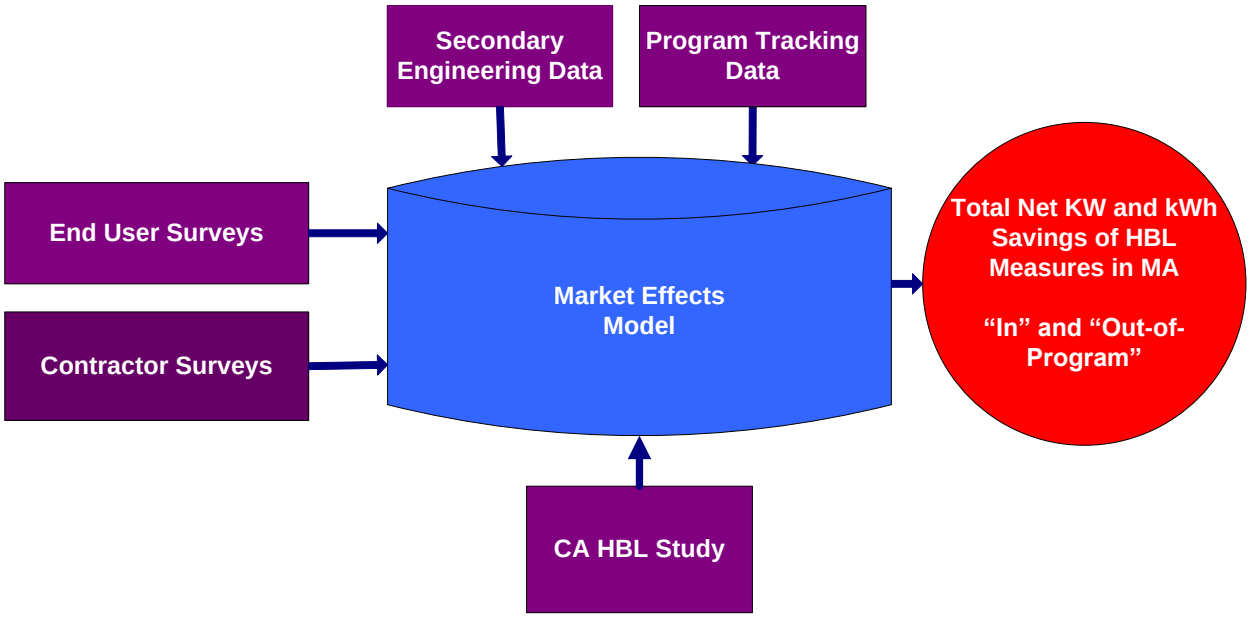
1. Combine data from the Massachusetts end user and contractor surveys with engineering data to estimate total gross demand and energy savings associated with HBL measures (*Sales of All Equipment & Sales of Energy Efficient Equipment* in Figure 1-1).

2. Compare gross savings estimates in Massachusetts to the comparison area savings estimates to identify total program attributable demand and energy savings in Massachusetts (*Program Attributable Energy Savings {dark blue}* in Figure 1-1).

3. Use program tracking data to remove program attributable saving that are currently accounted for by the program (*Program Tracked Sales {In Program}* in Figure 1-1).

4. Assess attribution of untracked energy efficient sales to the PA's energy efficiency programs (*Untracked Spillover* in Figure 1-1).

Figure 2-1: Analytical Framework for Phase 1 of HBL Market Effects Analysis



2.2.2 Data elements

As stated above, KEMA uses data from a variety of sources in the market effects analysis. The two main sources of information include data collected through primary research and data provided by the 2010 California and High Bay Lighting study, and the 2009 Wisconsin Market Effects study.[12] [13] In addition, we employ data from each of the PAs program tracking databases, and obtain engineering data from a number of secondary data sources. We provide a general description of each of these data elements below. A more comprehensive description of these data is provided in Section 3.2.

The primary research effort included telephone surveys as well as in-depth interviews with five key groups of market actors, as presented in Table 2-1.

[12] *High Bay Lighting Market Effects Study: Final Report.* Prepared for the California Public Utilities Commission Energy Division. KEMA June 18, 2010.

[13] *Focus on Energy Evaluation Business Programs: Channel Studies— Fiscal Year 2008*. Prepared for the State of Wisconsin Public Service Commission of Wisconsin. Prepared by KEMA. Final Report: January 17, 2009.

Because, each group of market actors views the HBL market from differing perspectives, they offer additional or sometimes unique pieces to the overall picture of potential market effects attributable to the HBL programs. Table 2-1 indicates the purpose of each data collection effort, the number of completed responses, and the data source(s) used to identify the sample. The end-user and contractor surveys provide the basis for constructing the market effects model we use to estimate the "in program" and "out of program" net energy savings attributable to HBL programs. In addition, each data collection effort provides data used to triangulate the full extent of market effects based on the preponderance of evidence from the various market actor groups.

Table 2-1: Primary data collection plan for HBL market effects analysis

Target population	Purpose of data collection	Type of instrument	Number of completes	Source
End-users	The population of Massachusetts based C&I firms who made high-bay lighting purchases in the past 2 – 3 years provides the estimated total size of the HBL market in the state.	Survey	125	D&B Selectory database
Lighting contractors	Electrical and lighting contractors that specify and install high-bay lighting fixtures and controls provide a broad understanding of the technology shares and specification trends in the HBL services they provide.	Survey	50 target/ (55 completed)	D&B Selectory database
Distributors	Retail firms that sell HBL products to contractors and end users represent a valuable source of information concerning changes in the regional demand for HBL products, as well as trends in the promotion and competitive position of HBL products.	In-depth interview	5	D&B Selectory database
Manufacturers	Companies that produce HBL products are aware of inter-regional differences in the promotion and distribution of energy efficient technologies, and can also provide evidence of production cost changes that may result from increased sales of these products.	In-depth interview	5	KEMA industry contacts
Program staff	Program staff provide information on program design and logic, motivations and barriers to program acceptance, and identify observed market effects.	In-depth interview	5	PA contacts

In addition to primary research data, we use the following three types of data in the analysis:

Control population data – We compared data collected from Massachusetts market actors to a control population consisting of the four-state region used in the 2010 California High Bay

Lighting Study that included Alabama, Georgia, Mississippi, and South Carolina.[14] In addition, we also compare the Massachusetts market actors' responses to a number of survey responses that were examined in Illinois, serving as the control state for the 2009 and 2010 Wisconsin study.[15]

Program tracking data – Each of the five electric PA's provided KEMA with program tracking records that allowed identification of gross and net savings associated with HBL measures. These data are essential for distinguishing between "in program" and "out of program" savings.

Other secondary data – The HBL market effects model requires additional data provided by various engineering databases. Specifically, we obtained data regarding the average lumens per square foot, and information concerning the average number of lumens per watt for different technologies. This is based upon IESNA[16], NYSERDA[17] as well as information provided by RUDD and other lighting manufacturers.[18]

[14] *High Bay Lighting Market Effects Study: Final Report.* Prepared for the California Public Utilities Commission Energy Division. KEMA June 18, 2010.

Final Work Plan Project 1A New Construction Market Characterization. Prepared for the Massachusetts Energy Efficiency Programs in Large Commercial & Industrial Evaluation Contractor (LCIEC). KEMA August 6, 2010.

[15] *Focus on Energy Evaluation, Business Programs: Supply-side Evaluation*. State of Wisconsin, Public Service Commission of Wisconsin. Prepared by PA Consulting and KEMA. April 22, 2010.

[16] Rea, Mark S., Editor-in-Chief. 2000. *IESNA Lighting Handbook,* (New York: Illuminating Engineering Society of North America).

[17] Technical Guide for Effective, Energy-Efficient Lighting. Prepared by The Lighting Research Center Rensselaer Polytechnic Institute for the New York Energy $mart℠ Small Commercial Lighting Program.

[18] Ruud Lighting, *High Bay Lighting Comparison Guide.* www.ruudlighting.com/literature/high_bay_lighting_guide.pdf, Accessed January 26, 2010..

2.3 Organization of report

The remainder of this report is structured as follows:

Methodology – Provides a detailed description of the methodology employed by this study including the sample populations, primary research efforts, and a description of the analytical approach.

Results – Presents results of both the market effects model and additional evidence of market effects based on the preponderance of evidence from market actor surveys and interviews.

Conclusions –Summarizes the market effects analysis, discusses limitations of the analysis, and provides recommendations.

Appendix – We also include the following three appendices at the end of the report:

Appendix A – provides a detailed description of the sampling approach used for each study, response rate and sample weight calculations.

Appendix B provides detailed tabulated results from each market actor study.

Appendix C contains the individual research instruments.

3. Methodology

In order to account for the full range of market effects, our methodology provides specific point estimates of the magnitude of net and gross savings that can be attributed to the program. We further distinguish "in program" from "out of program" net savings, which are defined as follows:

- **In program effects** – Gross and net (i.e. gross less free-ridership) savings from high-bay lighting measures that receive program incentives and are tracked by program tracking records.

- **Out of program effects (spillover)** – Purchases and installations of energy-efficient high bay lighting equipment that are attributable to the program, but did not receive program incentives, and therefore, are not tracked by program tracking data.

The modeled approach we use to estimate program-attributable savings is limited in its ability to isolate a true estimate of untracked spillover (i.e. out-of-program savings that attributable to the program) from savings that results from exogenous factors such as separate building codes and corporate policies. Therefore, we use data provided by market actor surveys to savings resulting from these estimate these exogenous factors, allowing us to isolate untracked spillover from out-of-program savings.

3.1 Study data

3.1.1 Primary research data

As discussed in Section 2, our basic approach to characterizing the market effects of the PAs' programs is to compare the rate of adoption of efficient high bay lighting and related indicators of their market acceptance in Massachusetts to the same indicators in a comparison area. KEMA developed the data for the comparison area, which comprises Mississippi, Alabama, Georgia, and South Carolina in the course of conducting a similar study of programs offered by California utilities. Thus, in developing primary data for the Massachusetts market, we focused on maintaining comparability with the methods and results of the earlier study, and on updating information in the broader market where required by the overall method. For each group of market actors addressed by the study, Table 3-1 shows the availability of control population data from the California HBL studies.

Table 3-1: Summary of Comparison Area Data

Market actor group	Study/Comparison Area		
	CA 2010		MA 2010
	CA	MS, AL, GA, SC	MA
Program Staff	X		X
Manufacturers	X	X	X
Distributors	X	X	X
Contractors	X	X	X
End Users	X	X	X

Table 3-2 summarizes the primary research efforts conducted to obtain data from each of the five groups of market actors in Massachusetts. The table also shows that each market actor survey was also conducted for the California study, and all but the program staff interviews were conducted in the comparison area. For each group of market actors, the table shows the type of instrument used to collect data, the target number of completed surveys and the final number of completed surveys. For both the end user and contractor surveys, more surveys were completed than targeted because a number of respondents returned calls to answer the survey after the quota for their strata were complete.

Table 3-2: Summary of primary research efforts by market actor group

Market actor group	Type of instrument	Target Completes	Completed surveys
End Users	CATI Survey	125	155
Contractors	CATI Survey	50	51
Manufacturers	In-depth interview	5	5
Distributors	In-depth interview	5	5
Program Managers	In-depth interview	5	5

The following provides a brief description of each of these five primary research efforts.

End user surveys

KEMA conducted a detailed survey of 155 HBL end users, who we defined as Massachusetts based C&I firms that installed or replaced high bay lighting in the past three years. End users

were selected using a stratified random sampling approach that controlled for the number of completed surveys by industry and company size.[19] These data provided the basis for estimating the total market size of high bay lighting and energy efficient high bay lighting in Massachusetts. The primary objectives of the end user survey are listed below:

- Estimate the total market for commercial and industrial high bay lighting;
- Determine the share of high bay lighting that is energy efficient;
- Provide evidence of market effects surrounding energy efficient high bay lighting;
- Identify perceived drivers/barriers in selecting energy-efficient high bay lighting;
- Identify decision makers and sources of information regarding lighting choices; and
- Determine the presence of program effects and free-ridership.

End user survey results are weighted to reflect the total number of firms in the D&B database by industry and employee size category for industries within the sample frame.

Contractor surveys

The research team collected data from a sample of 51 high bay lighting contractors (i.e. firms that install high bay lighting fixtures) in Massachusetts. Data collected through this survey are used to apportion estimates of the total market size (provided by the end user survey) by high bay lighting technology. Lighting contractors were selected using a stratified random sampling approach that controlled for the number of completed surveys by company size.[20] Information collected from these interviews is used to estimate the level of adoption of specific HBL technologies in Massachusetts to meet the following objectives:

- Estimate the share of high bay lighting that is energy efficient;
- Determine the share of high bay lighting by technology;

[19] See Appendix C.1 for a detailed description of the end user sampling approach.
[20] See Appendix C.2 for a detailed description of the contractor sampling approach.

- Investigate the promotion and customer adoption of lighting controls;
- Assess the influence of building codes on high bay specification;
- Investigate chain and franchise high bay lighting specification policies; and
- Assess the influence of the program on the promotion and marketing of energy efficient lighting.

Vendor survey responses are weighted to reflect the number of units of reported as sold or installed by the sample establishment as well as by the population weight of the size stratum from which the firm was drawn. Where the questionnaire seeks responses in the form of a number or percentage—say, the percent of fixtures installed that used efficient technologies—survey responses will be calculated using the combined ratio estimator $\hat{R}_c$:

$$\hat{R}_c = \frac{\sum_h \frac{N_h}{n_h} \sum_i B_{h_i} x_i}{\sum_h \frac{N_h}{n_h} \sum_i x_i},$$

Where

i = sample contractor, dealer, or distributor,

N_h = number of vendors in the population in sample stratum h,

n_h = number of vendors in the sample in stratum h,

B_{h_i} = vendor i's response (expressed as a number or percentage), and

x_i = number of units vendor i reported installed in the evaluation period.

If the question elicits a categorical response (e.g., yes/no), a B_{h_i} will be created for each possible response. For the selected response (responses if choose all that apply), B_{h_i} = 1. For the response/s not selected, B_{h_i} = 0.

This procedure essentially weights responses by the reported number of units sold or installed for each sample firm, thus providing an explicit representation of market share.

Lighting distributors and manufacturer interviews

KEMA conducted in-depth interviews with five lighting distributors and five lighting manufacturers in order to provide qualitative evidence of market effects resulting from HBL programs to meet the following objectives:

Provide evidence of sales trends, level of awareness, and attitudes toward energy efficient high-bay lighting;

Investigate the promotion and customer adoption of lighting controls; and

Assess the influence of the program on promotion and marketing of energy efficient lighting.

Program staff

Program Administrator staff represent a rich knowledgebase regarding current and past market trends and program effects. KEMA conducted five interviews with key players from each of the five PA's to meet the following objectives:

- Provide information on program design and logic;
- Identify potential motivations and barriers to program acceptance; and
- Identify observed market effects.

Table 3-3 summarizes the data collected from each of these five market actor groups. We present the sampling plan for each research effort and the actual market actor survey instruments in Appendices A and C, respectively.

Table 3-3: Inventory of primary research by market actor research instrument

Primary research questions	Contractors	End Users	Manufacturers	Distributors	Program Managers
Screening and Firmographics	√	√	√	√	
Sales/Inventory of HLB by technology					
Fluorescent lamps	√	√	√	√	
High pressure sodium	√	√		√	
LED	√	√	√		
Lighting controls	√	√			
Pulse start metal halides	√	√	√	√	
Overall	√	√	√	√	√
Factors influencing lighting choices					
Chains and franchises	√				
State and local building codes	√				
Program incentives	√				√
Reasons for installing	√	√	√	√	√
Awareness of energy efficient HBL products and their benefits	√	√	√	√	
Customer approval of HBL energy efficient technologies				√	
Marketing support and promotion of energy efficient HBL	√	√	√	√	
Recommendations of energy efficient HBL					
Extent recommendations are made	√			√	
Degree recommendations are followed	√			√	
Reasons for recommending	√			√	
Impact of ceiling height on recommendations	√				
Program information					
Awareness		√			√
Descriptions					√
Logic					√
Regional comparisons of energy efficient lighting					
Awareness			√		
Sales			√		
Programs			√		

Table 3-4 summarizes the specific topics covered by each of the market actor surveys and how they relate to the four aforementioned general research questions. The table shows that we collected data from each of the five market actor groups to address a range of topics pertaining to each of the four general research questions. We asked each group of market actors at least one set of questions pertaining to each of the general research topics. For example, all market actors were asked questions pertaining to sales of energy efficient HBL. Because of their limited perspective, end users were only asked about their own purchases of energy efficient HBL. Contractors, distributors, and manufacturers have a broader view of the market and are therefore able to provide insight into sales trends across multiple end users as well as other market actor groups.

