



ENVIRONMENTAL AND ECONOMIC RESEARCH AND DEVELOPMENT PROGRAM

Shedding Light on the Commercial Lighting Market in Wisconsin

Final Report
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EXECUTIVE SUMMARY

Lighting is one of the most substantial energy consuming end-uses and non-residential lighting is a major contributor to the energy savings achieved by the Wisconsin Focus on Energy program. Lighting alone accounted for 43% of the demand and 38% of the energy saved by Focus on Energy business programs in 2010 and 2011, making it the single largest end-use contributor to overall C&I program energy savings.¹

At the same time the lighting market is in a state of transformation. This creates uncertainty for many energy efficiency programs, which often rely heavily on technology replacement for a large portion of energy savings. Commercial lighting will continue to be a key driver for the savings as new technologies and strategies begin to make gains in market share.

Understanding the dynamics of this changing market is critical for Focus on Energy to achieve future program goals. For instance, one of the staples of energy efficiency programs -linear fluorescent lighting- has grown increasingly efficient in recent years, and new lighting systems, such as light-emitting diodes (LEDs), are beginning to encroach on fluorescent's territory.

The following research is intended to provide Focus on Energy staff with deeper insight into the current state of the Wisconsin non-residential lighting market, as well as a glimpse into how experts perceive the industry will look in five years. In short, experts believe that we are on the precipice of tectonic shifts in the products sold and installed now versus the near future.

1.1 KEY FINDINGS

Below we provide a summary of the key findings from this study. Results are based on two rounds of Delphi panel² surveys with lighting industry experts in Wisconsin.

LED appears likely to overtake fluorescent as the most frequently installed technology in the next five years. When panelists were asked what they install most today and what they expect to install five years from now, the results were dramatic. At present, the majority install linear fluorescent fixtures far more than other technologies. No panelist currently installs LEDs more frequently than fluorescents, but they have all worked with LEDs in the last year. The majority of panelists believe that in five years they will install LEDs *more* frequently than fluorescent. This suggests a rapid change in the applications for which LEDs are used since at present; LED are generally reserved for niche applications, such as case lighting or signage, and are not competing with linear fluorescent in ambient lighting situations. New products that make use of LEDs for ambient lighting will need rapid acceptance for this prediction to happen.

¹ This was calculated by using data provided to Opinion Dynamics by the program administrator for the 2010 and 2011 program years.

² A Delphi panel consists of a panel of experts that provide their opinions on a topic. The results are then aggregated and presented back to the group. The experts then refine their opinions based on the group feedback.

Panelists expect LED to become cost-competitive with linear fluorescent in 2015. Cost is an important consideration for customers. Based on current trends in price, panelists agreed that LEDs will achieve cost parity with linear fluorescent in 2015. This argument is bolstered by a McKinsey study that predicted LEDs saturation in general lighting will reach 45% in 2016 and nearly 70% in 2020.³

Restaurants and the Outdoor market segment appear to have the biggest challenges with respect to adopting efficient lighting. There was some consensus that Restaurants and Outdoor lighting are the least transformed of all of the markets covered in our research. Our panelists noted that those markets each have specific barriers that need to be addressed making them less receptive to upgrading lighting systems.

Additional research should be conducted to examine the outdoor lighting market in more detail. The outdoor segment presents different challenges from other sectors but panelists overwhelmingly believe that, overall, the outdoor segment represents potentially the greatest area of savings, between traffic lights, street and parking lighting, and signage. Panelists believe that, as outdoor projects tend to be expensive to begin with, the added cost of efficient lighting can be critical; especially since large fixture LEDs are especially costly and hard to source, compared to traditional lighting fixtures and lamps. Additionally, outdoor components of larger projects are often overlooked, and opportunities are missed. Focus on Energy may want to consider some additional research examining barriers within facility types to determine how the program can better address the unique needs of this market.

There are significant savings in the design/redesign market. Our panel reported working primarily on design projects and reported that only 25% of their projects represent one-to-one replacement. These findings align with the 2010 potential study and indicate significant program savings may be achieved through design. Panelists report designing above code in about 70% of projects requiring design. At the same time, they report only receiving incentives for 36% of those above code projects. This could be the result of “value engineering” where changes and substitutions are made during project implementation cause the final system to be less efficient than the original design or this could possibly indicate non-participant spillover. Additional research, focused specifically on design, could examine the course of a project from design through implementation to find out if that is indeed the case or if there are other barriers to these projects.

INTRODUCTION

The Focus Environmental and Economic Research and Development Program (EERD) provides financial support for research projects that benefit Focus on Energy. The goal is to provide planners and implementers with valuable insights from lighting market actors on changes that impact the commercial and industrial (C&I) lighting market.

Lighting is one of the most substantial energy consuming end-uses. According to a recent Department of Energy Market Characterization study, lighting accounts for approximately 700

³ “Lighting the way: Perspectives on the Global Lighting Market” by McKinsey and Company (2011).

¹⁴ “Lighting the way: Perspectives on the Global Lighting Market” by McKinsey and Company (2011).

Terawatt hours (TWh) of electricity usage, or about 19% of total electrical energy use in the US.⁴ Of that, three quarters is consumed in non-residential applications including commercial, industrial, and outdoor (including roadway lighting).⁵ Non-residential lighting is also a major contributor to the energy savings achieved by the Wisconsin Focus on Energy program. Lighting alone accounted for 43% of the demand and 38% of the energy saved by Focus on Energy business programs in 2010 and 2011. Furthermore it is the single largest end-use contributor to the commercial and industrial (C&I) program's energy savings.⁶

At the same time, the lighting market is in a state of transformation. This creates uncertainty for many energy efficiency projects that rely heavily on technology replacement for significant energy savings. As new technologies and strategies begin to make headway in the market, legislation aimed at phasing out inefficient technologies limits the influence programs have on efficiency levels selected by customers.⁷ It is no longer business-as-usual; programs will need to find additional ways to reach savings goals. Understanding the dynamics of the changing market is critical for Focus on Energy to achieve future program goals.

This paper presents a multi-stage study that explores the pressing issues affecting the commercial lighting market. It then seeks to prioritize those issues based on research conducted through a Delphi panel concerning the Wisconsin lighting market.

This report is the culmination of several research activities. First, a whitepaper on Wisconsin's current lighting market was developed to gain an understanding of the issues at play. This paper formed the foundation of the primary research, which involved a -Delphi panel approach where a group of lighting experts were questioned about the pre-identified topics. The Delphi panel approach involves asking experts about their opinions on a given topic, then compiling the results, presenting the findings back to the panel and asking them to adjust their answers based on group feedback. The intent is to achieve consensus on the subject matter.

METHODOLOGY

Below we provide a brief description of our methodologies for this project.

Delphi Panel

A Delphi-panel is a method of research that involves two or more rounds of questionnaires with a panel of experts in which they develop a forecast. The anonymous, aggregated results of each round are presented back to the panel and they refine their answers based on the feedback from the

⁴ US Department of Energy. Energy Efficiency and Renewable Energy-Building Technologies Program. 2010 US Lighting Market Characterization. Navigant Consulting. 2012. <http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf>

⁵ US Department of Energy. Energy Efficiency and Renewable Energy-Building Technologies Program. 2010 US Lighting Market Characterization. Navigant Consulting. 2012. <http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf>

⁶ This was calculated by using data provided to Opinion Dynamics by the program administrator for the 2010 and 2011 program years.