Table 3-4: Topics covered by market actor group and general research question

Research question	Topics covered	Contractors	Distributors	End Users	Manufacturers	Program Staff
Have HBL energy efficiency measures resulted in increased energy efficient HBL installations?	Changes in sales of energy efficient HBL	√	√		√	√
	Impact of program on sales of energy Efficient HBL	√	√			
	Recommendations concerning energy efficient HBL products	√	√			
	Regional differences in energy efficient HBL sales				√	
	Sales of HBL by technology	√		√		
Have HBL energy efficiency measures resulted in increased knowledge and awareness of energy efficient HBL technologies?	Attitudes towards energy efficient HBL		√		√	
	Awareness of benefits of energy efficient HBL	√				
	Awareness of HBL programs	√		√		
	Awarenss of program incentives		√	√		
	Evidence of spillover			√		
	Knowledge of energy efficent HBL technologies	√	√	√		√
Have HBL energy efficiency measure resulted in increased marketing and promotional activity of energy efficient HBL technologies?	Benefits in promoting energy efficent HBL				√	
	Influence of marketing support on promotion		√			
	Influence of marketing support on sales		√			
	Influence of programs on promotional activity	√	√			√
	Extent of market actor promotion of energy efficent HBL	√	√	√	√	
	Marketing activities for energy efficient HBL	√				
	Regional differences in promotion of energy efficient HBL				√	
	Sources of information for energy efficient HBL			√		
	Sources of marketing support		√			
	Trends in promotion of energy efficient HBL				√	√
	Types of promotional activity for energy efficent HBL				√	
Has the market for energy efficient HBL products seen an overall reduction to market barriers, such as production and distribution costs?	Influence of chains and franchises on HBL choices	√				
	Influence of building codes on HBL choices	√			√	
	Influence of corporate policies on HBL choices					
	Other factors influencing HBL choices	√	√	√	√	
	Future market trends				√	
	Objections to energy efficient HBL	√				
	Program effectiveness					√

3.1.2 Comparison area data

Our analysis isolates market effects resulting from the Massachusetts PAs HBL program measures from naturally occurring trends in the HBL market. In order to distinguish program induced market effects from naturally occurring trends, we compared our modeled energy savings to savings resulting from energy efficiency sales in a non-program region, the comparison area. The comparison area represents the baseline level of energy efficient technology adoption. However, due to widespread adoption of HBL programs among many states, only a limited number of suitable comparison states currently exist. Therefore, our analysis uses the comparison population from the 2010 California HBL study to identify the total program attributable market effects savings resulting from naturally occurring sales of energy efficient HBL.

3.1.3 Secondary data

The market effects model we used to derive estimates of net program savings requires two critical data elements derived from secondary sources: the lighting requirements of the space illuminated by new HBL purchases; and the installed efficacy of that equipment. The former is measured in terms of average lumens per square foot, while the latter provides a measure of the average watts per lumen of recent purchases. In order to use the control group from the 2010 California HBL study to construct the model for our analysis, we base our estimates of these two values on the same data inputs and assumptions used in the California study, but adjust the calculations to reflect the mix of HBL space and technology shares in Massachusetts. The following provides a brief description of these data elements.

Lumens per square foot –KEMA obtained the standard lighting levels for various types of high bay spaces from IESNA.[21] These estimates are then applied to the distribution of high-bay spaces provided by the Massachusetts end user survey to obtain the average lumens per square foot associated with recent HBL purchases.

[21] IESNA recommended lighting levels and CLP lighting power allowances from the New York State Energy Research and Development Authority Commercial Lighting Program, http://www.nyserda.org/sclp2/technicalGuide/about/avgIlluminance.asp?section=1.1.7, accessed February 2, 2010.

Lumens per watt – For each of the HBL technologies analyzed, we used the estimated number of lumens per watt. These data were derived from the IESNA *Lighting Handbook,*[22] *and Ruud*.[23] The IESNA *Lighting Handbook*[24] indicates that initial lighting levels of HBL technologies should be set such that the amount of lighting installed will provide a recommended lighting level after 40 percent of the fixtures' rated life has elapsed. In addition, lighting levels should be further adjusted to reflect ceiling height. We estimated the average lumen per watt installed for Massachusetts and the comparison area fixture sales by applying the results of the technology share analysis to the design efficacy of the various technology types.

3.1.4 Program tracking data

A key input to the HBL market effects model is the gross MWh savings for HBL measures. KEMA used the PA provided program tracking data to develop an operational definition of HBL measures. The tracking data did not specifically call out HBL measures, but did identify the lighting products covered. Therefore, the evaluation team employed the following steps to define HBL measures for this analysis:

1. Non-Lighting measures were excluded;
2. Data for years prior to 2006 were excluded;
3. Measure descriptions were screened for the terms "high bay", "T5," "pulse start metal halide," and
4. Following PA reviews, additional HBL measures were identified, including some high intensity fluorescent fixtures and occupancy controls.

3.2 Market effects model

Figure 3-1 provides a visual representation of the market effects model. The top half of the diagram shows the data inputs and processes we used to estimate the total MW resulting from recent HBL purchases in Massachusetts (MW installed). The bottom half of the diagram shows

[22] Rea, Mark S., Editor-in-Chief. 2000. *IESNA Lighting Handbook,* (New York: Illuminating Engineering Society of North America).

[23] Ruud Lighting, *High Bay Lighting Comparison Guide.* www.ruudlighting.com/literature/high_bay_lighting_guide.pdf, Accessed January 26, 2010.

[24] Rea, Mark S., Editor-in-Chief. 2000. *IESNA Lighting Handbook,* (New York: Illuminating Engineering Society of North America).

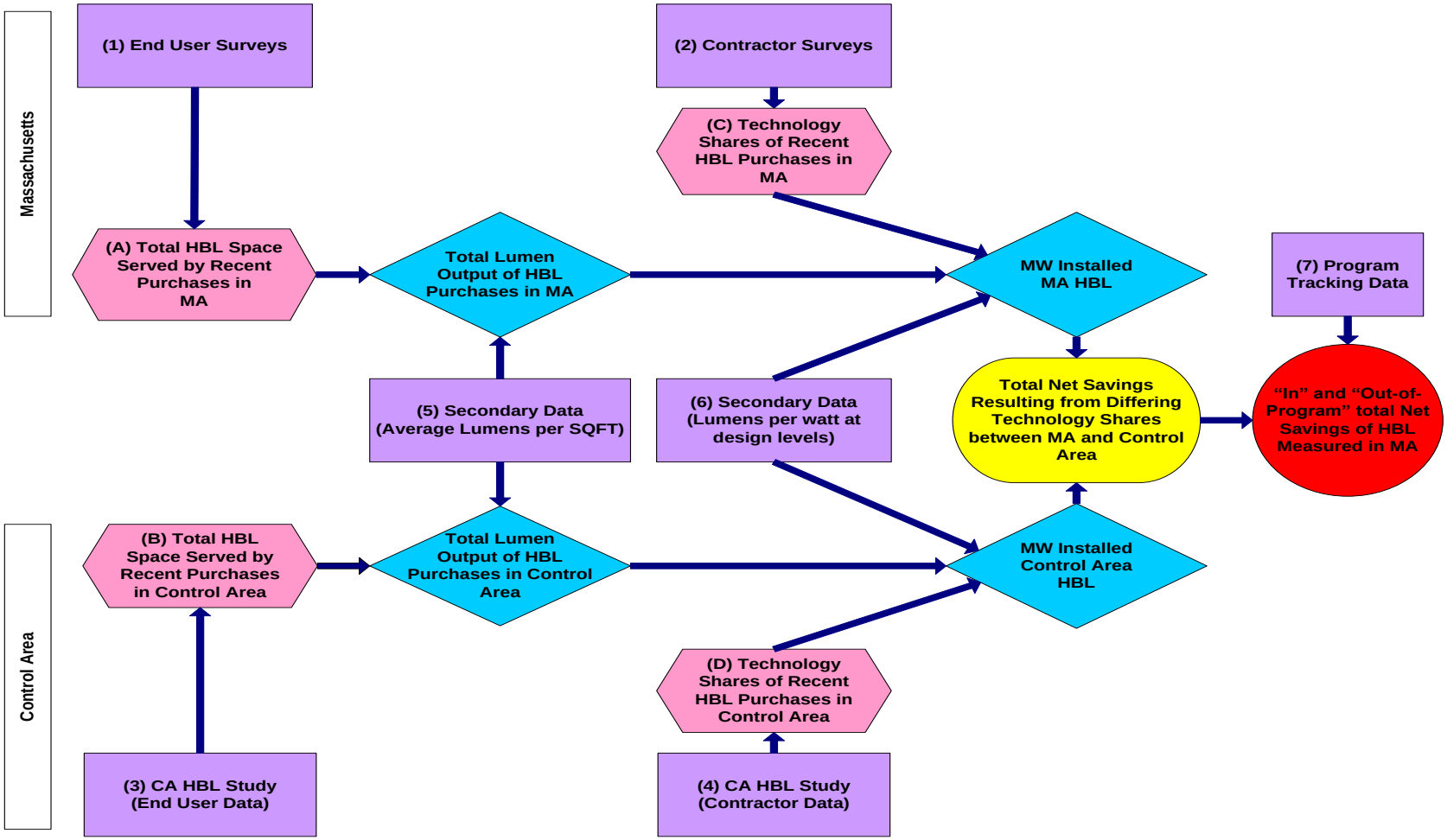
data and processes used to estimate the MW installed for the control population. We identify data inputs to the modeling process using purple rectangles. The pink hexagonal shapes represent processes in which we have synthesized data inputs, while the blue diamonds depict intermediary outputs.

Starting in the top half of the diagram first, the process of estimating MW installed in Massachusetts begins with the end user surveys, which we used to obtain the estimated square footage served by recent HBL purchases. Next, we incorporated engineering data concerning the average lumens per square foot for buildings in Massachusetts to estimate total lumen output of recent HBL purchases in Massachusetts. Third, we combined the estimated total lumens requirements of recent HBL purchases with engineering estimates of the average watts per lumen, and the contractor reported technology shares associated with recent HBL purchases. This provides us with the estimated MW installed in Massachusetts.

The bottom half of the diagram shows that we use the same process to estimate the number of MW that would be needed to provide lighting levels required by current standards to C&I high bay spaces in Massachusetts, assuming baseline levels of efficiency.[25] Next, we subtract the MW installed in the control area from the mega-watts installed in Massachusetts to arrive at the difference in installed MW that corresponds to the difference in the market share of energy efficient high bay lighting equipment between Massachusetts and the comparison area. Finally, incorporating the program tracking data supports an estimate of the portion of the difference in MW installed that is associated with program participants on the one hand, and with non-participants on the other. These correspond to “in program” measure adoptions and “out-of-program” measure adoptions respectively.

[25] Note the market effects model uses the control population from the 2010 California HBL study.

Figure 3-1: Graphical Overview of the Market Effects Model



3.3 Market effects model calculations

This section outlines the specific calculations KEMA uses in the market effects model to estimate "in-program" and "out-of program" net savings associated with the PAs HBL measures. The model we developed is similar to the model employed by the 2010 California HBL market effects study. We first discuss the specific modeling steps. These steps include the following:

1. **Estimation of market Size** – In this step, we estimated the total square footage associated with HBL purchases made in Massachusetts and the comparison area. Equation 1 below shows how we first estimated the population weighted total number of end users that made HBL purchases in both Massachusetts and the comparison area over the study period. Equation 2 shows how we translated the number of HBL purchases in the total square footage of HBL purchases in each region. As was seen in Figure 2-1, data for each of these calculations were obtained from the Massachusetts and California end-user surveys.

Equation 1: Number of end users making HBL purchases

Total end users who made HBL purchases in Massachusetts or comparison region	=	Population of end users	X	Percent end users with HBL	X	Percent of end users with HBL that made purchases during the study period

For a detailed description of end user and contractor weighting, see Section 3.1

Equation 2: Total high bay space impacted by HBL purchases

Total SQFT of High Bay Space Impacted by HBL purchases in Massachusetts or Comparison Region	=	Total end users who made HBL purchases in Massachusetts or comparison region	X	Average square feet of facilities	X	Average percent of facility that is high bay (i.e. > 15ft)	X	Percent of high bay space impacted by recent HBL purchases

For a detailed description of end user and contractor weighting, see Section 3.1

2. **Calculate the lumen requirements of HBL purchases** – In this step, we used engineering data provided by NYSERDA to translate the surface area impacted by recent HBL purchases from Step 1 into the total lighting requirement of the lit space. This process involved classifying facilities by industry into various building types. We then obtained engineering guidelines from NYSERDA that identify the lumen requirements of each space type. Finally, based on the percent of high bay space associated with recent purchases in each space type, we calculated the average lumen requirements of each region.

3. **Estimate the technology shares and wattage installed**: For both Massachusetts and the comparison area, we identified the percent of HBL purchases that employ different HBL technologies through surveys of lighting installation contractors, which were weighted according to the percent of all HBL projects completed by each respondent. We combine these technology shares with information pertaining to the average lumens per watt as identified by the *IESNA Lighting Handbook* to obtain the average efficacy of HBL purchases in each region.

4. **Estimate demand and energy use reductions in Massachusetts and the comparison area (total program attributable savings)** – In this step, we multiplied the surface area impacted by HBL purchases in Massachusetts by the average efficacy for purchases in each region (from Step 3) to estimate the average efficacy of HBL purchases in each region. Then, we subtracted the efficacy associated with purchases in the comparison region from those in Massachusetts to estimate the demand reductions in Massachusetts, net naturally occurring savings that are present in the comparison area. Finally, we multiplied the demand savings by an assumed value for average annual hours of use estimate program-attributable savings.

5. **Separate total savings into "in-program" and "outside the program" –** In this step, we subtract the tracked net savings provided by each of the PAs from the modeled result in step 4 to identify those savings attributable to the program.

As previously stated, we analyzed survey results from a broad range of market actors to provide supplemental evidence of market effects. In contrast to the modeled approach outlined above, this portion of the analysis relies on a preponderance of evidence obtained from primary research to determine the extent of program related changes to market share, availability, design specification, marketing practices, production costs, awareness, and perceptions of energy efficient HBL products.

4. Results

In this section, we present the results of our estimates of net savings based on the market effects model we defined in the previous section. First, the presentation of results follows the model development process as we identify the survey and other data collection results used as model inputs. After developing the final model, we present the resulting savings estimates for HBL measures in Massachusetts. Finally, we present additional evidence of market effects identified through the analysis of the various market actor surveys.

4.1 Market effects model results

To show how the market effects model results were calculated, this section describes the processes used in all five steps of the model.

4.1.1 Estimation of Market Size

The first step in estimating the savings attributable to HBL measures is to estimate the total market for HBL purchases over the past four years in both Massachusetts and the control area. Of course, it would be best to have information on the number, type, and wattage of fixtures sold for use in high bay spaces in Massachusetts. However, no market actors keep track of that kind of information. We therefore developed and implemented a multi-step method to estimate the number of fixtures sold and the total installed wattage they represent. As a first step, we defined the total market as the floor space served by HBL purchases over the study period. This value provided a limit to potential savings resulting from energy efficient HBL purchases. In the absence of published HBL purchase data, our estimate of HBL purchases in Massachusetts were based on the end-user survey results, while the control area estimates were derived from the 2010 California HBL study. Estimating the total floor space served by recent HBL purchases required the following two steps:

- Estimate the number of end users who purchased HBL during the study period; and
- Calculate the total square footage associated with those purchases.