⁷ As legislation phases out inefficient items, the difference between more efficient options and baseline technologies lessens, lowering the available savings for energy efficiency programs.

group. The theory behind this approach is that a structured panel of experts can provide a more accurate forecast than a single expert or a less structured process.

Opinion Dynamics Corporation conducted an online survey of 22 Wisconsin-based lighting specialists between March 27 and April 16, 2013. The lighting experts were drawn from several sources including the Focus on Energy trade ally search tool as well as the International Association of Lighting Designers membership list. Eleven of our panelists self-identified as designers including one mechanical engineer, five considered themselves to be distributors and one self-identified as a contractor. Additionally, they reported the proportion of design, installation and distribution work that their companies typically perform and the companies represented by our panel are diversified (see Table 1).

Table 1 : Proportion of Project Types

Type of work	Proportion of portfolio
Distribution	36%
Design	28%
Installation	22%
Other	14%

A second instrument was constructed based on results from the first round, and 17 of the original 22 panelists participated in the second survey. The Delphi panel questionnaires were based on secondary research about the commercial and industrial lighting market in Wisconsin.

Expert Interviews

The Opinion Dynamics Team interviewed regional and national experts in the lighting field to gain their insights into the commercial lighting market and to gather information that will be used to inform the second phase of this project experts represented the Consortium for Energy Efficiency, program implementation contractors like Franklin Energy and utility program managers from other jurisdictions with expertise and insight into the lighting market in the Midwest.

Secondary Research

We completed secondary research investigating:

- The state of market providers in Wisconsin; such as how many there are and what types of work they do.
- New technologies on the market; including the latest developments regarding LED and Advanced Lighting Controls.
- Saturation rates of existing equipment and what types of businesses are likely to have different lighting equipment.

Secondary data sources included papers written by governmental agencies such as the US Department of Energy, as well as reports from private sector and non-for-profit advocacy groups. The most frequently cited secondary sources include the 2010 Department of Energy Market Characterization Study and the 2013 American Council for an Energy Efficient Economy paper “Frontiers in Energy Efficiency: Next Generation Programs Reach for High Energy Savings.”

Previous Focus on Energy Research

As an established program, Focus on Energy has undergone numerous evaluations, studies and related research reviews. These reports were considered and referenced, where appropriate, throughout this paper.

Program Data

Commercial lighting program data for 2010 and 2011 was obtained from the Focus on Energy Program Administrator. Data included the types of lighting measures incentivized through the initiative and the associated energy savings.

Other Data Sources

Analysis was supplemented with data from the US Census Bureau on the various market actors in Wisconsin. Additionally, at the end of this document an appendix outlines key terms as defined by the US Department of Energy's ENERGY STAR program. Many were applied throughout this document. The full glossary of lighting terms from ENERGY STAR is accessible here: http://www.energystar.gov/index.cfm?c=business.EPA_BUM_Glossary.

4. LIGHTING INFRASTRUCTURE IN WISCONSIN

The business lighting market in Wisconsin is robust, thanks in large part to the Focus on Energy Program. According to 2010 US Census data, Wisconsin has more than 1,300 electrical contractors and 270 electrical equipment wholesalers (distributors). The Focus on Energy "Find it with Focus" tool currently lists almost 600 lighting trade allies.

Table 2: Lighting Market Actors in Wisconsin in 2010*

NAICS	Type	Establishments in Wisconsin in 2010
335122	C&I Electric Lighting Fixture Manufacturer	8
33511	Electric Lamp Bulb and Part Manufacturer	None listed
42361	Electrical Wiring Supplies and Related Equipment Wholesalers	270
23821	Electrical or Other Wiring Contractors	1,346
541490	Other Specialized Design Services (lighting designers)	9
541310	Architectural Services	251
541330	Engineering Services	843

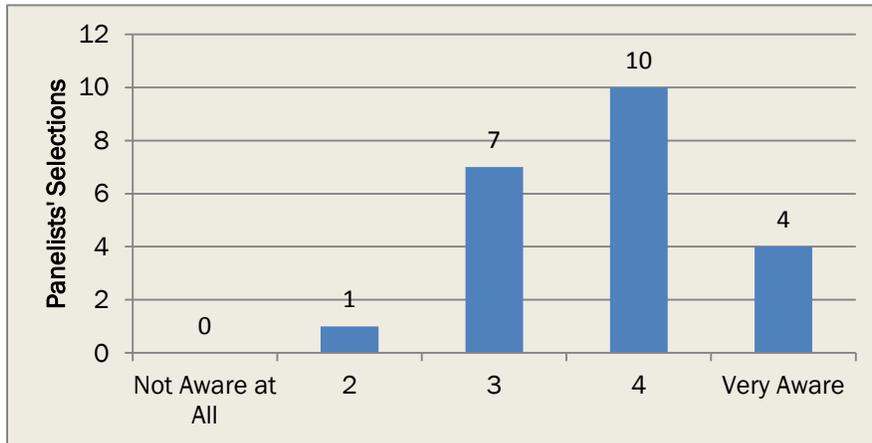
* Source: United States Census Bureau

4.1 PROGRAM AWARENESS

Our panelists reported high awareness of Focus on Energy among both market providers and customers. Figure 1: Lighting Market Providers' Awareness of Focus on Energy or Utility Lighting

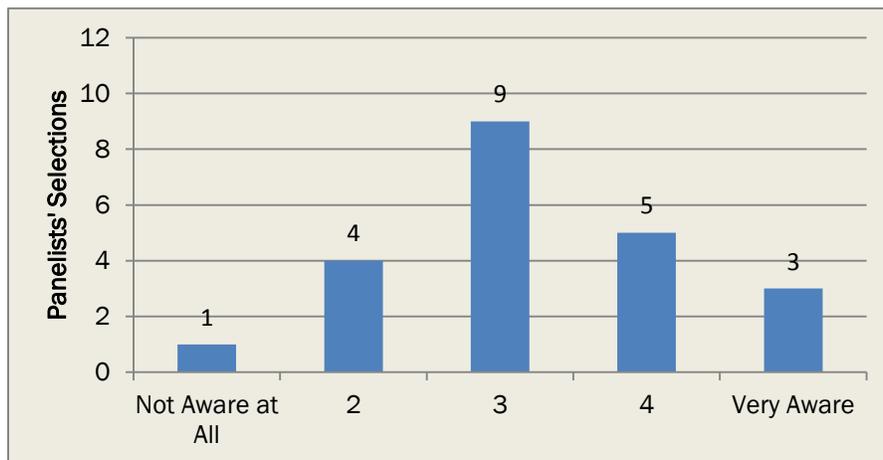
Programs (n=22) Figure 1 illustrates panelists' perceived levels of awareness of their peers using a scale that ranged from one to five, where one meant not at all aware, and five meant very aware.

Figure 1: Lighting Market Providers' Awareness of Focus on Energy or Utility Lighting Programs (n=22)



Panelists reported moderate to high levels of awareness among customers, as shown in Figure 2.