Table 4-1 below presents the calculated number of end users who made HBL purchases during the study period for both Massachusetts and the control region. For comparison purposes, we also present the calculations used in the 2010 California HBL study. Due to the timing of the two studies, data collected through the CA study are reported for 2006 through 2008, while the Massachusetts data are reported for 2007 through 2010. As seen in Table 4-1, the estimated

number of end users who made HBL purchases was calculated in two steps. First, we estimated the number of end users with HBL by multiplying the population of end users by those who have HBL. Then, we multiplied the number of end users with HBL by the percent of end users who made purchases during the study period to obtain the estimated number of end users who made purchases during the study period.

Table 4-1: Estimates of Market Size: Number of HBL purchases from 2007 to 2010

Row	Metric	Massachusetts[1]	Comparison Area[2]	California[2]	Notes/Sources
1	Population of End-Users	22,679	37,608	59,413	Dun & Bradstreet Selectory Database: Manufacturing + Selected Commercial NAICS codes
2	% with High Bay Spaces	67.7%	23.0%	30.70%	Customer Surveys.
3	Population of End-Users w/ High-bay Spaces	15,355	8,650	18,252	Row 1 * Row 2.
4	Percent of end-users w/ high bay spaces who purchased high bay lighting	75.8%	25.5%	28.50%	Customer Surveys
5	***End users who purchased high bay lighting***	11,642	***2,203***	***5,203***	Row 3 * Row 4

1. Massachusetts end users – 2007 to 2010 purchases
2. Comparison area and California end users 2006 to 2008 purchases

Table 4-1 shows that the total number of end users in Massachusetts is lower than both California and the comparison region, however, the percent that made HBL purchases is significantly higher. Table 4-2 below presents the structural characteristics of facilities in Massachusetts relative to the comparison California areas, thus providing insight into the difference in HBL purchases. First, this table shows that the average floor space of Massachusetts facilities is much smaller than in the comparison area and California. In addition, a greater proportion of Massachusetts firms have ceilings greater than 15 feet. As seen in Table B-23 in Appendix B, facilities in the comparison area report that a greater share of their high bay space consists of ceilings that are 25 feet or higher. Therefore, Massachusetts' facilities are smaller with lower ceilings in their high bay spaces, while the larger facilities in the comparison area have less high bay space, but with greater ceiling heights.

Table 4-2 presents the estimation process for total floor space impacted by recent HBL purchases. Row two of the table shows the average square footage of recent HBL purchases in each region, while row three presents the percent of the respective facility space that is high bay

(i.e. greater than 15 feet). The product of these two values provides the average high bay space at each facility (Row 4). Multiplying the Row 4 value by the number of end users purchasing HBL (Row 1) and the average percent of high bay space served by the HBL purchase (Row 5) provides an estimate of the floor space served by the HBL purchases.

Table 4-2: Estimates of Market Size: Square feet served by 2007 – 2010 purchases

Row	Metric	Massachusetts[1]	Comparison Area[2]	California[2]	Notes/Sources
1	***End users who purchased high bay lighting***	11,642	***2,203***	***5,203***	Table 4.1 Row 5
2	Average square feet of purchasers' facilities	70,801	128,880	203,258	Customer Survey
3	Percentage of facility sf with ceiling height > 15 f	75%	68%	61%	Customer Survey
4	Average square feet of high bay space	53,285	87,638	123,987	Row 2 * Row 3
5	Average percent of high bay space served by 2006 – 2008 purchases	75%	56%	71%	Customer Survey
6	***Total square feet of space served by purchases***	***466.9 million***	***107.8 million***	***458.1 million***	Row 1 * Row 4 * Row 5

4.1.2 Lighting requirements of HBL purchases

Once we identified the amount of space impacted by HBL purchases, the next step was to determine the lighting requirements of the lit space. This step required first that we estimate the distribution of total floor space served by HBL purchases according to use. We then apply lighting design and engineering standards to estimate the number of lumens required to provide adequate illumination in those spaces.

Table 4-3 shows that the average lumens per square foot of high bay space associated with recent HBL purchases in Massachusetts is 40.2. The derivation of this estimate required the following steps:

1. We identified the floor space (in square feet) from Dunn & Bradstreet's Selectory database across the population of end users identified in the sampling plan presented in Appendix A. We grouped high bay space in each NAICS code according to the buildings types shown in Table 4-3.

2. Next, we similarly grouped end user survey responses by the nine building types listed and identified the percent of each building type that is high bay.

3. Multiplying the total floor space in each building type by the percent of space that is high bay provided the estimated total high bay space for each building type.

4. We then divided the high bay space in each building type by the roughly 620 million sq ft of high bay space in Massachusetts to obtain the percent of all high bay space in Massachusetts located in each building type.

5. Using NYSERDA data on lumens per square foot by building type and the percent of high bay space by building type, we calculated the weighted average of lumens per square foot across all Massachusetts facilities.

6. Finally, we multiplied the 466.9 million square feet of high bay space in Massachusetts by 40.2 lumens per square foot to estimate the total lumen output of HBL purchases, equal to 18,773 lumens.

Table 4-3: Estimate of Lumens of HBL Installed

Building Sector	Surface area (SQFT)[1]	Percent of space in building sector that is high bay[2]	High bay space in MA[3]	Percent of all MA high bay space accounted for by building sector	LUM/SF[4]
Office	23,582,043	58%	13,562,269	2%	30
Restaurant	6,441,349	89%	5,759,146	1%	10
Retail	112,163,262	90%	100,390,606	16%	30
Food Store	31,979,546	79%	25,209,796	4%	50
Warehouse	12,310,009	71%	8,698,499	1%	14
School	179,317,861	26%	45,887,441	7%	30
Health	34,651,050	89%	30,906,658	5%	50
Miscellaneous	158,092,781	92%	145,758,382	23%	34
Manufacturing	305,297,010	80%	244,154,252	39%	50
Total/Average	**863,834,913**	**72%**	**620,327,049**	**100%**	**40.2**

1. Non-Manufacturing: Dun & Bradstreet Selectory Database. 2010. Manufacturing source: U.S Bureau of Census. 2002 Economic Census. Table 1: Selected Statistics by Economic Sector.
2. Massachusetts end user survey. KEMA 2010.
3. (Total square feet) X (Percent of Space that is High Bay; 620 million sqft X .75 = 467 million sqft of high bay space served by purchases from 2007 to 2010.
4. Technical Guide for Effective, Energy-Efficient Lighting. Prepared by the Lighting Research Center Rensselaer Polytechnic Institute for the New York Energy $mart[SM] Small Commercial Lighting Program.

4.1.3 Estimation of Technology Shares and Wattage Installed

Once we identified the average lighting requirements of lit space in Massachusetts, the next step was to convert lumens to the necessary energy requirement necessary to provide the desired lighting levels. The translation from lumens to wattage depends upon the distribution of technologies used to produce the light provided. Consequently, this step accounts for changes in technology shares between Massachusetts and the comparison area and corresponding differences in energy consumption between the two regions.

We obtained data concerning the share of various lighting technologies from both the contractor and end user surveys. Because contractors are exposed to multiple projects across multiple firms and industries, they maintain a broader view of HBL technology adoption. Therefore, contractor survey responses provided the basis for the distribution of HBL projects across the various technologies.

As seen in Table 4-4, the distribution of lighting technologies in Massachusetts is very similar to California, except for “HID: Pulse start metal halide” and “Other: Technologies such as Induction or LED.” The “Other” category includes regular incandescent as well as more efficient LED and

induction fixtures. Analysis of the verbatim responses to the "Other" category from Massachusetts contractors revealed that a number of the largest contractors have moved away from program sponsored bulbs and are now primarily installing LED fixtures. This finding indicates that contractors recognize the benefits of energy efficient lighting, absent program incentives. This table also shows that Massachusetts and California contractors report substantially higher shares of T-5 fluorescent tubes than the comparison area.

Table 4-4: Contractor-reported Technology Shares of High Bay Lighting Installations

Technology	Massachusetts[1]	Comparison Area[2]	California[2]
Fluorescent Tube: T-5/ Electronic Ballast T-5	64%	29%	65%
Fluorescent Tube: T-8 /Electronic Ballast T-8	13%	16%	14%
Fluorescent Tube: All other, including T12/Magnetic Ballast	1%	11%	1%
HID: Pulse-start metal halide	3%	31%	14%
HID: High-pressure sodium	1%	8%	3%
HID: Other HID such as mercury vapor or probe-start metal halide	1%	3%	1%
Other: technologies such as Induction or LED	17%	2%	2%

1. Massachusetts contractor shares for 2007 to 2010
2. Comparison area and California contractor shares for 2008

Table 4-4 presents initial and design level efficacies for each lighting technology. The *IESNA Lighting Handbook* indicates that lighting design levels should reflect the expected amount of lighting after 40 percent of the fixture's useful life. KEMA recognizes that actual installation levels may differ from recommended, but in the absence of data to suggest the appropriate we adjusted the design level efficacy to account for an average installation levels, we assume, on average the data in Table 4-5 are representative of actual practices. In addition, design efficacies should be adjusted downward to account for ceiling height. As seen in the last column of Table 4-5, ceiling height of 27 feet. We estimated the average lumen per watt installed for the Massachusetts and comparison area fixture sales by applying the results of the technology share analysis to the design efficacy of the various technology types.

Table 4-5: Efficacy of High Bay Lighting Technologies

	Efficacy: Lumens/Watt		
Technology	Initial	Design (40% of Rated Life)	Adjusted for Height & Fixture Efficiency
Fluorescent Tube: T5HO/Electronic Ballast T5HO	93	88	66
Fluorescent Tube: T-8 /Electronic Ballast T-8	92	88	68
Fluorescent Tube: All other including T-12	62	58	45
HID: Pulse-start metal halide: 250w	95	64	43
HID: Pulse-start metal halide: 400w	110	78	53
HID: High-pressure sodium	96	78	53
HID: Other HID probe-start metal halide: 250w	82	54	36
HID: Other HID probe-start metal halide: 400w	100	65	44
Other: technologies such as Induction or LED	70	62	47

Based on the information in Tables 4-4 and 4-5, we estimated the average lumens per watt at design levels for HBL using the technology shares in Massachusetts and the comparison area as follows:

1. Massachusetts technology shares = 61.6. lumens per watt; and
2. Comparison area technology shares = 56.01 lumens per watt.
3. Dividing each of these through by 18,773, the total lumen output of recent HBL purchases, provides the separate estimates for the number of MW installed to meet the lumen requirements of Massachusetts HBL purchases.
4. MW Massachusetts efficacy = 18,774 lumens / 61.6. lumens per watt = 304.7 MW
5. MW comparison area efficacy = 18,774 lumens / 61.6. lumens per watt = 335.2 MW
6. Finally, dividing the MW installed at each efficacy level by the total square footage served by Massachusetts HBL purchases provides the watts per square foot required to provide the necessary lumen output served by Massachusetts HBL purchases under each efficacy level.

Using this approach we estimate the following values for watts per square foot in both Massachusetts and the comparison area:

- Watts per Square foot Massachusetts efficacy = 304.7 MW / 466.7 sqft = 0.65 watts/sqft
- Watts per Square foot Comparison area efficacy = 335.7 MW / 466.7 sqft = 0.72 watts/sqft

4.1.4 Estimation of Demand and Energy Use Reductions: Massachusetts and the Comparison Area

In this section, we describe the process by which the model inputs identified above are combined to estimate the total program-attributable savings.

Table 4-6 below details the steps used in this computation. In the first step of this calculation, we combined the technology shares for each region and the corresponding efficacy of each technology to obtain the estimated efficacy of purchases in each region (Rows 2 and 3). Next, we estimated the total MW of HBL purchased in both regions by dividing the total number of square feet (Row1) by the lighting efficacy for purchases in each region, Rows 2 and 3 respectively. Subtracting the MW installed in the comparison area (Row 5) from that in Massachusetts (Row 4) provided the difference in baseline and actual installed capacity (Row 6), 30.5 MW. Finally, we multiplied this difference by an assumed estimate of average annual operating hours (2,975 hours) to estimate the difference in energy consumption between the program and comparison areas, 90.7 GWh/year.[26] This value represents our estimated total program-attributable energy savings. Because this estimate removes savings associated with naturally occurring sales of energy efficient high bay lighting (i.e. sales in the no program comparison area), it represents total program-attributable savings only.

[26] For comparison purposes, the 2010 CA study found 97.2 GWh/year in annual savings.

Table 4-6: Demand and annual energy use reductions

Row	Item	Value	Notes/Sources
1	Total square feet served by 2007 – 2010 HBL Purchases	466.9 million	Estimated from MA end-user survey
2	Average watts per square foot (lighting power density): Program Area Efficacy	0.65 w/sf	Estimated based on technology share results from the MA contractor survey
3	Average watts per square foot (lighting power density): Baseline Efficacy	0.72 w/sf	Estimated based on technology share results from the Comparison Area contractor survey
4	Total MW of high bay lighting purchased: Program Area	304.7 MW	Row 2 * Row 1
5	Total MW of high bay lighting purchased: Baseline Efficacy	335.2 MW	Row 3 * Row 1
6	**Difference in MW installed: Program Area v. Baseline Efficacy**	**30.5 MW**	Row 5 – Row 4
7	**Difference in GWh/Year Usage: Program Area v. Baseline Efficacy**	**90.7 GWh/Year**	Row 6 * average annual operating hours per – 2,975 hours/year

4.1.5 Savings "Outside the Program" and Attribution to Program Effects

In the final step in the modeling process, we separated the 90.7 GWh of savings into "in-program" and "out-of-program" savings. The former are savings that receive program incentives and are consequently tracked by program records. Therefore, this step in the analysis used the average net savings estimates provided by the PA's program tracking data to distinguish between "in-program" and "out-of-program saving" net savings.

Program tracking data KEMA obtained from each of the five PAs contained 8,044 transactions that were likely to have involved high bay lighting over the past four years. These data are summarized in Table 4-7 which presents the number of rebates and fixtures, as well as gross and net energy savings. The table shows HBL measures account for over 145 GWh in gross and 137 GWh in net savings since 2007. However, the data clearly demonstrate that tracked savings are not constant throughout the time period. Specifically, the initial level of savings in 2007 and 2008 is much higher than that seen in the latter two years, particularly, 2010. In order to reduce the impact of higher in-program savings realized in the early part of the study period, we use the 2010 level of program tracked savings to account for program tracked net and gross savings.

Table 4-7: HBL Gross GWh Savings

	2007	2008	2009	2010	Total 2007-2010
Number of Rebates	1,338	2,326	2,018	2,362	8,044
Gross KWH	41,583,334	37,146,575	35,117,719	31,429,898	145,277,526
Net KWH	42,291,102	34,118,482	32,990,534	27,646,559	137,046,677

* 2010 Net to gross ratio 88%

As seen in Table 4-8, we identified savings associated from "out-of-program" adoptions by subtracting annual program tracked net savings from the modeled estimate of program-attributable savings.

Table 4-8: Energy Savings Associated with out of program adoptions

Row	Calculation Step	Value
1	Energy savings associated with adoption of efficient HBL technologies, net of baseline adoptions. Conceptually this quantity includes net savings estimated through *Protocol* methods (adjusted gross savings * (1-free ridership rate))	90.7 GWh/Year
2	Net savings estimated via 2010 impact evaluations (program transactions only)	27.6 GWh/Year
3	**Savings from out-of-program adoptions, net of baseline adoptions: Row 1 – Row 2**	**63.0 GWh/Year**

Difference of 0.1 due to rounding

In summary, our market effect model identifies 90.7 GWh/year in savings associated with energy efficient HBL purchases in Massachusetts. We further separate these savings into 27.6 GWh of "in-program" and 63.0 GWh of "out-of-program" savings. However, this estimate of "out-of-program" net savings includes true program-attributable savings, also called spillover, as well as savings that may result from other factors that influence the market in Massachusetts but not in the comparison area. Such factors might include building codes and standards, as well as corporate purchase and construction practices that have evolved over time. While the market effects model does not distinguish between spillover and energy efficient sales resulting from exogenous factors, the analysis of additional evidence of market effects presented in Section 4.2 includes a qualitative analysis of these factors.

4.1.6 Addressing uncertainty in high bay space and purchase assumptions

The research team constructed two additional scenarios to address the uncertainty concerning the percent of Massachusetts firms reporting to have high bay space and the percent that indicated making HBL purchases in the past four years. In order to address this uncertainty, we estimated total savings due to the adoption of energy efficient HBL technologies under the following three scenarios:

1. **Scenario 1** – Assumes 67.7 percent of end users have high bay space and 75.8 percent of those firms made HBL purchases between 2007 and 2010, as identified by the Massachusetts end user survey. This serves as our baseline savings estimates and provides the same estimate of in-program and out-of-program savings identified above.

2. **Scenario 2** – Averages the Massachusetts and California results for each of these parameters, providing 49.2 percent of firms with high bay space, and 52.2 of those firms making purchases during the study period.

3. **Scenario 3** – Assumes the same percent of end users have high bay space and percent of those firms made HBL purchases as identified by the survey of California end users, 30.7 percent and 28.5 percent, respectively.

Table 4-9 below presents the results of each of these scenarios. The data clearly show that using the percentages directly from the Massachusetts end user survey (Scenario 1) provides a relatively high estimate of program tracked and out-of-program savings. The results from Scenario 2, result in 45.3 GWh/year in savings, which provides for 17.7 GWh/year in out-of-program savings. Finally, Scenario 3, which assumes the same level of high bay space and purchase activity as the California high bay lighting study actually provides less savings than is currently tracked by Massachusetts program records at only 15.5 GWh/year in savings, which is exceeded by the 27.6 GWh/year in program tracked savings, resulting in negative 12.2 GWh/year in out-of-program savings. This suggests that the California study under estimates savings associated with energy efficient HBL purchases.

Table 4-9: Alternate scenarios for estimated in-program and out-of-program savings

Savings measure	Scenario 1: [a] MA high bay space and purchase parameters	Scenario 2: [b] Average MA and CA high bay space and purchase parameters	Scenario 3: [c] CA high bay space and purchase parameters
Energy savings associated with adoption of efficient HBL technologies, net of baseline adoptions. Conceptually this quantity includes net savings estimated through *Protocol* methods (adjusted gross savings * (1-free ridership rate))	90.7	45.3	15.5
Net savings estimated via 2010 impact evaluations (program transactions only)[d]	27.6	27.6	27.6
Savings from out-of-program adoptions, net of baseline adoptions: Row 1 – Row 2	63.0	17.7	(12.2)

a. Assuming MA end user survey findings: 67.7% of end users with high bay space; 75.8% made HBL purchases
b. Assuming CA end user survey findings: 30.7% of end users with high bay space; 28.5% made HBL purchases
c. Assuming average of MA and CA end user survey findings: 49.2% of end users with high bay space; 52.2% made HBL purchases
d. The electric PAs report 3.8 GWh per year attributable to free ridership

Although we do not have evidence to suggest that estimates of the percent of the population with high bay space and who made recent HBL purchases as provided by the Massachusetts end user survey are indeed incorrect, KEMA recommends the level of savings provided by Scenario 2 as a conservative estimate for total savings resulting from energy efficient HBL in Massachusetts.

4.2 Preponderance of evidence of market effects results

In this section, we provide evidence of market effects based on the results of primary research data obtained from each of the five groups of market actors. As discussed in section 3.3, we categorized survey and interview questions from each research instrument according to four general research questions. Under each research question, we separated the relevant survey and interview questions into specific topics, allowing for comparison within each topic across market actor groups. This approach allowed us to triangulate market effects based on evidence provided by the spectrum of market actors being considered.

This section is divided into four sub-sections, in which we present research findings relevant to the four research questions. Within each sub-section, we provide a summary table that organizes the findings from each group of market actors under the topics covering the respective research question. For the contractor and end-user results, we identify those findings that show a statistically different result from the comparison population at either the 90 or 95 percent confidence level. In each table, we also indicate whether the result demonstrates positive, negative or neutral evidence of market effects.

4.2.1 Research Question 1: Have HBL energy efficiency measures resulted in increased energy efficient HBL installations?

Table 4-10 below summarizes the research findings relevant to Research Question 1, that the program has resulted in increased installations of energy efficient HBL and controls. While much the information relevant to this research question is used in the market effects model above, including this research question allows us to contrast sales trends across market actors. We divide information pertaining to this research question into five topics: Sales of HBL by technology; Changes in sales of energy efficient HBL; Impact of programs on energy efficient HBL; Recommendations concerning energy efficient HBL products; and Regional differences in energy efficient HBL sales.

Table 4-10: Research question 1: Have HBL energy efficiency programs resulted in increased energy efficient HBL installations?

Topics Covered	Market Actor Group	Evidence	Statistical Significance	Direction of Effect
Sales of HBL by technology	Contractors	Contractors report T5 fluorescent tubes accounted for 64% percentage of all fixtures used in high bay situations in Massachusetts relative to 29% in the comparison area , and 28% in IL.	90%	positive
		Only 6% of projects reported by contractors in Massachusetts installed pulse start metal halide fixtures compared to 31% in the comparison area.	95%	neutral
		Contractors representing 46% of Massachusetts HBL projects report installing occupancy sensors compared to 22% in IL.	95%	positive
		17% of projects reported by contractors in Massachusetts installed "other" HBL types including induction LED and incandescent. Adoption of LEDs and induction is a positive effect indicating increased focus on energy efficient lighting, but incandescent is a negative effect indicating less efficient lighting.	90%	neutral
	End Users	End users report 79% of high bay space in MA served by fluorescent tube fixtures compared to 55% in the comparison area	95%	positive
		68% of end users who installed fluorescent tubes report installing T8's and 37% report T5's compared to 45% and 16% in the comparison area	95%	positive
		22% of end users who installed fluorescent tubes report installing induction lights compared to 5% in the comparison area	90%	negative
		80% end users who installed HID fixtures report installing pulse star metal halide compared to 14% in the comparison area	95%	positive
		43% end users report installing occupancy or motion sensors and 26% installed daylight controls compared to 12% and 3%, respectively, in the comparison area	95%	positive
		23% installed daylight controls compared to 14% in the comparison area	not sig	positive
Changes in sales of energy efficient HBL	Contractors	Contractors that represent 78% of projects report high bay fluorescent lighting has increased over the last two years compared to 76% in the control region.	not sig	neutral
		Contractors that represent only 7% of projects report high bay pulse start metal halide lighting has increased over the last two years compared to 35% in the control region.	95%	negative
	Distributors	2/5 distributors report increased sales of fluorescent HBL fixtures over the past 2 years.	na	neutral
		4/5 distributors report increased sales T5 fluorescent HBL has lead to a decline in metal halide sales.	na	positive
	Manufacturers	All five manufacturers report that their sales of fluorescents for high bay applications have increased in the last two years, and that the trend toward increasing sales of fluorescents for HBL applications will continue, but are divided about the applicability of these trends to Massachusetts.	na	positive
		Two reported that their HID sales had increased, one reported a decrease, and two others don't manufacture the technology and/or didn't answer. Their comments suggested that none of the five consider this technology a major area of investment or emphasis going forward.	na	neutral
		Four of five manufacturers agree that fluorescent HBLs T-5s and T-8s responsible the technologies responsible for their MA HBL sales.	na	positive
	Program Staff	Three PAs report that HBL sales have increased, while two do not know.	na	positive

Table 4-11: Research question 1: Have HBL energy efficiency programs resulted in increased energy efficient HBL installations?

Topics Covered	Market Actor Group	Evidence	Statistical Significance	Direction of Effect
Impact of program on sales of energy Efficient HBL	Contractors	Contractors that represent 87% of projects rate the importance of utility programs on the market share of energy efficient HBL 8-10 out of 10 compared to only 73% in California	not sig	positive
	Distributors	2/5 distributors report increased sales of fluorescent HBL fixtures due to rebates. These two rate the program 8-9 out of 10 in its effectiveness.	na	positive
		2/5 rate the program 2-3 out of 10 in its effectiveness.	na	negative
	Manufacturers	Three respondents identified the role of utility programs and/or rebate levels as responsible for greater sales in the northeast, CA, and the mid-west.	na	positive
Recommendations concerning energy efficient HBL products	Contractors	Contractors that represent 82% of projects report customers follow their recommendations for energy efficient HBL all or most of the time relative to 75% in the comparison area.	not sig	positive
	Distributors	4/5 distributors report that they always recommend energy efficient HBL to contractors. One reports only sometimes recommending energy efficient fixtures.	na	positive
		4/5 distributors report that contractors generally accept recommendations for energy efficient HBL .	na	positive
Regional differences in energy efficient HBL sales	Manufacturers	Three of the five manufacturers consider the East /Northeast region, or Massachusetts specifically, to be the national leader in terms of their HBL sales.	na	positive
		While MA programs are viewed as successful, three of the 5 manufacturers rank CA programs as most effective in promoting energy efficient HBL. They site the need to reduce paper work and streamline the process as them main limitation of the MA programs. One felt Massachusetts is most effective.	na	neutral

Key findings from the information presented in Table 4-7 include the following:

Sales of HBL by technology

Table 4-11 illustrates that Massachusetts has a well-formed market for energy efficient HBL and controls. We found corroborating evidence of extensive market share of these products across market actors. Our survey of end users found that a statistically significant share of Massachusetts firms reported that a greater share of overall HBL purchases were for T5 and T8 fluorescent fixtures and pulse start metal halide than in the control area. In addition, we found that end users in Massachusetts also report that a greater number of projects included various lighting controls.

We found that the evidence provided by lighting contractors is somewhat less clear. While these firms do report that a greater share of installations includes fluorescent fixtures than in the comparison area, this result is not statistically significant. However, contractors representing

roughly 17 percent of projects in Massachusetts report installing “Other” fixture types, including LEDs and induction. Further analysis of these responses revealed that a number of the largest contractors did, in fact, indicate that they install LED fixtures, which is possibly the result of a shift in the market toward energy efficient products. In addition, we found that contractors report that a lower percent of Massachusetts projects specified pulse-start metal halide fixture than in the comparison area. We identify this as a negative effect on program attributable market effects because these are program-sponsored fixtures, thus lower sales implied that the program has not resulted in increased sales and market effects are lessened. While this finding represents a negative market effect, additional evidence provided by each group of market actors concerning this technology reveals that these fixtures are at a strategic disadvantage to fluorescent fixtures, LEDs, and other types of energy efficient HBL due to delayed strike time. Consequently, we believe that lower sales of these fixtures do not necessarily detract from the positive effects resulting from increased fluorescent fixture sales.

Changes in sales of energy efficient HBL

In contrast to the first topic, which looked at the sales (or market) share of different technologies, information contained under this topic allowed us to examine the change in sales of energy efficient HBL products. Since end users are only able to report on sales to their own facility, their perceptions of sales trends are limited. Therefore, we limit information presented under this research topic to the remaining four groups of marker actors. Information obtained from these market actors suggest that the change in sales over time provides a less clear indication of market effects than sales (or market) shares of energy efficient products.

Our examination of these data suggests that this finding may result from a variety of factors that include the timing of this market effects study, market saturation, and transition to newer, more advanced energy efficient technologies. For example, while manufacturers are split on whether pulse start metal halides sales have increased or decreased over time, they are in agreement that HIDs are not a major investment are for them. This result is seen across market actors, as contractors and distributors also report declining sales of metal halides.

Although market actors are in agreement that sales of fluorescent fixtures have increased, they do not consistently reported that these changes took place over the past two years. For example, only two out of five distributors reported that fluorescent fixture sales increased over the past two years. While manufacturers also reported increased sales of fluorescent fixtures, they cannot specifically identify that Massachusetts sales increased. Finally, contractors

reported a greater proportion of Massachusetts projects involve T5's and T8's than the comparison area, but this result was not statistically significant.

Impact of programs on energy efficient HBL

Our analysis shows that programs have a positive impact on the sale of energy efficient HBL. The overwhelming majority (87 percent) of Massachusetts' contractors reported that programs are important determinants of the share of energy efficient HBL. While the results also show that distributors are split on the effectiveness of the HBL programs, the two distributors who rated the program's effectiveness low expressed frustration with paperwork as their reason. The remaining two distributors who answered the question rate the program very high in terms of its effectiveness. Manufacturers also indicated that the programs are successful in increasing sales, although, once again are less supportive of pulse-start metal halide fixtures.

Recommendations concerning energy efficient HBL products

Market actors are actively recommending energy efficient HBL products in Massachusetts. Four out of five distributors report that they always recommend energy efficient HBL to contractors. The remaining distributor indicates they sometimes make such recommendations, but not always. However, this distributor also indicated that they are typically not able to make recommendations because contractors arrive with a pre-defined bill of goods to fulfill. In addition, contractors that represent the vast majority of projects (82 percent) state that end users follow their recommendations for energy efficient HBL lighting always or most of the time.

Regional differences in energy efficient HBL sales

Data pertaining to this topic come from manufacturers who are exposed to HBL sales across the country. Three of the five firms interviewed indicate that Massachusetts is a leader in energy efficient HBL sales. However, only one felt that nationally, Massachusetts programs are the most successful in promoting sales. While three others indicated that while Massachusetts is successful, it lags California due to the excessive paperwork requirements associated with the programs.

4.2.2 Research Question 2: Have HBL energy efficiency programs resulted in increased knowledge and awareness of energy efficient HBL technologies?

Table 4-12 below summarizes research findings relevant to Research Question 2 which examines whether the programs have resulted in increased knowledge and awareness of energy efficient HBL technologies. We divide information pertaining to this research question into four topics: Attitudes towards energy efficient HBL; Awareness of the benefits associated with energy efficient HBL; Awareness of HBL programs; and Knowledge of energy efficient HBL technologies. We present a summary of our findings on each these topics in the discussion that follows.

Attitudes and awareness of energy efficient HBL

Table 4-12 shows that both distributors and manufacturers reported favorable attitudes towards energy efficient HBL products. All five of the distributors interviewed reported that they received favorable feedback from contractors regarding energy efficient HBL products. Further, all five manufacturers indicated that energy efficient lighting is an essential part of their corporate strategy. Although this finding is not specific to Massachusetts, when coupled with the fact that these manufacturers feel Massachusetts leads the pack in terms of energy efficient products, it provides a powerful indication that the PA's programs play a significant role in shaping attitudes in the industry.

Awareness of the benefits of energy efficient HBL

The results of these questions indicate that awareness of energy efficient HBL lighting technologies is high in Massachusetts, but could still improve. Contractors who represent nearly two thirds of all HBL projects indicated that customers are aware of the full range of options for energy efficient HBL before undertaking their projects, although, this result is not statistically different from the comparison area. In addition, while contractors indicated that energy savings drive a substantial share of HBL projects, 11 percent also indicated that greater education and training are needed. Further, contractors that represent 41 percent of projects reported that concern or awareness about saving energy is a determining factor in the choice of HBL equipment in Massachusetts. However, we also found that three out of 5 distributors reported that contractors are aware of the full range of benefits of energy efficient HBL, indicating that contractor awareness still remains high.

Table 4-12: Research question 2: Have HBL energy efficiency measures resulted in increased knowledge and awareness of energy efficient HBL technologies?