Figure 2: Customers' Awareness of Focus on Energy or Utility Lighting Programs (n=22)



4.2 DIVERSIFICATION OF PROVIDERS

A 2010 Focus on Energy Business Program Supply Side study by PA Consulting and KEMA indicated that lighting market providers in Wisconsin, such as distributors, were more likely to offer design and specification services than similar businesses in Illinois. The assumption is that these companies offer customers more comprehensive services, boding well for design-based programs in Wisconsin. Our research confirmed this finding. Indeed most panelists' firms undertook more than one type of work, and many performed at least some installation, distribution, and design (see Table 1).

4.3 PROJECT TYPES & BUSINESS SECTORS

One of the key research objectives was to identify areas where the Focus on Energy program can increase energy savings. Panelists were asked a series of questions related to situations where customers would make lighting decisions, including routine replacement, construction of a new building or a major renovation. Interviewees were asked which business sectors were the most receptive to completing an energy efficient lighting project and which were markets were most and least transformed.

4.3.1 REPLACEMENT, RENOVATION & NEW CONSTRUCTION

Our research shows that major renovation projects represent a significant opportunity for intervention. Panelists reported that their most frequent work was on major renovations, followed by new construction and routine equipment replacement (see Table 3). Routine replacement accounted for only 25% of panelists' reported work.

Table 3 : Percentage of Lighting Projects Completed by Round One Panelists, by Magnitude (n=22)

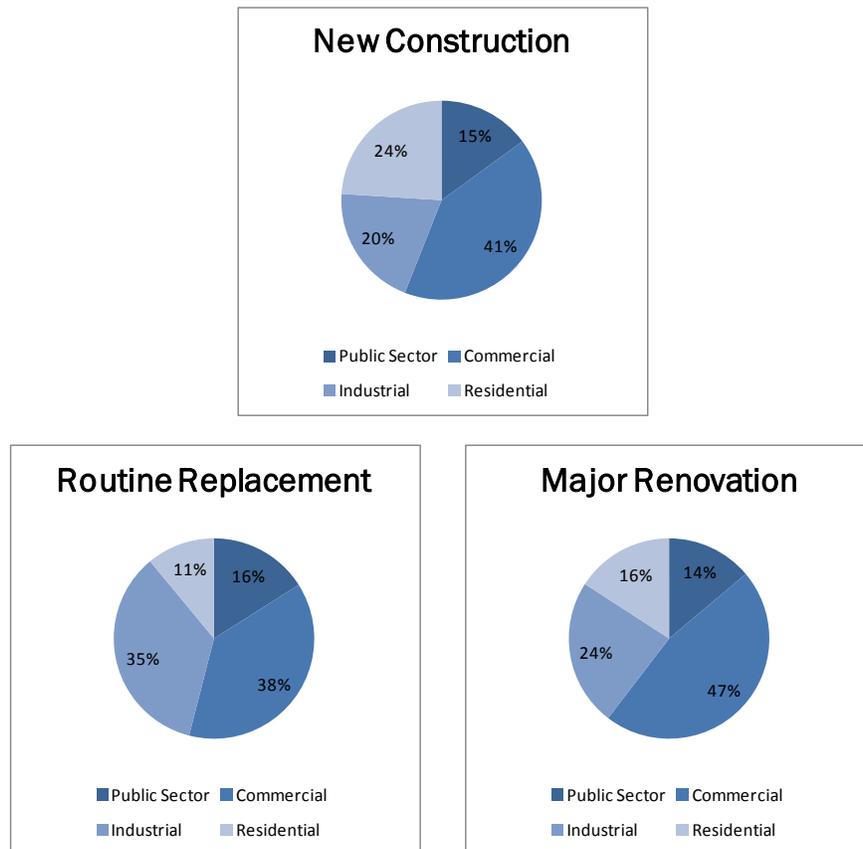
Project type	Percentage
Major Renovation	36%
New Construction	28%
Routine Equipment Replacement	25%
Outdoor Equipment Installation	12%

A 2010 Focus on Energy business supply side analysis confirms our findings. In that study KEMA interviewed suppliers about typical projects they would undertake. Survey participants indicated that 20% of their work was routine replacement and 80% came from new construction or major renovation/remodeling.⁸

Diving deeper, panelists were then asked a series of questions about which sectors were conducting different types of projects. All three categories – major renovation, new construction and routine replacement – were dominated by the commercial sector. In fact, nearly half of major renovation projects were commercial. These responses are summarized in Figure 3.

⁸ 2010 BP Supply Side Evaluation (KEMA).

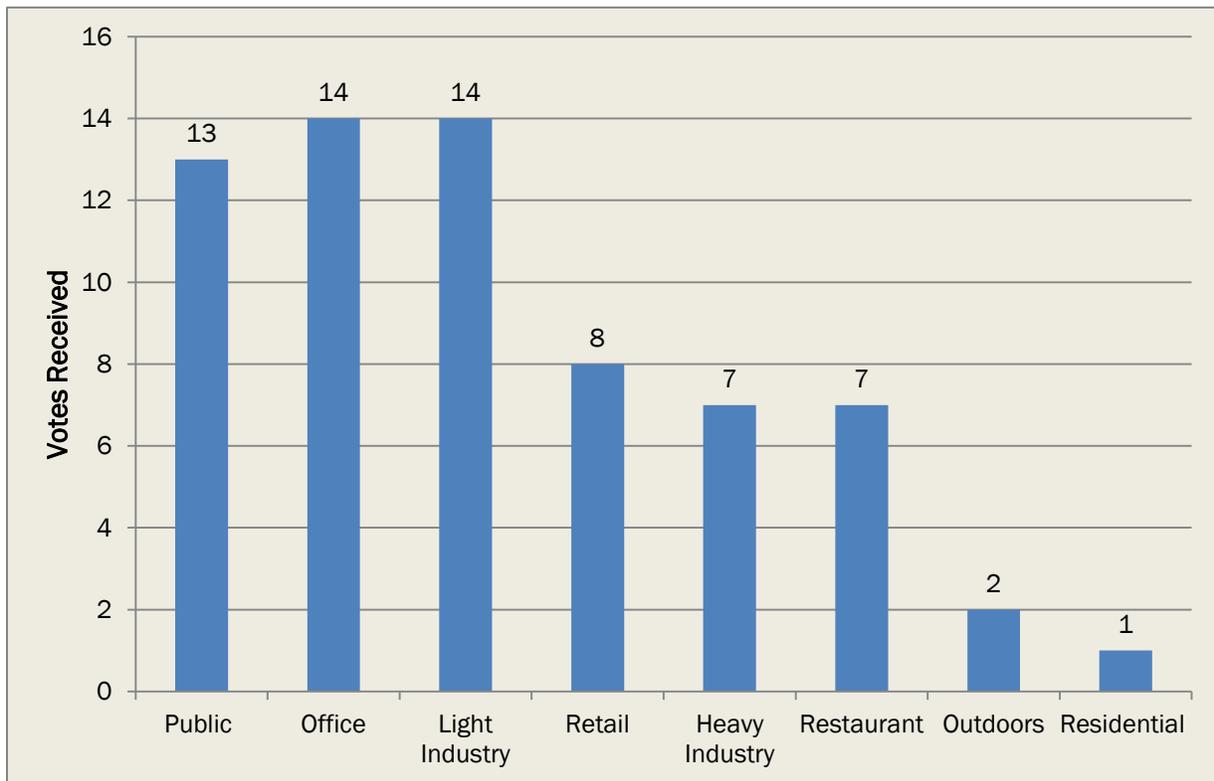
Figure 3: Percent of Projects by Scope and Market Sector



4.3.2 MARKET SECTORS

To gain perspective on which sectors were most and least likely to undertake energy efficient lighting projects, panelists were asked to rank business sectors by their receptiveness to efficient lighting upgrades. The sectors were chosen to align with the Focus on Energy application forms at the time of the survey. Figure 4 displays the number of panelists who ranked each sector in their top three during the first round interviews.