Topics Covered	Market Actor Group	Evidence	Statistical Significance	Direction of Effect
Attitudes towards energy efficient HBL	Distributors	All 5 distributors report that they receive positive feedback form contractors regarding fluorescent HBL.	na	positive
	Manufacturers	All five manufacturers report that energy efficient lighting plays a major role in their corporate strategy.	na	positive
Awareness of benefits of energy efficient HBL	Contractors	Contractors that represent 41% of Massachusetts projects indicate that concern/awareness about saving energy are main factors in determining the market share of high bay fluorescent lighting in the next two years relative to 22% in the comparison area.	not sig	positive
		Contractors that represent 0% of Massachusetts projects indicate that concern/awareness about saving energy are main factors in determining the market share of high bay pulse start metal halide lighting in the next two years relative to 2% in the comparison area.	90%	negative
		Contractors that represent 11% of Massachusetts projects report that greater education for contractors/architects is needed to increase the installation of energy-efficient high bay lighting in the commercial and industrial sectors.	na	negative
		Contractors that represent 63% of Massachusetts projects indicate that the majority of customers are aware of the full range of options for energy-efficient high bay lighting available to them before they provide recommendations about the lighting system compared to 17% in the comparison area	na	positive
	End Users	44% of end users in MA who installed fluorescent HBL heard of the technology through a previous projects compared to 38% in the comparison area.	not sig	positive
		60% of end users in MA who installed pulse-start metal heard of the technology through previous projects compared to 0% in the comparison area.	95	positive
	Distributors	Three of 5 distributors report that contractors are aware of the full range of energy efficient options for HBL.	na	positive
	Program Staff	Three PA's indicate that customer awareness of energy efficient products has increased in the past two years, while the remaining tow indicate that is has increased more over the past five years.	na	positive
Awareness of HBL programs	Contractors	Contractors that represent 82% of projects are aware of utility sponsored energy efficiency programs	na	positive
	End Users	61% of end users are aware of programs for HBL compared to 52% in CA	95%	positive
	Distributors	All five distributors are aware of utility programs. Four of the five participate in the programs. On of the five indicated that rebates are handled solely by contractors.	na	positive
	Distributors	Two of five distributors attribute increased sales to program incentives	na	positive
Knowledge of energy efficient HBL technologies	Contractors	68% of end users heard of fluorescent HBL equipment prior to their recent HBL purchase in Massachusetts compared to 53% in the comparison area.	not sig	neutral
		28% of end users had not heard of fluorescent HBL equipment prior to their recent HBL purchase in Massachusetts compared to 43% in the comparison area.	90%	positive
	Distributors	All 5 distributors believe T5 fluorescent bulbs are energy efficient, while 4 of five believe T8's are energy efficient. Three of 3 distributors believe pulse start metal halides are energy efficient, while two did not respond. Two of three distributors believe LED's are energy efficient.	na	positive
	Manufacturers	All five manufacturers consider T5 and T8 fluorescent bulbs are energy efficient	na	positive
		Three of 5 manufacturers consider pulse start metal halide fixtures to be energy efficient based on lumens per watt.	na	positive
	Program Staff	All PA's believe customer awareness is high.	na	positive

Awareness of HBL programs

Contractors, end users, and distributors all report a high level of awareness of efficiency programs. However, we see that 11percnet of contractors report that increased education is needed. We identify this finding as a negative impact on market effects as it demonstrates that the Massachusetts electric PA's have not been effective in providing sufficient education to contractors regarding energy efficient lighting options..

Knowledge of energy efficient HBL technologies

Our findings reveal that market actors are very knowledgeable about energy efficient technologies in Massachusetts, thus suggesting the programs are successful in educating end users, contractors, and distributors. Contractors that represent over two-thirds of all HBL projects indicated that end users were knowledgeable of efficient technologies prior to projects.

4.2.3 Research Question 3: Have HBL energy efficiency programs resulted greater marketing and promotional activity of energy efficient HBL technologies by market actors?

The extent to which market actors promote and market energy efficient technologies provides a valuable indicator of the presence of program induced structural changes in the HBL market. Thus far, our analysis shows that market actors reported substantial sales of energy efficient HBL. Further, the market actors reported that sales in Massachusetts are higher than other regions of the country and attribute that increased level of activity to the success of HBL programs. We also found that knowledge, awareness and acceptance of energy efficient HBL products is relatively high in Massachusetts, although a number of market actors reported the need for increased education and training regarding the benefits of energy efficient technologies.

We now turn our analysis to an examination of marketing and promotional activity concerning the technologies sponsored by the HBL programs. Increased product promotion is a signal that market actors have established efficient marketing channels and recognize existing business advantages of the program sponsored products beyond the program incentives. Table 4-13 summarizes information pertaining to Research Question 3. Key findings from this analysis are provided below.

Table 4-13: Research question 3: Have HBL energy efficiency programs resulted greater marketing and promotional activity of energy efficient HBL technologies by market actors?

Topics covered	Market Actor Group	Evidence	Statistical Significance	Direction of Effect
Extent of market actor promotion of energy efficient HBL	Contractors	Contractors that represent 74% of projects report talking directly to customers to promote energy efficient high bay lighting technologies	na	positive
		Contractors representing 66% of Massachusetts HBL projects report recommending occupancy sensors compared to 21% in IL.	95%	nuetral
		Contractors representing 73% of Massachusetts HBL projects report recommending energy efficent HBL always or most of the time compared to 86% in the comparison area and 80% in CA. This difference is statistically not significant. By comparison, contractors represetngin 90% of IL projects report recomending T5 or T8 fluroesecent fixtures, while only 80% of WI projects installing these technologies wererecomended by contractors	not sig	nuetral
	End Users	For 9% of end users in MA who installed pulse-start metal the contractor recommended using them compared to 15% in the comparison area.	not sig	negative
		For 80% of end users in MA who installed fluorescent tubes, the contractor recommended using them compared to 67% in the comparison area.	not sig	positive
	Distributors	Four of 5 distributors report that contractors do generally accept the distributor's recommendations for energy efficient products. The fifth reported that contractors typically cannot accept them because they have a pre-established bill of materials.	na	negative
		All five distributors recommend energy efficient lighting options, and 4 of the 5 make such recommendations "always", one does so "sometimes".	na	positive
	Manufacturers	Only 1 of the 5 manufacturers interviewed does any promotion directly to customers, and this is only for the five percent of their sales that originates with national accounts.	na	neutral
Sources of information for energy efficient HBL	End Users	47% of end users in MA who installed pulse-start metal heard of the technology through lighting vendors compared to 3% in the comparison area.	95%	positive
		53% of end users in MA who installed fluorescent HBL heard of the technology through lighting vendors compared to 19% in the comparison area.	95%	positive
		26% of end users in MA who installed pulse-start metal heard of the technology through architects and engineers compared to 3% in the comparison area.	90%	positive
		13% of end users in MA who installed fluorescent HBL heard of the technology through architects and engineers compared to 6% in the comparison area.	not sig	neutral
		13% of end users in MA who installed pulse-start metal heard of the technology through utility representatives compared to 0% in the comparison area.	not sig	neutral
		10% of end users in MA who installed fluorescent HBL heard of the technology through utility representatives compared to <1% in the comparison area.	not sig	neutral

Table 4-14: Research question 3: Have HBL energy efficiency measure resulted in increased marketing and promotional activity of energy efficient HBL technologies?

Topics covered	Market Actor Group	Evidence	Statistical Significance	Direction of Effect
Sources of marketing support	Distributors	Four of 5 distributors indicate they do not receive any market support from manufacturers. One of the 5 did receive brochures from a manufacturers and ran a joint promotion with them.	na	neutral
Trends in promotion of energy efficient HBL	Manufacturers	Three of 5 manufacturers report increased HBL promotion, one a decrease and one reported no change.	na	positive
Types of promotional activity for energy efficient HBL	Manufacturers	Three of the 5 manufacturers utilize discounting and pricing mechanisms	na	positive
		One of the 5 manufacturers mentioned cooperative advertising	na	positive
		One of the 5 manufacturers uses calculation tools and one mentioned their website	na	positive
		Two also described their training efforts (e.g. training, webinars, and/or regional distributor presentation).	na	positive
		Other methods mentioned by manufacturers include: weekly special offers, direct mail, and telemarketing	na	positive
Influence of marketing support on promotion	Distributors	Four of the 5 distributors had received no marketing support for their HBL product offers from manufacturers.	na	negative
		One of 5 distributors received brochures from the manufacturer. They reported that such marketing support is effective and can increase sales, but would have marketed the HBL products without this marketing support.	na	neutral
Influence of programs on promotional activity	Contractors	Contractors that represent 61% of projects rate the importance of utility programs on their promotional activity 8-10 out of 10.	na	positive
	Distributors	Two of 4 distributors who responded rated the influence of program promotion (8-9) out of 10, while gave ratings of 2-3 out of 10.	na	neutral
Benefits in promoting energy efficient HBL	Manufacturers	Three of 5 manufacturers report an increase in HBL promotion in order to capitalize on the growth in customer interest due to the incentives, and their internal investment in better promotional vehicles: new fixture lines, new website/ social media investments.	na	positive
Regional differences in promotion of energy efficient HBL	Manufacturers	None of the five manufacturers see any difference in their marketing strategy in Massachusetts relative to the rest of the country.	na	neutral
		Four of the 5 manufacturers agreed that Massachusetts distributors are more active in promoting energy efficient products than are distributors in other parts of the country.	na	positive

Extent of market actor promotion of energy efficient HBL

Information provided by contractors, end users, and distributors clearly shows that market actors are engaged in extensive promotion of energy efficient HBL products in Massachusetts. Contractors representing nearly three-quarters of all HBL projects reported promoting energy efficient technologies through talking directly to customers. This information is corroborated by the 80 percent of end users who installed fluorescent HBL that learned about this technology from their contractor. Finally, we see that distributors also actively promote energy efficient HBL, with 4 out of 5 always making recommendations.

Our findings also show that market actors do not actively promote pulse-start metal halides in Massachusetts, due to their relatively lower efficiency and less desirable product attributes. This is consistent with our earlier finding that pulse-start metal halides are a lagging technology.

Sources of information for energy efficient HBL

Table 4-15 shows that HBL measures resulted in the increased promotion of energy efficient fluorescent fixtures and, to a lesser extent, pulse-start metal halide lamps. We find that a significantly greater proportion of end users in Massachusetts reported that lighting vendors as the primary source of information concerning high bay fluorescent fixtures and pulse-start metal halide lamps than in the comparison area. In addition, we also found that significantly more end users in Massachusetts learn about pulse-start metal halide lamps from architects and engineers than in the comparison region. While not statistically different from the comparison area, we also note that over one-quarter of Massachusetts' end users hear of pulse-start metal halide lamps from architects and engineers. Finally, utility representatives are also a major source of information concerning fluorescent and pulse-start metal halide HBL.

Influence of programs on promotional activity

Contractors and distributors indicated that utility programs have a high degree of influence on their level of promotional activity. In addition, our analysis of regional differences in promotional activity showed that all five manufacturers indicated that Massachusetts distributors are more active in promoting energy efficient HBL than in other regions of the country.

4.2.4 Research Question 4: Have market barriers either impeded the effectiveness of, or been reduced by energy efficient HBL programs?

Whereas the first three research questions focused primarily on the presence or absence of positive indicators of market effects, the fourth research question examines a number of factors that may limit the effectiveness of HBL programs. Specifically, we considered the role of market barriers in the determination of market effects. In the analysis that follows, we review research findings that identify the extent to which market externalities lessen savings attributable to the HBL programs. We also examine the degree to which the programs have worked to reduce some of these external barriers. For topics represented in this table, we do not interpret the findings as positive or negative as this characterization is ambiguous or not relevant for many of the topics listed.

Table 4-15 presents a summary of the research findings relevant to Research Question 4. We categorize these findings into the following five topics: Influence of chains and franchises and other corporate policies; Influence of building codes; Impact of LEDs; Other factors influencing HBL choices; and Objections to energy efficient HBL.

Table 4-15: Research question 4: Have market barriers either impeded the effectiveness of, or been reduced by energy efficient HBL programs?

Topics covered	Market Actor Group	Evidence	Statistical Significance
Influence of chains and franchises and other corporate policies on HBL choices	Contractors	Contractors representing 61% of projects installed lighting at a chain or franchise in the past.	na
		Of those contractors who had installed lighting at a chain or franchise, 25% of projects were for chains or franchises.	na
		Contractors representing 58% of projects performed by firms who worked with chains and franchises indicate the customer had predefined lighting specifications, 100% of which required energy efficient lighting.	na
		93% of those chain and franchise projects had the same specifications across all locations of the firm.	na
	End Users	38% of end users have a corporate head quarters relative to 44% in the comparison area.	not sig
		60% of the end users that have a corporate headquarters (i.e. 60% of 38%) indicate that the head quarters is responsible for decisions concerning lighting relative to 40% (40% of 44%) in the comparison area.	90%
		36% of end users in MA report have corporate environmental policies compared to 49% in the comparison area	90%
		Of those firms with an environmental policy, 95% of firms in MA indicate that energy management is a part of that policy relative to 80% in the comparison area.	90%
Influence of building codes on HBL choices	Contractors	Contractors representing 97% of HBL projects are aware of MA building codes for HBL.	na
		Of those contractors aware of codes, 11% said codes influenced their selection of HBL equipment on 91% of their projects. So codes influenced lighting selection on 97% x 11% x 91% = 9.7% of projects.	na
		Of those 9.7% of projects influenced, 46% had a level of influenced rating 5-7/10, while 54% had a rating of 8-10/10.	na
	Manufacturers	Three of the four manufacturers indicate that standards are helping their business.	na
		Finally, three of the five manufacturers report that efficiency legislation at the federal level has the most impact on their HBL business. Whereas they previously dealt with a relative handful of states, the role of the federal government (e.g., through EPACT) and other federal-level activities like LEED now take a much greater share of their attention.	na
LED's impact on the market	Manufacturers	There is strong consensus that customer LED sales will also increase. These trends are attributed variously to: a) continued technology improvements; b) cost declines, bringing the technology into customer reach; and c) the "cool" factor – *"and the fact that people just think LEDs are cool – early adopters want to move with it."*	na
		LEDs are unlikely to be suited for applications over 20'. Above 30' HID will prevail because of the lighting quality. HB LEDs are also unsuited for locations subject to temperature build-up, as LED life is affected by heat. LED applications in retail may also be limited by the amount of glare that merchandisers will find acceptable.	na
	Contractors	A number of the largest contractors report currently only selling LEDs	na

Table 4-16: Have market barriers either impeded the effectiveness of, or been reduced by energy efficient HBL programs?

Topics covered	Market Actor Group	Evidence	Statistical Significance
Other factors influencing HBL choices	Contractors	Contractors representing 11% of projects report that the versatility of new technologies influences customer choices for Massachusetts compared to 0% in the comparison area.	not sig
		Contractors representing 32% of projects report that the lower price of new technologies influences customer choices in Massachusetts compared to 0% in the comparison area.	not sig
		Contractors representing 12% of projects report that the rebates influence customer choices in Massachusetts compared to 1% in the comparison area.	not sig
		Contractors representing 14% of projects report that the better light of new technologies influences customer choices in Massachusetts compared to 16% in the comparison area.	not sig
	Contractors	Contractors representing 94% of projects report that the cost of electricity influences customer choices in Massachusetts compared to 21% in the comparison area.	95%
		Contractors representing 6% of projects report that the lower price of new equipment influences customer choices in Massachusetts compared to 31% in the comparison area.	90%
	Manufacturers	Strike time is a major obstacle for this technology	na
	End Users	34% of end Massachusetts end users report saving energy is their primary reason for choosing specific lighting technologies compared to 20% in the comparison area.	not sig
		22% of end Massachusetts end users report saving money is their primary reason for choosing specific lighting technologies compared to 30% in the comparison area.	not sig
		28% of end Massachusetts end users report improving the light quality is their primary reason for choosing specific lighting technologies compared to 20% in the comparison area.	not sig
	Distributors	Four of five distributors report that contractors site many commercial advantages of the fluorescent high-bay products: "instant on" capability (no requirement for cooling between on-off operations); low maintenance costs; high energy savings; high lumen/Watt; and long life expectancy.	na
Objections to energy efficient fluorescent HBL	Contractors	Contractors representing 22% of projects report that the price of the equipment is a primary objection in Massachusetts compared to 24% in the comparison area.	not sig
		Contractors representing 5% of projects report that the light quality is a primary objection in Massachusetts compared to 6% in the comparison area.	not sig
		Contractors representing 2% of projects report that reliability is a primary objection in Massachusetts compared to 11% in the comparison area.	not sig
		Contractors representing 11% of projects report that maintenance costs are the primary objection in Massachusetts compared to 15% in the comparison area.	not sig
		Contractors representing 66% of projects report no objections to installing in fluorescent HBL Massachusetts compared to 17% in the comparison area.	95%
	Contractors	Contractors representing 11% of projects report that the price of the equipment is a primary objection in Massachusetts compared to 9% in the comparison area.	not sig
		Contractors representing 3% of projects report that the light quality is a primary objection in Massachusetts compared to 0% in the comparison area.	not sig
		Contractors representing 10% of projects report that maintenance costs are the primary objection in Massachusetts compared to 3% in the comparison area.	not sig

Influence of Chains and franchises on energy savings from HBL programs

Chains and franchises (C&F) are businesses which operate multiple locations under some degree of corporate management. Because many C&F firms are regional or national, their corporate policies may be governed by regulations in other regions of the country. C&F firms that have their own internal design practices requiring energy efficient lighting reduce total program effects because energy efficient installations at these facilities cannot be attributed to the program. However, the extent to which these firms set policies that address lighting specifications is not known. While the evaluation team is conducting a more comprehensive examination of these businesses under Project 1B of the 2011 EM&V, we used the primary research effort conducted for this market effects study as a means of gaining initial insight into the influence these firms exert on lighting design standards. The research team asked contractors to report on the influence of C&F internal design policies on the specification of HBL projects in Massachusetts. We used this information to provide an estimate of the amount of savings attributable to these C&F policies. Equation 3 below presents out estimate of these energy savings.