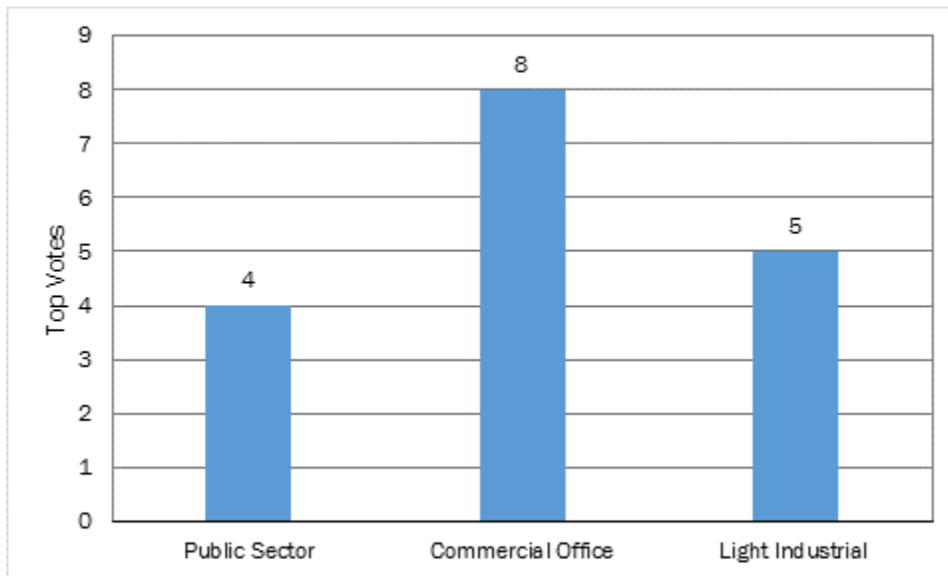
Figure 4: Round 1 – Perceived Receptiveness to Efficient Lighting by Market Segment (n=66*)



*N=66 included the top three votes from all 22 participants

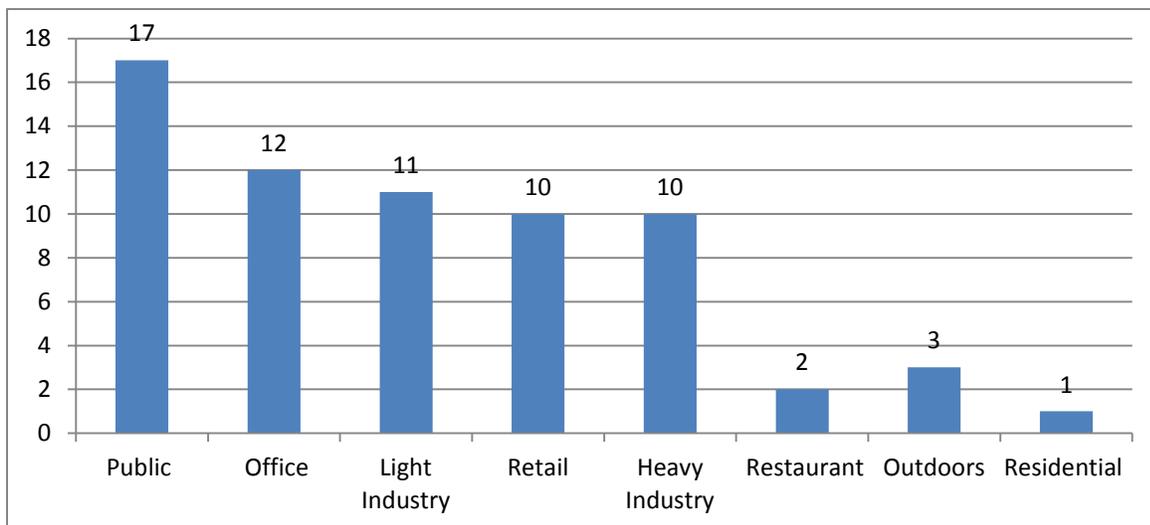
In round one a single market segment did not stand out as the most receptive; office, light industrial, and public sectors all received a similar number of votes. During the second round, we focused the panelists on the top five sectors identified in round one. With this tightened focus, a majority of respondents stated that offices were the most receptive to energy efficient lighting projects, as shown in Figure 5.

Figure 5: Round 2- Most Receptive Market Sectors (n=17)



We also asked panelists to identify the sectors that had already been transformed. Here, panelists were more in agreement that the public sector was the most transformed followed by offices and light industry (Figure 6).

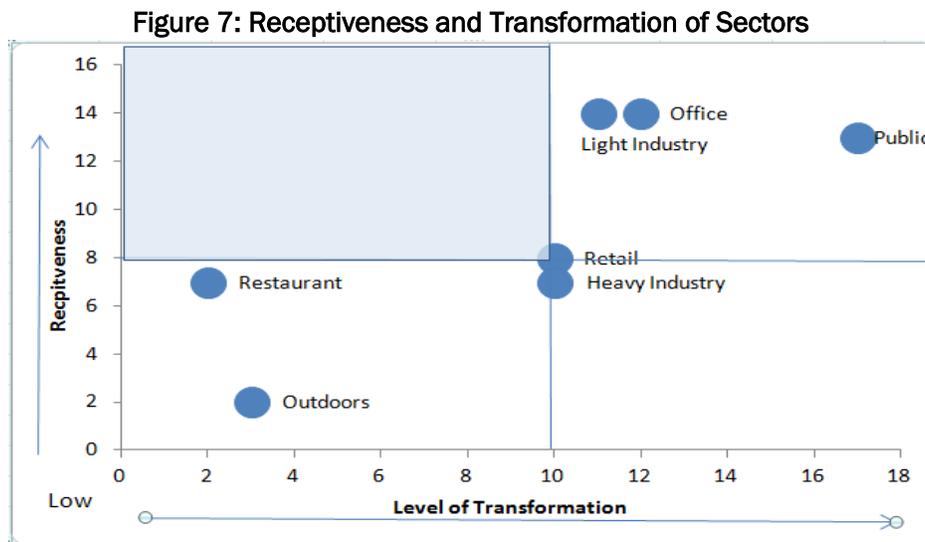
Figure 6: Round 1 - Transformation to Energy Efficient Lighting by Market Segment (n=66*)



*N=66 because we took the top three votes from all 22 participants

As there was relative agreement in the first round, the second round dove deeper into the public sector. Panelists overwhelmingly said there were still opportunities there, though it was the most transformed market. Specifically, smaller government agencies, such as schools and small local offices, were identified as less likely to have upgraded their lighting, but still interested in pursuing efficiency options. Additionally, panelists identified LED, efficient outdoor lighting and advanced lighting controls, as future opportunities for public sector facilities.

Figure 7 plots each of the sectors by receptiveness and transformation according to the panel. The upper left quadrant represents segments that are highly receptive to energy efficient lighting projects but not yet transformed, thereby representing the greatest opportunities for intervention. None of the sectors fell into this quadrant as seen in Figure 7.



Restaurants and the Outdoor segment appear to be the most challenging to reach; having been transformed least and selected as the least receptive. Panelists identified unique barriers to adoption, specific to those two markets. For restaurants, primary barriers were financial and technological. Restaurants often survive on thin profit margins and do not have the capital available to larger firms to invest in new lighting. Moreover, incentives are often too small to elicit interest. At the same time, restaurants often use lighting that requires special fixtures and controls, such as dimming. As such, programs that discount T8/T5 fluorescent tube or CFL lighting are of less interest to this market than the commercial office or light industry segments.

Still there are opportunities in restaurants. One panelist stated:

Most restaurants operate 18 to 20 hours a day 313 days per year and use mainly incandescent lamps. The CFL or LED replacement will use 75% or less electricity and have a low labor cost to install.

Panelists felt that this segment will be quick to adopt more efficient lighting once LED's become more common and affordable. According to another panelist:

Advancing LED technologies offer better lighting (e.g. higher CRIs⁹) that are appropriate for restaurants. Specific applications with most potential are directional lighting (R/PAR/MR/Cans) and refrigerated case lighting.

The outdoor segment presents different challenges. Panelists overwhelmingly believe that, overall, the outdoor segment represents the greatest potential savings, between traffic lights, street and parking lighting, and signage. Panelists explained that because outdoor projects tend to be more

⁹ CRI stands for Color Rendering Index. Light sources with higher CRIs stay more true to the actual color of the objects they are illuminating.

expensive than other projects, the added cost of efficient lighting can be a significant barrier. This is particularly the case for LEDs since large fixture LEDs are especially costly and hard to source compared to traditional lighting fixtures and lamps. Additionally, outdoor components of larger projects are often overlooked and opportunities are missed.

Panelists were optimistic, however, that these are surmountable barriers. According to one panelist:

To the extent that municipalities did not capitalize on ARRA¹⁰ funding, there remain general illumination opportunities (esp. for streets and roadways). There is also significant potential remaining for non-public outdoor area lighting (e.g. parking lots), and installation of lighting controls (either networked or on an individual fixture basis) to reduce power usage during periods of low activity - especially in combination with LED technology, which is dimmable where conventional technologies were not. As LED technology improves and costs fall, these projects will become more attractive. Additionally, this sector is ripe for the application of advanced controls and automation, which would further reduce energy consumption.

For Focus on Energy to increase the penetration of energy efficient lighting in the restaurant and outdoor sectors, panelists agreed on two recommendations; (1) increase incentive size and the number of qualifying products, especially for LEDs, and (2) build awareness of Focus on Energy programs by educating customers on the benefits of efficient lighting and resources available.

4.4 EQUIPMENT, CONTROLS, AND DESIGN

In this report, we discuss the three technical energy savings approaches for lighting: equipment, design, and controls. These three categories are not entirely mutually exclusive. For example, a designer must consider equipment and controls when designing a lighting system. However, design-based program approaches are more comprehensive while equipment-based approaches focus on a specific retrofit or replacement situation. Controls strategies can apply to either design or equipment-based situations. As mentioned earlier, the “Routine Replacement” category accounts for only about 25% of the work undertaken by our panelists so there are saving opportunities with more comprehensive installations that include design and advanced controls (Table 3). This report does not address behavioral approaches to energy savings largely because this is still a relatively new approach and, in the case of C&I lighting, controls are often more effective than human behavior modification.

4.4.1 EQUIPMENT

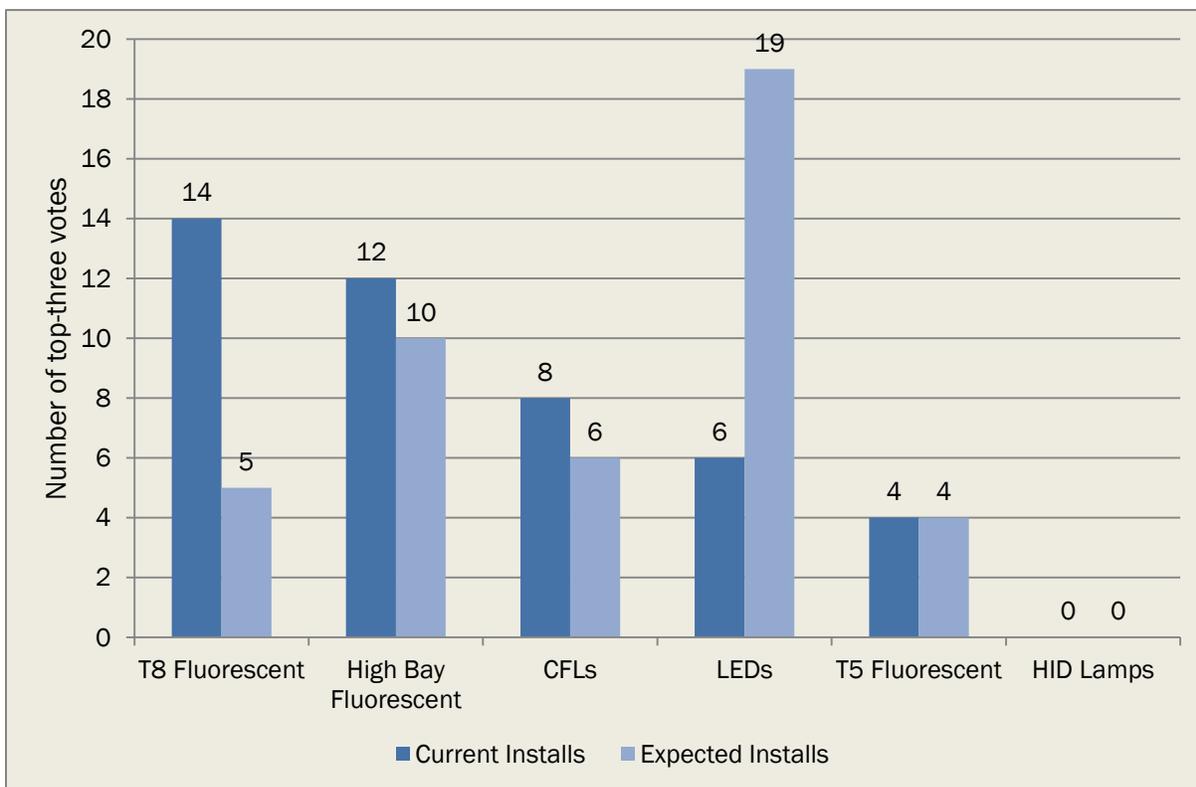
Equipment-based energy efficiency options are frequently offered as “prescriptive” or “standard” measures in energy efficiency programs. Here savings are achieved by replacing existing or specified equipment with higher efficiency options, generally as a one-for-one replacement. For example, many programs offer incentives for replacing high-pressure sodium fixtures with ceramic metal halide. Equipment-based projects are often easier for customers to implement because they do not require entire system redesign. For program managers, equipment-based programs are more

¹⁰ ARRA: American Recovery and Reinvestment Act

straightforward because they do not require complicated calculations to determine the energy savings and incentive.

Panelists were asked about the rebated lighting equipment that they install or sell today and their expectations for future installations. Incandescent was not included because it is not rebated by the program and does not generate energy savings. The results are shown in Figure 8 and point to a dramatic shift in the lighting market in the next five years. Most panelists anticipate installing more LEDs than linear fluorescents five years from now with T8 fluorescent seeing the biggest decline.