Equation 3: Influence of C&F corporate policies on savings from HBL programs

Percent of projects represented by contractors who have installed HBL for a C&F		61%	
Percent of those contractor's projects that were installed at a C&F	X	25%	
Percent of those C&F projects that had predefined lighting specifications	X	58%	
Percent of those specifications that required energy efficient lighting	X	100%	
Percent of those C&F establishments that have the same codes across establishments	X	93%	
Percent of all projects influenced by C&F building specifications		8.2%	
Total HBL savings in MA	X	45.3	GWh
Savings resulting from building codes		3.7	GWh

Using information reporting the percent of projects that involved C&F firms, the percent of those firms with lighting specifications, and the percent that have the same specifications across establishments, we estimated the percent of all HBL projects influenced by C&F lighting specifications. Multiplying this value by our modeled estimate of the total energy savings

attributable to HBL efficiency programs provided an estimate of the amount of savings from C&F lighting specifications.[27] This amount should be subtracted from the out-of-program savings estimate provided in section 4.1.5. In addition to policies set by C&F firms, we also investigated the influence of other corporate policies on HBL specifications. For this information, we relied on data collected through the end user survey. Equation 4 presents our analysis of the savings that result from these policies.

As seen in equation 4, we estimated the amount of savings resulting from corporate policies by first multiplying the percent of end users with a corporate headquarters by the percent whose headquarters is responsible for lighting decisions. Next, we multiplied this product by the percent of firms who have a corporate sustainability policy and the percent of those whose sustainability policy includes energy management. This provided our estimate of the percent of end users with internal policies that influence lighting, roughly 8 percent. Multiplying this result by 45.3 GWh, gives our estimate of savings resulting from corporate policies, roughly 3.5 GWh.

Equation 4: Influence of corporate policies on savings from HBL programs from end user survey results

End users that have a corporate head quarters		38%	
The percent of end users that have a corporate headquarters who is responsible for decisions concerning lighting	X	60%	
36% of end users in MA report have corporate environmental policies	X	36%	
Firms with an environmental policy in which energy management is a part of that policy	X	95%	
Percent of end users with internal policies that influence lighting	X	7.8%	
Total HBL savings in MA	X	45.3	GWh
Savings resulting from corporate policies		3.5	GWh

[27] See Section 4.1.3: KEMA recommends using the Scenario 2 level of savings, 45.3 GWh.

Influence of Building codes on energy savings from HBL programs

In addition to corporate policies, the influence of building codes impacts the degree to which savings are attributable to HBL programs. Specifically, savings from projects in which lighting specifications are restricted by building codes should not be included in program-attributable savings. Therefore, we used data collected from contractors to estimate the share of savings for which building codes are responsible. This calculation is shown in Equation 5 below.

To estimated the share of savings attributable to building codes we started with the percent of projects represented by contractors that are aware of building codes governing HBL (97 percent). This is multiplied by the by the percent of projects associated with contractors who say codes influenced their HBL lighting choices (11 percent), and then by the percent of their projects that are influenced by codes (91 percent). This provides the percent of all projects influenced by codes, (7.4 percent). Next, we weight that 9.7 percent by the level of influence of codes on those projects. From the table we see that 46 percent of the 9.7 percent are 60 percent influenced by codes (46% x 60% x 9.7% = 2.7% of projects), while 54 percent of the 9.7 percent are 90 percent influences (54% x 90% x 9.7% = 4.71% of projects). The sum of these two provides the 7.4% of projects impacted by building codes, which when multiplied by 45.3 GWh of total HBL savings in Massachusetts yields our estimate of savings attributable to building codes, 3.4 GWh.[28]

[28] See footnote 27.

Equation 5: Savings resulting from building codes

Percent of projects represented by contractors who are aware of codes influencing HBL choices		97%	
Percent of projects represented by contractors who say codes influence their lighting choices on projects	X	11%	
Percent of those contractor's projects in which codes have an influence	X	91%	
Percent of all projects influenced by codes		9.7%	
Percent of codes with 50-70% influence	X	46.0%	
Percent of codes with 80-100% influence	X	54.0%	
Percent of all projects influenced by codes weighted by the degree that the code influence of lighting		7.4%	
Total HBL savings in MA	X	45.3	GWh
Savings resulting from building codes		3.4	GWh

LED's

Increased adoption of LEDs provides an indication of a shift in the market toward greater awareness and demand for energy conservation. Our analysis shows that both contractors and manufacturers are focused on the greater use and production of LEDs. As previously stated, a number of the largest contractors report only selling LED's which leads to our estimated contractor shares of "other HBL" of 17 percent. However, it is important to note that LEDs are just one of the technologies included in the "other" category. One possible explanation for this shift is that lower cost program sponsored technologies are responsible for demonstrating the benefits associated with life-cycle cost savings that result from energy efficient fixtures. The realization of these savings has resulted in willingness to adopt innovative technologies at a higher acquisition cost, provided they demonstrate life-cycle cost savings.

However, manufacturers' interviews cautioned that the extent to which LED's are able to displace fluorescent fixtures is limited because they are unlikely to be suited for applications above 20 feet due to problems associated with light dispersion, or in applications that require limited glare.

Other factors influencing HBL choices

Table 4-17 presents a number of additional factors that influence HBL decisions. Looking at end users, we see that cost is a primary concern of specific HBL technologies. This is particularly true in Massachusetts relative to the comparison area. However, the fact that end users are also driven by concerns for energy savings suggests that they may link costs and energy savings, particularly in today's climate of sustained elevated energy prices.

Contractors that represent only 12 percent of Massachusetts HBL projects reported that rebates are a primary factor in determining lighting choices, while 32 percent indicate that lower prices of new technologies are a driving factor. In addition, our analysis shows that, while greater education is still needed, Massachusetts distributors report that contractors are aware of the benefits of energy efficient HBL. However, this result cannot be compared to the comparison group as only five Massachusetts distributors were interviewed. Provided acquisition costs continue to decrease and/or new products are able to realize even greater efficiency, then relatively high fuel prices coupled with product acceptability provides the appropriate market conditions for sustained energy savings resulting from HBL products.

4.3 Spillover effects

In this section, we incorporate the findings in section 4.2 into the "out-of-program savings" estimates calculated in Section 4.1 to isolate the true out-of program savings (i.e. spillover) from savings resulting from C&F and corporate policies and building codes. As discussed in Section 4.2, savings resulting from these additional sources do not represent program-attributable savings because they come from exogenous factors, rather than from program-related market effects.

While savings from corporate policies and building codes should be removed from out of-program savings, we must account for uncertainty regarding the degree to which these estimates are independent of one another. This is because our estimate of C&F policy savings is based on data provided by the survey of contractors, while the estimate of corporate policies is based on the survey of end users. Further, we could not determine whether any of the corporate policies are in response to building codes. Finally, there is uncertainty concerning the extent to which corporate policies are in response to Massachusetts efficiency programs. Therefore, we examined spillover under the following three separate scenarios to account for this uncertainty:

A. Savings derived from C&F policies, corporate policies, and building codes are independent (i.e. 100 percent additive);

B. Savings derived from C&F policies, corporate policies, and building codes overlap by 50 percent (i.e. 50 percent additive); and

C. Savings derived from C&F policies, corporate policies, and building codes are not additive.

Table 4-17 shows our estimate of spillover under Scenario A in which the three sources of exogenous savings are independent. Under this scenario, our estimate of total exogenous savings is 10.6 GWh/year, which we subtract from the 17.7 GWh/year of out-of-program savings calculated above. This leaves 7.1 GWh of savings from spillover and 34.7 GWh/year in total program-attributable savings.

Table 4-17: Scenario A spillover calculation C&F, corporate policy, and building code savings independent (100 percent additive)

Row	Metric	Savings GWh / year	Calulation
1	Savings resulting from C&F policies	3.7	
2	Corporate policies	3.5	
3	Savings resulting from building codes	3.4	
4	Senario A: Three savings are indepent (100 percent additve)	10.6	(Sum Row 1, 2, 3)
5	Savings from out-of-program adoptions net of baseline adoptions (Table 4.6	17.7	
6	**Senario 1 Spillover savings**	**7.1**	(Row 1 - Row 2)
7	Net savings estimated via 2010 impact evaluations	27.6	(Table 4.6)
8	**Total Program attributable savings**	34.7	(Row 7 + Row 8)

Next, Table 4-18 presents our estimate of spillover under Scenario B in which the three sources of exogenous savings are only 50 percent independent. Under this scenario, our estimate of total exogenous savings is 5.3 GWh. Subtracting this from the 17.7 GWh of out-of-program savings leaves 12.4 GWh/year in spillover savings and 40.0 GWh/year in total program-attributable savings.

Table 4-18: Scenario B spillover calculation C&F, corporate policy, and building code savings 50 percent additive

Row	Metric	Savings GWh / year	Calulation
1	Savings resulting from C&F policies	3.7	
2	Corporate policies	3.5	
3	Savings resulting from building codes	3.4	
4	Senario Two: 50 Percent of savings are additive	5.3	50% *(Sum Row 1, 2, 3)
5	Savings from out-of-program adoptions net of baseline adoptions (Table 4.6	17.7	
6	**Senario 1 Spillover savings**	**12.4**	(Row 1 - Row 2)
7	Net savings estimated via 2007 - 2010 impact evaluations	27.6	(Table 4.6)
8	**Total Program attributable savings**	40.0	(Row 7 + Row 8)

Finally, Table 4-19 shows our estimate of spillover and total program-attributable savings under Scenario C. Because exogenous savings are not additive, we only remove 3.7 GWh/year of savings from out-of-program savings, leaving 14.0 GWh/year in spillover savings. Our estimate of total savings under this scenario is 41.6 GWh/year.

Table 4-19: Scenario C spillover calculation C&F, corporate policy, and building code savings are not additive

Row	Metric	Savings GWh / year	Calulation
1	Savings resulting from C&F policies	3.7	
2	Corporate policies	3.5	
3	Savings resulting from building codes	3.4	
4	Senario Three: Savings are not additive	3.7	(Max Row 1, 2, 3)
5	Savings from out-of-program adoptions net of baseline adoptions (Table 4.6	17.7	
6	**Senario 1 Spillover savings**	**14.0**	(Row 1 - Row 2)
7	Net savings estimated via 2007 - 2010 impact evaluations	27.6	(Table 4.6)
8	**Total Program attributable savings**	41.6	(Row 7 + Row 8)

Table 4-20 presents the breakout of total savings resulting from energy efficient HBL purchases in Massachusetts into program tracked net savings, exogenous savings, and untracked spillover savings. For comparison, we also provide similar estimates for savings estimates provided by Scenarios 1 and 3 presented in Section 4.1.6. Finally, we represent Untracked Spillover savings provided by Scenario as a percent of program tracked gross savings. From the table we see that the level of untracked spillover identified by Scenario 2 is 39 percent of program tracked gross savings. This value is consistent with the estimated percentage identified in the 2010 Wisconsin HBL study which estimated untracked spillover at 34 percent of gross tracked savings. Manufacturers interviews confirmed that sales of energy efficient HBL in Massachusetts is consistent with that of Wisconsin, and only surpassed by California.

Table 4-20
Estimated market effects from the electric PA's HBL programs

Savings measure	Scenario 1: MA high bay space and purchase parameters	Scenario 2: Average MA and CA high bay space and purchase parameters	Scenario 3: CA high bay space and purchase parameters
Total savings resulting from energy efficient HBL	90.7	45.4	15.5
2010 Program tracked net savings*	27.6	27.6	27.6
Exogenous savings	10.62	5.3	0
Untracked spillover savings	**52.42**	**12.4**	**(12.17)**
2010 Program tracked gross savings	31.43	31.43	31.43
Spillover as a % of program tracked gross savings	167%	39%	-39%

5. Conclusions

5.1 Overview

The overall goal of this study was to assess the extent to which the PA's energy efficiency programs related to HBL affected the adoption of energy efficient high-bay lighting equipment and controls. To accomplish that goal, we developed a quantitative model to estimate the effect of the PAs' programs on the rate of adoption of energy-efficient high bay lighting technologies among all customers, whether or not those customers participated in the promotional programs. The model was based primarily on a comparison of the market share of energy-efficient high bay lighting products sold in Massachusetts during the past four years to the market share of those products in a four-state comparison area in which no programs to promote energy-efficient commercial lighting had been in effect. This analysis showed conclusively that the market share of energy-efficient high bay lighting was significantly higher in Massachusetts than in the comparison area, and that they volume of efficient fixtures purchased in Massachusetts far exceeded the number of units rebated by the PAs' programs.

To place the results of this quantitative analysis in perspective, we supplemented it with additional evidence of market effects provided by interviews with a broad range of key market players. This additional information provides further evidence of behavioral changes among the purchasers and vendors associated with increased market share for efficient high bay lighting. These behavioral changes include increased awareness of the performance benefits of energy-efficient HBL equipment among vendors and end-users and increased marketing and specification of efficient equipment by vendors. Using these results, we estimated an upper and lower bound for the portion of "out-of-program" purchases of efficient HBL equipment that could be attributed to the program. We also used these results to develop a "weight of evidence" case in support of the hypothesis that the PAs' programs were causally related to the observed differences between Massachusetts and the comparison area in the market share of energy-efficient high bay lighting. This additional information allowed us to isolate spillover effects from savings that likely resulted due to other influences, such as changes in commercial building codes.

5.2 Key Findings

5.2.1 Quantitative Estimate of Total Energy Savings from Adoption of Efficient High Bay Lighting in Massachusetts

During the study period, 51 percent of customers in key commercial and industrial segments purchased and installed high bay lighting. Spaces lit by these purchases accounted for 75 percent of total floor space in the targeted markets. In contrast, the 2010 California HBL study found that only 9 percent of customers purchased high bay lighting, accounting for 29 percent of lit space. Due to this discrepancy, we estimated market effects under three separate scenarios, each varying the percent of customers with high bay lighting and the percent who made purchases during the study period as follows:

1. **Scenario 1** – Assumes 67.7 percent of end users have high bay space and 75.8 percent of those firms made HBL purchases between 2007 and 2010, as identified by the Massachusetts end user survey. This serves as our baseline savings estimates and provides the same estimate of in-program and out-of-program savings identified above.

2. **Scenario 2** – Averages the Massachusetts and California results for each of these parameters, providing 49.2 percent of firms with high bay space, and 52.2 of those firms making purchases during the study period.