Figure 8: Current and Expected Equipment Installations



A few panelists believed that T8 fluorescents would still be their most frequently installed lamp type in five years' time indicating some uncertainty about the evolution of the commercial lighting market. These panelists cited the historic success of fluorescent lighting generally, as well as the continuing improvement of fluorescent lighting, as the primary reasons they thought fluorescents would still out-sell LEDs.

Linear Fluorescent

In terms of "standard" projects, fluorescent tube lighting is by far the largest contributor to lighting savings for most programs. This includes fixtures found in office spaces or classrooms as well as "high bay" fluorescent lighting fixtures which are more common in industrial settings or warehouses. Fifteen of our twenty-two panelists reported that some form of linear fluorescent (either a T8, high bay fluorescent or T5) was the primary technology they install or sell at this time. A majority of panelists reported selling or installing T8 fluorescent and high bay fluorescent lighting most frequently. Fourteen of twenty-two panelists ranked T8's as one of their top two lamp types installed

while twelve of twenty-two gave those rankings for high bay fluorescents (Figure 8).

According to the DOE Market Characterization study, T12s currently make up about 33% of the installed base of linear fluorescent lighting in commercial buildings compared to the 66% that was found in 2001. However, as shown in the table below, T12s still account for 43% of energy consumed by linear fluorescent lighting because of their lower efficacy.

Table 4: 2010 Share of Energy Consumption by Linear Fluorescent Type¹¹

Technology	Commercial	Industrial
T5	6.4%	8.7%
T8 Less than 4ft	0.4%	0.0%
T8 4ft	44.4%	47.8%
T8 Greater than 4ft	2.4%	4.3%
T12 Less than 4ft	0.4%	0.0%
T12 4ft	28.4%	17.4%
T12 Greater than 4ft	14.0%	17.4%
T8 U-Shaped	2.4%	0.0%
T12 U-Shaped	0.8%	0.0%
Miscellaneous	0.8%	0.0%

Compact Fluorescent Lamps

Compact Fluorescent Lamps (CFLs) are currently the third technology most often installed currently by the panelists and they remain in the third place ranking five years from now. CFLs rely on the same technology as linear fluorescent however they are intended for socket-based applications in lamps and fixtures. CFLs have become increasingly popular and accounted for about 5% of the lighting savings from non-residential projects through 2010 and 2011.¹² Although they expect to be installing CFLs slightly less frequently in five years than they do today, CFLs will continue to be one of the most frequently installed lighting technologies. The loss in market share for CFLs will likely be the result of greater LED market penetration.

High Intensity Discharge

High Intensity Discharge (HID) fixtures include metal halide, high-pressure and low-pressure sodium, and mercury vapor lamps. These lamps produce light by creating an arc between two electrodes inside a gas-filled tube. HID fixtures are commonly seen in high and low bay applications in industrial and warehouse settings, and outdoors. They are known for their long restrike time—the period it takes to come to full brightness after igniting. HID represents about 6% of the installed base of fixtures in non-residential applications.¹³

High bay fluorescent fixtures often replace HID and can reduce energy usage up to 40%, depending on the application. Because they do not have a long restrike period, customers can add occupancy

¹¹ 2010 US Lighting Market Characterization. Navigant Consulting. 2012.
<http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf>

¹² Focus on Energy program savings data.

¹³ 2010 US Lighting Market Characterization. Navigant Consulting. 2012.
<http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf>

sensors to reduce hours of operation. High bay fluorescent lighting is one of the largest sources of electric savings for the Focus on Energy business programs. LED lighting may start tapping into the HID market share as well. The Focus on Energy program got less than 1% of its savings for lighting from high efficiency HID products.¹⁴

Indeed, none of the panelists reported selling or installing HID lighting frequently (see Figure 8). As a result of this finding in the first round, we shifted the questioning in the second to focus on more pertinent topics to the program such as LED.

Light Emitting Diodes (LED)

According to the DOE Market Characterization study, by 2010, LED lighting had penetrated less than 1% of the general lighting market (across both residential and non-residential applications). Furthermore, although the overall share of lighting attributed to LED remains low, growth in the number of fixtures has surged, from about 37,000 non-exit sign LED fixtures installed in 2001 to about 7.5 million non-exit sign LED fixtures installed in 2010. Much of the growth in indoor LED has been in niche applications including display lighting (such as LED refrigerated case lighting). Outdoor LED usage, including use as traffic signals and roadway lighting, has also surged. In 2010, LED made up 10% of the installed base of outdoor lighting.¹⁵

The Delphi panel confirmed this finding. Although they do not install LED frequently today, nearly all panelists (20 out of 22) reported installing LED lighting in at least one project in the past year. Panelists mentioned outdoor, cold-case, and spot/down lighting as the most common LED installations, as well as fixtures where access makes bulb replacement difficult. These installations were primarily located in retail and office settings.

What is perhaps surprising is the speed at which LED are beginning to change the lighting market. By 2015, our panelists expect LED to surpass T8s and high bay fluorescents as the most frequently installed technology.

Results from the Delphi panel suggest that directional spot lighting, task lighting, and display case lighting were the most likely to transition first. However, experts also said that over the next few years high bay lighting, outdoor lighting, and even general space illumination would begin to rapidly transform. The panelists did caution, however, that initial costs and poor equipment quality have the potential to delay this transformation beyond five years.

Panelists gave several reasons why they expect to be installing an increasing number of LED in the near future. These included:

- The falling prices of LED (The most frequently response)
- Increasing longevity and efficiency of LED
- Low maintenance costs of LED

¹⁴ This is according to the program data we received from the program administrator covering the period of 2011 and 2012.

¹⁵ US Department of Energy. Energy Efficiency and Renewable Energy-Building Technologies Program. 2010 US Lighting Market Characterization. Navigant Consulting. 2012. <http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf>

- Increasing awareness of LED, and customers’ understanding of the benefits of energy efficiency

To understand how LED may impact Wisconsin, the panelists were asked what year they thought LED would become cost competitive with fluorescent tube and HID lighting, as well as other commercially viable products for ambient lighting. Results did not change between rounds one and two. Just over half of the panelists expected that LED would achieve parity with other technologies by 2015 at the latest. Others felt it will take between one and five years longer while nearly one-quarter do not expect LED to achieve cost-competitiveness at all. (Table 5).

Table 5: Round 2- Predicted Year LEDs Achieve Cost- Competitiveness with Other Lighting Technologies

Year Arriving at Parity with Other Commercially Viable Lighting	Percent	Cumulative Percent
Already are	9%	9%
2014	9%	18%
2015	36%	54%
2016	5%	59%
2017	9%	68%
2019	5%	73%
2020	5%	78%
Never	23%	

Nearly three out of four panelists stated that they relied on qualified product lists or industry equipment ratings when selling and/or installing LEDs. The most commonly mentioned lists included:

Table 6: Round 1 - Most Commonly Mentioned Qualified Products Lists or Industry Equipment Ratings

List Mentioned	Percent Mentioning
Energy Star	65%
DLC (Design Lights Consortium)	50%
CEE	35%
Lighting Facts	11%

4.4.2 DESIGN

Design-based approaches to energy efficiency involve looking at all aspects of the lighting system, including controls and lighting equipment, in a holistic manner. Savings from design are difficult to capture through “prescriptive” or “standard” incentive programs because they involve entire systems instead of single fixtures. Typically, design-based lighting solutions are most applicable to new construction and existing building renovations, as they are more complex than one-for-one

replacements. The savings for designed projects primarily come from tailoring light levels in specific areas as needed, compared to lighting entire spaces to meet the needs of whichever task needs the highest level of light.

Panelists reported that approximately 40% of their projects involved a complete redesign of customer lighting systems. Of those projects involving a complete lighting redesign, panelists reported that they designed systems more efficient than code nearly 70% of the time; however interestingly they stated that only 36% of those projects that involved a Focus on Energy rebate. The barrier most often mentioned by panelists was excessive paperwork during the application process. Panelists also mentioned that they would like to see higher incentive rates; although this is not always possible.

The average percent efficiency above code achieved by our panelists was reported at 21%¹⁶. In the second round we asked panelists if they thought that 20% above code was realistic and cost effective; 76% of respondents confirmed that it was.

When asked about the strategies they employed to exceed code, half of the panelists identified three techniques: proper fixture spacing and placement (ensuring they aren't over-lighting a space), reliance on natural light wherever possible, and focusing on task lighting versus general illumination. They also frequently mentioned controls as a key component to these projects, as well as integration of LED technology in high use fixtures. However, they also noted that their customers' budgets and priorities drive their decisions in these areas.

4.4.3 CONTROLS

Controls save energy by reducing the length of time that lighting equipment operates, or reducing wattages drawn by fixtures (along with corresponding brightness) when ambient lighting conditions are sufficient to warrant reduced light levels. Basic controls include occupancy sensors, manual dimming, and timers that are easily added to existing fixtures. More advanced controls systems allow for individual control and daylight harvesting, along with integration with building management systems, which can often be a part of a comprehensive design-based project.

We asked panelists about the proportion of projects they completed or sold that included some form of control device. Occupancy sensors were identified in the first round as the most commonly installed control system, whereas individual (workspace) controls were the least commonly installed control type. This pattern suggests that lighting market providers tend to offer more "equipment-based" approaches to controls as opposed to more advanced "design-based" controls. Table 7 summarizes the complete responses from round one.

Table 7: Round 1- Percent of Projects Involving Controls by Type

Control Type	Percent
Occupancy Sensors	48%
Dimmers	25%
Energy Management Systems	18%

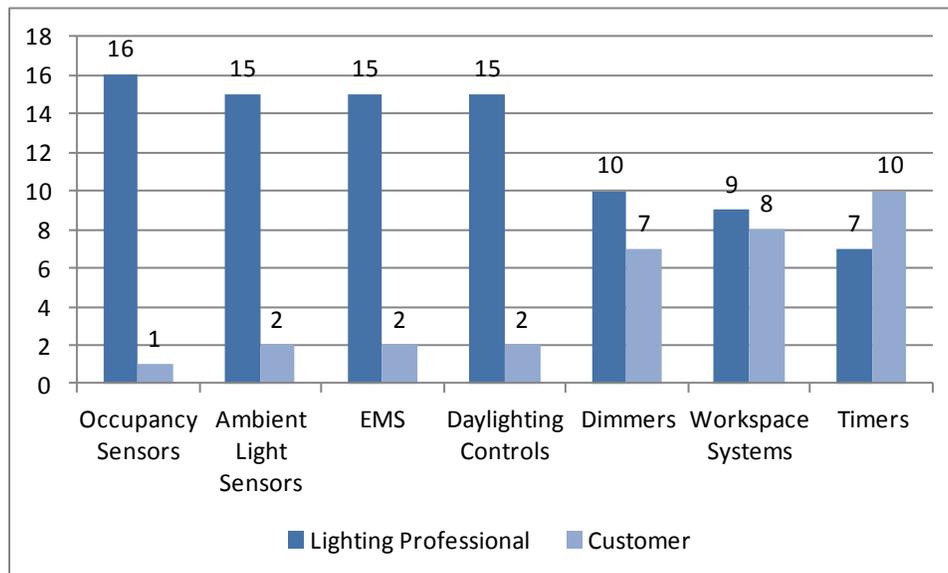
¹⁶ This represents the average with a few outliers removed because they appeared to be data entry errors

Day-lighting Controls	17%
Ambient Light Sensors	16%
Timers	15%
Individual (workspace) control systems	10%

To understand the dominance of occupancy sensors as compared to other controls strategies, panelists were asked to identify the situations in which they were most likely to install them. Panelists reported that typically occupancy sensors are installed in rooms with intermittent use, such as private offices, bathrooms, storage areas, closets, and hallways. Four respondents said that they always install occupancy sensors over other types because they are universally applicable, and tend to save the most in energy over time.

To delve deeper into the decision making process for different types of control systems, panelists were asked whether they recommended or their customers requested the various control types for most installations. Results are summarized in Figure 9 below.

Figure 9: Round 2 Professional Recommendation vs. Customer Request in Lighting Control Systems (n=17)

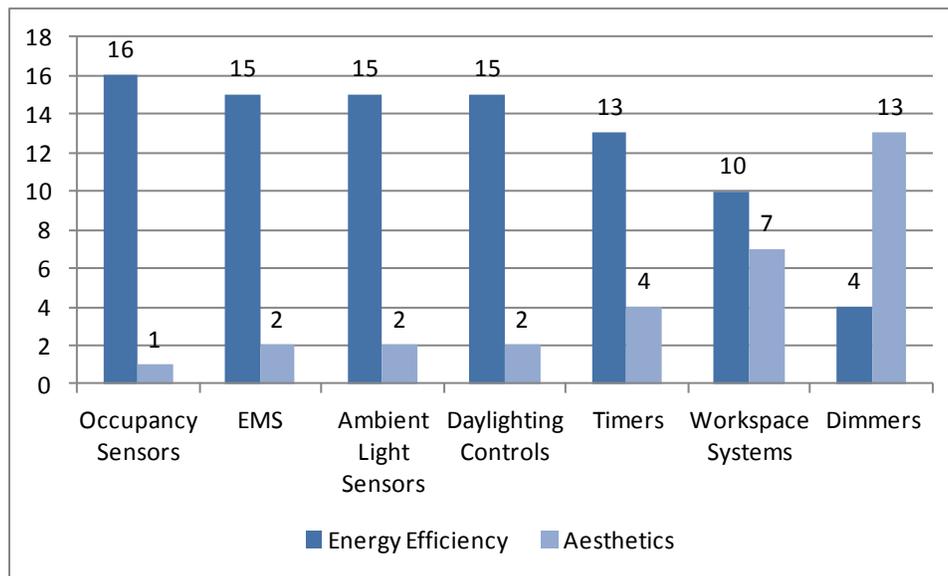


Nearly all panelists said that they recommend the installation of occupancy sensors, ambient light sensors, energy management systems, day-lighting controls. Dimmers and workplace systems were more split between professional recommendations and customer requests. Timers were the only control type that customers request more frequently than the panelists recommend.

We also asked the panelists whether energy efficiency or aesthetics were the reason for the installation of different control types. Energy savings was the main reason for the installation of all control technologies except for dimmers, which were installed for aesthetic reasons. Results are displayed in Figure 10 below.