3. **Scenario 3** – Assumes the same percent of end users have high bay space and percent of those firms made HBL purchases as identified by the survey of California end users, 30.7 percent and 28.5 percent, respectively.

The difference between MA and comparison areas in market share of efficient high bay lighting technologies during the study period: T-5s – 64 versus 29 percent, T-8s 13 percent versus 16 percent, Pulse Start Metal Halides 3 percent versus 31 percent, LEDs 17 percent versus 2 percent. The difference between MA and comparison areas in the mean efficacy of HBLs installed was 65 watts square foot verses 72 watts square foot, respectively.

Under Scenario 1, the difference in efficacy translated to reduced wattage installed of 30.5 MW and reduced consumption of 90.7 GWh per year. Under Scenario 2, the difference the difference in efficacy translated to reduced wattage installed of 15.2 MW and reduced consumption of 45.3 GWh per year. Under Scenario 3, the difference the difference in efficacy translated to reduced wattage installed of 5.2 MW and reduced consumption of 15.5 GWh per year. Due to uncertainty concerning the compatibility of the comparison area and temporal

effects, the study team recommends the level of savings provided by Scenario 2, which projects 45.3 GWh in savings resulting from increased adoption of energy efficient HBL in Massachusetts.

5.2.2 Allocation of Savings to In-program and Out-of-Program Projects

Based on the results of previous evaluations, savings from high bay lighting projects supported by PA programs accounted for 34% of all savings due to accelerated adoption of efficient HBL technologies in Massachusetts, as gross program tracked savings amounted to 31.4 GWh in 2010. Net savings, accounting for free ridership, amounted to 27.6 of the 31.4 GWh per year. Subtracting net savings from our Scenario 2 estimate of the total savings resulting from energy efficient HBL in Massachusetts (45.4 GWh/year), provides roughly 17.7 GWh per year in out-of program savings attributable to reduced wattage in Massachusetts.

5.2.3 Attribution of Out-of-Program Savings to Program Effects and Total Net Savings

Assuming Scenario 2, we estimated 17.7 GWh/year in savings results from untracked adoptions of increased energy efficient lighting in Massachusetts. However, a portion of this savings, 5.3 GWh/year, cannot be attributed to the program because it results from exogenous influences rather than being program induced. We identified and analyzed the following three sources of this exogenous savings:

1. **Savings from chain & franchise corporate policies** – We estimate that design and construction policies of national chain & franchises account for 3.73 GWh/year (8.2 percent) of the 45.3 GWh/year total savings resulting from greater efficacy in HBL in Massachusetts.

2. **Savings from other corporate policies** – We estimate that design and construction policies of non-chain & franchise firms account for 3.53 GWh/year (7.8 percent) of the 45.3GWh/year total savings resulting from greater efficacy in HBL in Massachusetts.

3. **Savings from building codes** – We estimate building codes account for 3.35 GWh (7.4 percent) of the 45.3 GWh/year total savings resulting from greater efficacy in HBL in Massachusetts.

In combining savings attributable to these exogenous factors, we assume that 50 percent of the estimated savings from each source are independent of the other two sources, and therefore additive. This provides our estimated savings estimate for these three exogenous sources of

5.3 GWh/year. This reduces the amount of out of program savings by this amount to provide our estimate of untracked spillover savings of 12.4 GWh/year.

5.2.4 Other Indicators of Market Effects

Other indicators that showed that the PA programs led to market effects include the following:

1. Changes in awareness of efficient HBL benefits and benefits to their business.
2. Contractors are aware of the full range of benefits of energy efficient HBL, indicating that contractor awareness still remains high, but could still improve;
3. Distributors and manufacturers reported favorable attitudes towards energy efficient HBL products;
4. Contractors, end users, and distributors all report a high level of awareness of efficiency programs; and
5. End users were knowledgeable of efficient technologies prior to projects
6. Changes in marketing and specification practices.
7. Market actors are engaged in extensive promotion of energy efficient HBL products;
8. HBL measures resulted in the increased promotion of energy efficient fluorescent fixtures and, to a lesser extent, pulse-start metal halide lamps; and
9. Utility programs have a high degree of influence on their level of promotional activity.
10. Changes in barriers
11. Increased adoption of LEDs provides an indication of a shift in the market toward greater awareness and demand for energy conservation;
12. HBL programs lowered barriers to adoption of energy efficient lighting by helping customers and contractors to focus purchase decisions on life-cycle rather than acquisition costs of HBL products.

5.3 Limitations

5.3.1 Limitation to the Approach

The LCIEC Team acknowledges several limitations to the market effects approach that should be considered when assessing the validity of the untracked spillover estimate and the attribution of market effects.

5.3.2 Compatibility of Comparison Area

The loss of the comparison market is an increasingly problematic limitation for using quasi-experimental techniques to estimate market effects attributable to C&I and residential energy efficiency programs. There are a number of phenomenon that are contributing to this challenge that include: the development of energy efficiency programs in the no-program areas, the success of national programs such as ENERGY STAR, ARRA funded initiatives, the promotion of high efficiency technologies by national supply-side firms, and the acceptance and commitment to energy efficiency by end-use customers with locations in both program and non-program areas.[29]

Quasi-experimental designs lack random assignment to the experimental and control groups thereby introducing exogenous factors that may contribute to the differences in the dependent variable (i.e. adoption of energy efficient HBL equipment) between the experimental and control groups. Therefore it is critical when employing quasi-experimental designs to select controls groups that are as similar to the experimental groups as possible. Characteristics to consider when selecting control groups include:

1. Alignment of socioeconomics of the two areas (e.g. education levels, income levels, urban versus rural).

2. Climate differences between comparison areas (particularly for weather sensitive measures).

3. Similarity of commercial and industrial bases.

[29] Barry, J. Ryan, Bloch, Goldberg, Prahl and Rosenberg. *State-to-State Comparison to Establish Existence of Market Effects in the Non-Residential Sector*. IEPEC Proceedings 2009.

4. Prevalence of demand side differences that are not associated with the existing energy efficiency program; such as, prior utility demand side management activity, presence of national supply-side and end-use customer firms, and the cost of energy.[30]

Clearly, if Massachusetts (or California) was the only state to have energy efficiency programs that promote energy efficient HBL equipment then Alabama, Georgia, Mississippi, and South Carolina would not have been selected for the control group. Pennsylvania (excluding Philadelphia), Ohio, and Michigan were originally selected as the comparison area for the CA study. However during initial market actor interviews, several market actors mentioned "intermittent experiences with HBL programs which could affect awareness levels of efficiency and specification practice."[31] Furthermore several HBL programs were entering the development stage throughout the Midwest and therefore the CA Study Team decided that although these states were more similar to CA based on the criteria listed above, it was more important to select a comparison area without prior or existing HBL programs.

The selection of dissimilar comparison groups makes it more difficult to isolate the effect of the energy efficiency programs on the adoption of energy efficient high bay lighting equipment. Researchers can attempt to identify the exogenous variables but it is not possible to definitively identify and neutralize all of them. The LCIEC Team investigated the end user survey data for MA and the comparison area and secondary data sources to identify additional exogenous factors not accounted for in the report and discuss how they may affect the study outcomes.

KEMA contrasted a range of survey results from end users in Massachusetts, California, and the comparison region in order to examine the appropriateness of the four state southern region comparison area for the market effects study. These results are presented in Table 5-1.

The data show that the inventory of Massachusetts end user facilities is older, smaller, and has lower ceilings than in both the comparison region and California. The relative age and size of Massachusetts facilities partially explains the higher proportion of lighting projects over the past few years as a greater share of structures in the comparison area were recently built. Further, because facilities in Massachusetts are much smaller, renovation costs should be substantially lower than in larger facilities.

[30] Ibid.

[31] California Public Utilities Commission Energy Division. High Bay Lighting Market Effects Study. Final Report June 18, 2010. Page 20.

Recall, in executing the primary research efforts, each study selected a sample of firms proportional to their distribution across industries. As can also be seen in Table 5-1, a greater share of firms in the comparison area are used in the warehousing and process manufacturing industries, while Massachusetts has slightly greater proportion of food sales stores. This difference may result in greater savings as warehouse and manufacturing facilities are likely to have multiple shifts requiring continual usage of HBL.

We also report a number of metrics specific to HBL itself. First, we see that Massachusetts has nearly 25 percent more fluorescent fixtures installed than the comparison region. While recent purchases are partly responsible for this difference, the fact that the Massachusetts electric PA's efficiency programs have been ongoing for much longer than the study period is likely responsible for a large share of this difference. Consequently, it is reasonable to assume that a longer term study would result in even greater savings attributable to the electric PAs programs impacting HBL. Finally, the data show that a greater share of Massachusetts projects result from older fixtures, while those in the comparison area occur due to new construction or retrofits.

Table 5-1: Profile of end users: Massachusetts, California, and the comparison area survey results

Metric	MA	CA	SE
Average Number of Employees	91	169	161
Average Square Footage	31,978	203,258	128,880
% Pay Electric Bill Directly to Utility	86%	87%	88%
Tenure	23% Since 2000	42% Since 2000	48% Since 2000
	24% In the 1990s	25% In the 1990s	12% In the 1990s
	16% In the 1980s	12% In the 1980s	11% In the 1980s
	4% In the 1970s	6% In the 1970s	13% In the 1970s
	8% In the 1960s	4% In the 1960s	10% In the 1960s
	8% In the 1950s	6% In the 1950s	5% In the 1950s
	1% In the 1940s	5% In the 1940s	1% In the 1940s
	3%1900-1939	0%1900-1939	0%1900-1939
	1% Before 1900	0% Before 1900	0% Before 1900
Age of Building	35	31	27
% High Bay Space 15-25 ft	58%	61%	68%
% High Bay Space >25 ft	17%	35%	30%
Space Type	28% Retail	31% Retail	31% Retail
	5% Manufacturing-process	14% Manufacturing-process	10% Manufacturing-process
	15% Education	12% Education	14% Education
	10% Manufacturing-assembly	11% Manufacturing-assembly	13% Manufacturing-assembly
	7% Warehouse/Storage	11% Warehouse/Storage	14% Warehouse/Storage
	3% Office	7% Office	1% Office
	0% Other Commercial	4% Other Commercial	4% Other Commercial
	7% Other industrial	3% Other industrial	3% Other industrial
	5% Health Care	3% Health Care	2% Health Care
	7% Services	2% Services	3% Services
	1% Public Assembly	2% Public Assembly	<1% Public Assembly
	10% Food sales	<1% Food sales	5% Food sales
	2% Food service	<1% Food service	1% Food service

Table 5-1 (cont): Profile of end users: Massachusetts, California, and the comparison area survey results

Metric	MA	CA	SE
% High Bay Space Served by:			
HID:	13%	13%	36%
Fluorescent:	78%	76%	55%
CFL:	7%	4%	3%
Incandescent:	3%	2%	3%
Other:	<1%	4%	2%
Lighting Maintenance (internal or external staff)	48% Internal	79% Internal	68% Internal
	37% Service contract	9% Service contract	26% Service contract
	12% Other	8% Other	4% Other
	3% Building owner	4% Building owner	2% Building owner
Reason for Purchase	30% Retrofit	31% Retrofit	52% Retrofit
	8% New Construction	21% New Construction	17% New Construction
	27% Remodel	21% Remodel	15% Remodel
	31% Replace on Burnout	21% Replace on Burnout	9% Replace on Burnout
	3% Other	6% Other	5% Other
% of Space Affected	2% Between 1-10%	6% Between 1-10%	21% Between 1-10%
	10% Between 11-25%	3% Between 11-25%	13% Between 11-25%
	7% Between 26-50%	17% Between 26-50%	19% Between 26-50%
	4% Between 51-75%	8% Between 51-75%	11% Between 51-75%
	76% Between 76-100%	67% Between 76-100%	50% Between 76-100%

In addition to comparing self-reported survey data from end users in each region, we also obtained various economic indicators from published sources. These data are presented in Table 5-2 below. Important differences between Massachusetts and the comparison area that may impact the use of the comparison area as a true control group include the following:

1. Electric prices in Massachusetts are 1.7 to 2 times higher than in the southern states, while incomes are only 1.2 to 1.6 times higher. These higher rates are likely to result in greater attention to efficiency measures, thereby reducing the amount of savings attributable to the electric PAs programs.
2. The level of education in Massachusetts is also higher than in the south. While it is very difficult to quantify, increased education is often believed to correlate to a higher level of

social awareness. This effect can be seen by Massachusetts ACEEE 2010 Efficiency scorecard, which indicates Massachusetts ranks second in the US, while the southern region ranks between 37th and 49th. This finding also provides evidence that some of the out-of-program energy savings is likely the result of cultural differences rather than program related market effects.

Finally, while not depicted in Table 5-2 according to EPA's "National Awareness of Energy Star" report[32] Massachusetts has historically had high levels of energy-efficient technology promotion and awareness. In contrast, the states in the southeast comparison group have not previously had high levels of energy star and energy efficient technology awareness. This report discusses the results of the CEE 2010 ENERGY STAR Household Survey by building on prior years' survey results and focusing on the extent to which consumers recognize the ENERGY STAR label, understand its intended messages, and utilize (or are influenced by) the label in their energy-related purchase decisions. Promotion of energy efficiency benefits and rebates, and general awareness of the ENERGY STAR® program varies considerably across the country; each of the top 57 designated market areas (DMAs) are classified as "high publicity" "low" or "other". The report shows that Massachusetts has had high levels of energy star awareness since the study began in 2000. On the other hand, the designated market area (DMA) in Georgia, Atlanta, has only been recognized as high publicity since 2008 and the Greenvll-Spart-Ashevll (SC), Little Rock-PineBluff (AR) and Birmingham (AL) DMAs have been categorized as low since the study conception.

[32]EPA Office of Air and Radiation, Climate Protection Partnerships Division. *National Awareness of ENERGY STAR® for 2010: Analysis of 2010 CEE Household Survey*. U.S. EPA, 2011.

Table 5-2: Comparison of key economic indicators between Massachusetts and the comparison area

Metric/ Source	MA	AL	MS	GA	SC
Electric Prices					
EIA- 2010, All sectors	0.1445 $/kwh	0.0851 $/kwh	0.0817 $/kwh	0.0858 $/kwh	0.0853 $/kwh
Gross State Product					
USgovernmentrevenue.com	$391.5 Billion	$179.9 Billion	$98.1 Billion	$416.8 Billion	$169.7 Billion
% Urban vs. Rural					
(% Housing units Urban)					
2000 Census data Table H002	91.10%	55.00%	48.70%	70.70%	61.20%
Education					
(Percent of population over 25 with High School Degree)	88.4%	80.8%	78.9%	82.9%	82.2%
(Percent of population over 25 with Bachelors)	37.8%	21.5%	19.1%	27.1%	23.5%
2005-2009 American Community Survey					
Median Household Income					
2009 Census data	$59,393	$49,777	$35,078	$43,340	$41,101
Square feet per employee					
2003 CBECS	New England: 939	East South Central:1,109	East South Central:1,109	South Atlantic: 732	South Atlantic: 732
Private non-residential construction spending					
2009 Census data	$6,382 million	$7,618 million	$2,505 million	$6,681 million	$3,428 million
ACEEE 2010 Efficiency Scorecard Ranking	2	49	50	37	40

5.3.3 Temporal Issues

In developing the primary research instruments, KEMA considered a number of important factors pertaining to the relevance of data collected to near term evidenced of market effects, respondent recall, and compatibility of the results to the comparison area. In weighing the combined impact of the time period selected on these factors, the research team chose to analyze end user HBL purchases over the past four years (2007 to 2010) for the following reasons:

1. The primary reason for selecting the multiple year study was to mirror the California HBL study as much as possible, which asked end users to report on projects that occurred between 2006 and 2008. While the research team felt extending the timeframe back to 2006 (five years) would add too many exogenous factors to the analysis, we felt the four year study period enabled us to capture enough data to compare to the California results, and also include more recent activity as the economy recovered;
2. Multiple years provide for a much greater volume of projects, and consequently a greater response rate as there is a higher probability that firms undertook HBL project than in a single year;
3. Extending the study period smoothes out programmatic changes and annual market spikes that may bias the results of a single year study.

This market effects analysis includes data from 2009 and 2010 which the California study did not include. The incorporation of these additional years provides for greater adoption of energy efficient HBL as the economy recovered from the economic down turn that began in 2007. While our analysis does attempt to mitigate the impact of this temporal change by annualizing savings resulting from differences in technology shares, the modeled approach does not account for changes to the technology shares that may have occurred in the comparison area after 2008. In this section we analyze the impact of this longer time frame and also provide a supplemental analysis in which we attempt to assess the impact of this difference on our estimated program-attributable savings.

As a first step in understanding the impact of the study period length on the market effects analysis, we examined the tracking data provided by the Massachusetts eclectic PAs. As seen in Table 5-3, program tracked sales and estimated savings increased sharply from 2007 to 2008, but then leveled off between 2008 and 2010.

Table 5-3: Massachusetts electric PA's HBL tracking records by year

	2006	2007	2008	2009	2010	Total	Total 2007-2010	Average 2007-2011
Num Rebates	681	1,338	2,326	2,018	2,362	8,725	8,044	2,011
Gross KWH Sav	42,754,804	41,583,334	37,146,575	35,117,719	31,429,898	188,032,330	145,277,526	36,319,382
Gross KW Sav	7,529	7,741	7,395	7,948	7,156	37,769	30,240	7,560

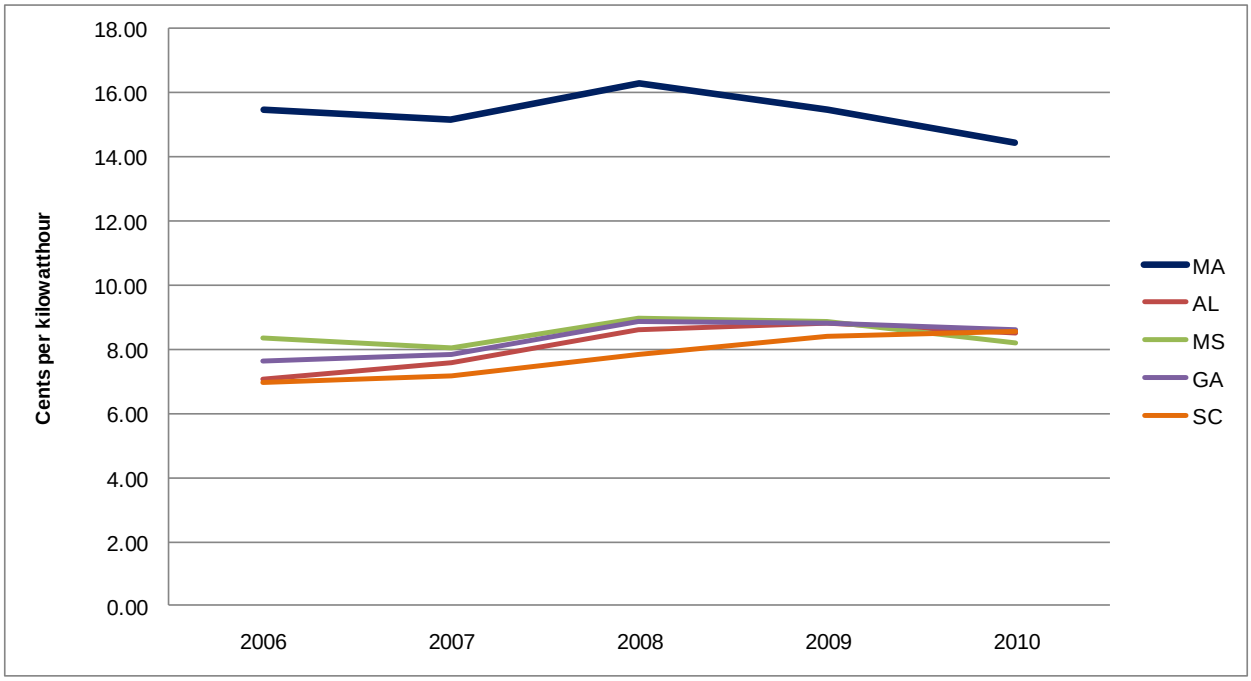
Understanding the implication of this finding on the modeled estimate of savings requires understanding the following key points regarding the model inputs:

1. The basis for savings estimates from the model is the differences in technology shares between the two regions;
2. Technology shares were obtained from the contractor survey;
3. The contractor survey for the comparison area obtained information pertaining to 2008 only, while the Massachusetts survey captured shares for 2009 and 2010. Therefore the relevant time frame from Table 5-3 to consider is 2009 to 2010.

Considering the data in Table 5-3, we see that the number of rebates has remained relatively flat during the period in which contractors were asked to report on technology shares of HBL projects. Because we do not know the trend in technology shares for the comparison region between 2009 and 2010, we now turn to various economic indicators to see whether any exogenous factors may lead to an increase in the share of energy efficient technology during that period than was recorded by the California HBL study.

Figure 5-1 shows the trend in electricity process in Massachusetts and each of the four states in the comparison area. The chart shows that energy prices fell by 5.0 percent and 6.5 percent in Massachusetts over the past two years, respectively, an 11.5 percent decrease over the past two years. Prices also declined for each of the past two years in Mississippi and Georgia, but those declines only amounted to a two year decrease of 9.2 percent and 3.0 percent, respectively. Meanwhile, prices in South Carolina actually increased in each of the past two years. Alabama saw prices increase and then decrease, so the overall effect was close to zero change. Falling prices in Massachusetts should lead to less exogenous pressure to adopt energy efficient technologies, thereby supporting the evidence of relatively high program-attributable market effects.

Figure 5-1: Average electricity prices by state

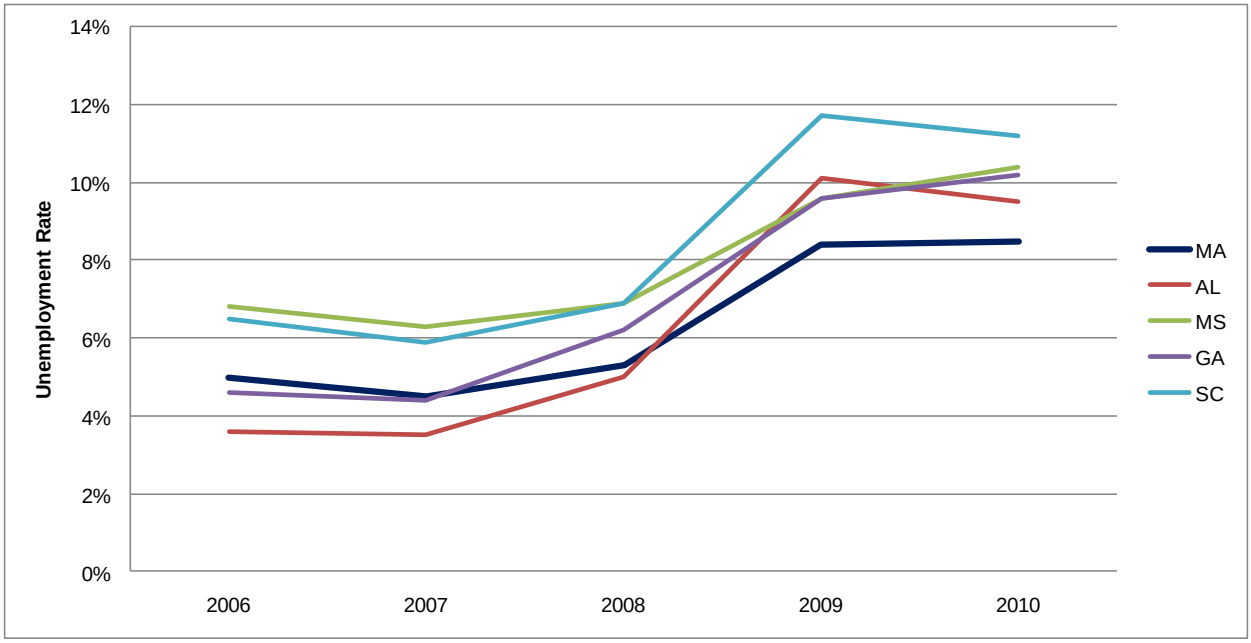


Source Bureau of Labor Statistics: http://www.bls.gov/schedule/archives/all_nr.htm#SRGUNE

Next, we consider whether relative economic conditions could lead to a reduction in the amount of program-attributable savings. Stronger economic conditions in Massachusetts than the comparison area would suggest that purchasing power in the comparison area is stymied by economic conditions.

Figure 5-2 compares the unemployment rates of each state since 2006. The data show that Massachusetts has one of the lowest unemployment rates each year relative to the states in the comparison region. Lower unemployment provides an indication that the Massachusetts economy was not impacted by the recent recession to the same extent as states in the comparison area. The finding would place downward pressure on the level of program attributable savings are firms in the comparison area are able to spend less on renovations, thereby impeding their ability to make efficiency improvements.

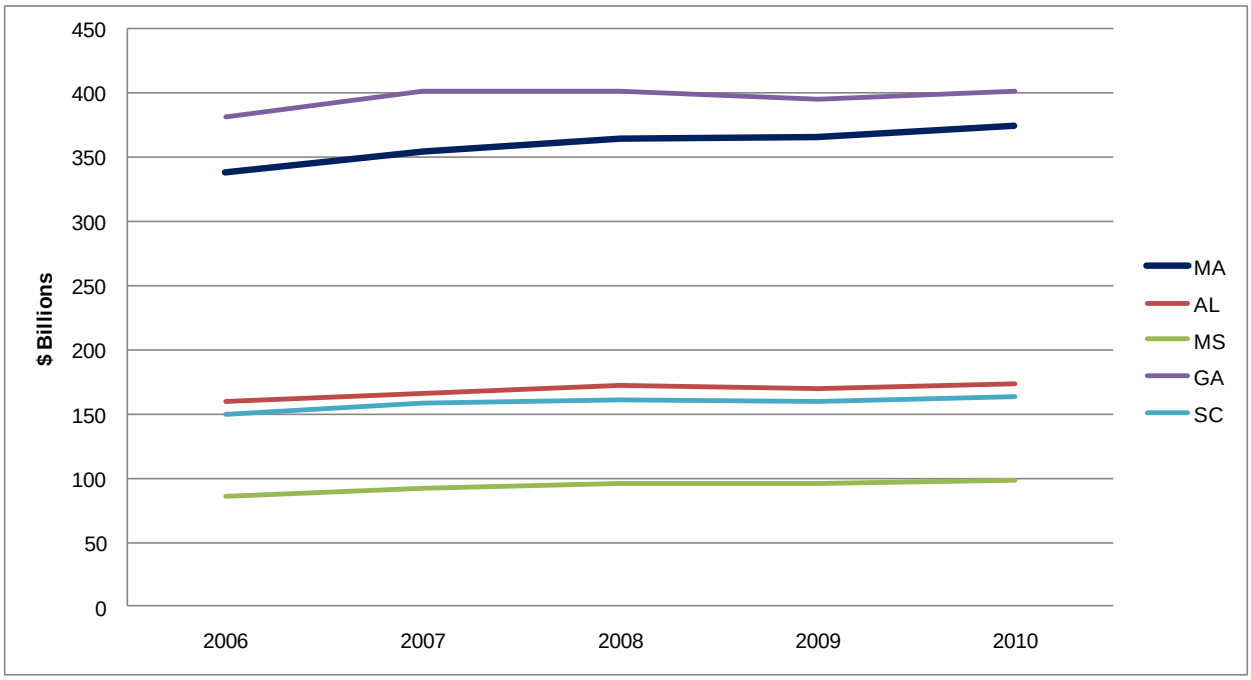
Figure 5-2: Annual unemployment rate by state



Source Bureau of Labor Statistics: http://www.bls.gov/schedule/archives/all_nr.htm#SRGUNE

Finally, Figure 5-3 shows trends in Gross state product for Massachusetts and the comparison area. The diagram clearly illustrates that the Massachusetts economy is much larger than three of the four states in the comparison area. Only Georgia generates more value added goods and services than Massachusetts, and the remaining three states combined are just slightly target than Massachusetts. However, the data do show that each state has experienced similar trends in the value of goods and services over the past two years.

Figure 5-3: Annual gross state product by state



Source Bureau of Labor Statistics: http://www.bls.gov/schedule/archives/all_nr.htm#SRGUNE

5.3.4 Removing impacts associated with different length study period

As previously stated, the impact of the additional study year on savings estimates is limited to changes in contractor reported technology shares over the past two years. This is because the market effects model estimates savings based on the wattage required to provide the necessary level of lumens to illuminate high bay space impacted by Massachusetts purchases of HBL during a set number of annual hours of operation. Savings estimates in the model result from the difference in technology shares between the two regions. However, technology shares from the Massachusetts survey reflect 2009 to 2010 purchases, while share from the comparison area reflect 2008 survey response. Therefore, we can estimate the impact on savings estimates resulting from the discrepancy in time period by adjusting the technology shares in the comparison area to reflect changes that occurred since 2008.

KEMA examined the estimated level of savings assuming a one percent increase per year in the share of T-5 and T-8 fluorescents, as well as pulse start metal halide fixtures in the comparison area. We further assumed corresponding decreases in the remaining technologies proportional to their 2008 technology shares. By substituting the revised 2010 technology shares into the HBL model, we computed revised estimates for total savings resulting from energy efficient HBL

purchases in Massachusetts under scenarios 1 and 2 mentioned above. These estimates are presented in Table 5-4 below. The table shows that untracked spillover remains positive, but it is reduced under each scenario. However, it is important to note that these estimates assume simultaneous increases in T-5 and T-8 fluorescents, as well as pulse start metal halides, and that these increases are offset by proportional decreases to less efficient technologies only.

Table 5-4: **Alternative savings estimates: Assuming increased shares of energy efficient HBL in 2010 in the comparison area**

Savings measure	Scenario 1: MA high bay space and purchase parameters	Scenario 2: Average MA and CA high bay space and purchase parameters
Total savings resulting from energy efficient HBL	76.7	38.3
2010 Program tracked net	27.6	27.6
Exogenous savings	7.8	4.7
Untracked spillover	**41.3**	**6.0**
2010 Program tracked gross savings	31.4	31.4
Spillover as a % of program tracked gross savings	1.3	0.2

5.3.5 Other limitations

Our analysis faced limitations that are common to any research that provides modeled results from primary research and a range of other sources. Limitations to our analysis include the following:

- Precision of estimates of lumens per square foot of Massachusetts facilities and estimated lumens per watt – These parameters are critical in our model of energy savings. We relied on industry standard engineering specifications for high bay spaces to provide average estimates of lumens per square foot and lumens per watt.

- Extrapolation of survey results by industry segments – The accuracy of all studies that rely on survey findings is constrained by the need to extrapolate results from a sample of the population. While we took great care to ensure that the heterogeneous nature of the market was preserved, it is not possible to completely eliminate error from any sample.

- Uncertainty surrounding exogenous factors impacting energy efficient HBL sales – Our analysis of spillover was limited to those factors we could identify though survey findings collected to meet a number of research objectives. A more focused research effort is necessary isolate and measure exogenous factors contributing to energy efficient HBL sales.

- Variation in the interpretation of survey questions – While the research team used great care in crafting research instruments, the manner in which respondents interpret questions varies according to their own perceptions and experiences.

6. Recommendations

Based on the modeled approach and the preponderance of evidence presented in this market effects study, KEMA recommends the electric PAs claim untracked spillover energy savings associated with Massachusetts HBL measures. We recommend the Scenario 2 energy savings estimate of 12.4 GWh per year or 39 percent of 2010 program tracked gross savings. This value is consistent with the untracked spillover estimate of 34 percent of program tracked savings estimated for Wisconsin in the 2010 Wisconsin HBL study.

Several of the electric PAs are currently claiming low levels of participant and or non-participant energy savings for HBL measures. Prior to claiming the untracked spillover savings recommended by this report the PAs must remove participant and or non-participant spillover energy savings for HBL measures already being claimed to avoid double counting.