Figure 10: Round 2- Energy Efficiency vs. Aesthetics as Primary Drivers in Lighting Control Systems

Decision-Making (n=17)



Advanced Controls

Lighting controls have undergone significant advancements in recent years. Integration into the building automation system can tune advanced controls to an entire facility or individual users by sensing occupancy. They can also dim fixtures when enough daylight is present. In addition, wireless advanced controls make it easier to add to existing equipment.

There is not one official definition of Advanced Lighting Controls (ALC) systems though it is widely understood that these systems integrate more than one technology. Indeed, the majority of panelists defined “Advanced Lighting Controls” as the ability to control multiple technologies at once. Another common definition was automation – i.e., setting the controls to operate without direct guidance. Improved aesthetics and user experience were also noted.

There was little consensus about which sectors would benefit most from advanced lighting control installation. Panelists mentioned heavy and light industrial settings, commercial office and retail settings, and public buildings. It was also suggested that newly constructed large facilities, such as warehouses and facilities with irregular occupancy hours, would benefit.

In the first round, panelists were asked about customer barriers to installing advanced controls. Approximately 70% of respondents believed that the upfront cost or the length of return on investment were likely to dissuade customers from implementing such a project. Additionally, more than 40% cited knowledge or behavioral barriers, such as apprehension about new technology in general. Finally, more than 30% of respondents suggested that the nature of existing lighting technologies would avert some customers— i.e., new controls might not function appropriately with older lighting fixtures thereby requiring a facility-wide upgrade.

During the second round of the survey, we asked panelists to rank order their responses from the first round in terms of the importance of each barrier to implementing ALC systems. Financial barriers was the top response with 12 of 17 panelists saying it was the most or second most important barrier. Compatibility with existing systems was another highly ranked barrier that ranked

either first or second by 9 of 17 panelists.

ALC systems are relatively complex. Educating market providers about these systems is an approach that other programs have successfully implemented. California, for instance, has started to offer training and educational resources to professionals who install lighting systems. The California Advanced Lighting Controls Training Program (CALCTP) is a collaborative effort of utilities, state agencies, University of California Davis, and the National Electrical Manufacturers Association (NEMA) that certifies electricians for the installation, testing and commissioning of advanced lighting systems.^{20F17}

Panelists were divided on whether they believed their peers were comfortable with advanced lighting control systems. Out of 22 first round panelists, 7 (32%) believed that most of their peers were comfortable with the systems, while 10 (45%) did not. The rest reported not knowing. Panelists stated that both customers and lighting specialists need to become more familiar with ALC systems and proper applications of it in the field. Most panelists (15) suggested training as a means of increasing their peers' comfort levels with advanced lighting controls.

4.5 WHAT DOES THIS MEAN FOR WISCONSIN?

Wisconsin has an established, statewide energy efficiency program, Focus on Energy, which offers incentives to customers (both residential and non-residential) to encourage them to implement energy efficiency projects that they would not have otherwise done without incentives, or to help them complete these projects sooner than they otherwise would have. The Focus on Energy program has undergone some structural changes in recent years and the program offerings have changed significantly. We reviewed the current program offerings to put our findings into context for what it means for the statewide program.

4.6 AWARENESS

Our panelists reported high levels of program awareness of the Focus on Energy program among lighting market providers and slightly lower (although still high) levels of awareness among their customers. Customer-focused education and outreach would be beneficial in helping trade allies promote more energy efficient options to their customers. Additionally, 45% of the panelists reported that their peers were not comfortable installing advanced lighting controls which could speak to the need for training of market providers.

4.6.1 MARKETS

Panelists indicated that Light industry, Office and the Public sectors are the most receptive to energy efficiency projects. The Public sector was also the most transformed, however panelists suggested that local governments and school districts are still receptive to efficient lighting projects. The Restaurant and Outdoor sectors were indicated to be the least receptive and also the least transformed.

The program has several new offerings that might reach these targeted sectors. The Chain Stores and Franchises offering which targets businesses with 5 or more locations in the state offers an

¹⁷ The CALCTP program can be found at: <https://www.calctp.org/content/what-calctp>

opportunity to engage both retail operations and restaurants. The Large Energy Users program may be able to reach the industrial customers. In Table 8 we have attempted to match the sectors identified in our analysis with the new program offerings that might be able to best serve those customers.

Table 8: Sectors Matched to Program Offerings

Sector	Offerings
Public	Retrocommissioning, Business Incentives, SMART Lighting
Office	Business Incentives, SMART Lighting, Design Assistance Track, Retrocommissioning
Light Industry	Large Energy Users, SMART Lighting
Outdoor	Business Incentives
Restaurants	Chains & Franchises, Small Business, Business Incentives, Design Assistance Track
Heavy Industry	Large Energy Users, SMART Lighting, Design Assistance
Retail	Chains and Franchises, SMART Lighting, Small Business, Business Incentives, Design Track

4.6.2 EQUIPMENT

Linear fluorescent is by far the largest contributor to the Focus on Energy program’s savings (58.5% of the kWh and 61.2% of the KW savings) 2010 and 2011 (Table 9).

Table 9: Focus on Energy Lighting Savings 2010-2011

Technology	% of Energy and Demand Savings	
	kWh	KW
Fluorescent Tube	58.5%	61.2%
Custom	9.7%	7.5%
LED	8.9%	6.4%
Control/Sensor	8.9%	3.6%
Other	8.0%	8.5%
CFL	5.3%	12.0%
HID	0.8%	0.8%

One of the most significant findings from the panel-led research was that participants agreed that they will sell, specify and install more LED than fluorescent lighting in five years. This will drastically change the landscape for the program. Currently the primary barrier to LEDs is the initial upfront cost, but many panelists expect LEDs to reach cost-competitiveness with fluorescent by 2015. The Focus on Energy program currently offers incentives for some types of LED. As technology improves and costs come down it will make sense to broaden the LED offerings.

4.6.3 DESIGN

The majority (76%) of our panelists believe that it is cost effective and realistic to design systems that beat code by 20% suggesting there is a large potential for energy savings. And our panelists reported that they are designing above code 70% of the time but also reported that only 36% of their new construction or major renovation projects included some form of program discount.

The Focus on Energy program has new, design-based offerings for Businesses including the SMART Lighting program which offers incentives to businesses and the design teams that work on the projects. This new offering, launched in 2013, may help address the relatively low rate of rebated projects when compared to projects that are designed above code. As mentioned earlier, excessive paperwork is often seen as a barrier to participation in the program so a streamlined participation process (possibly one that fits in with existing state code requirements) may help boost participation.

4.6.4 CONTROLS

The program currently offers prescriptive incentives for occupancy sensors, while timers and dimmers can qualify for custom incentives. Occupancy sensors contributed to about 9% of the kWh energy savings that the Focus on Energy program achieved in 2010 and 2011.¹⁸ Panelists report that they install occupancy sensors on 48% of their projects making them the most popular option.

One potential barrier that the panel identified was a lack of comfort among lighting professionals regarding the installation of advanced lighting controls systems. This likely indicates a need for additional training on these technologies. Additionally, customers appear to be making decisions regarding controls systems based more on aesthetics than energy savings. More customer education would likely help address this barrier as well.

CONCLUSION

The results of our panel indicate that the lighting industry is on the precipice of major changes. Probably the most significant finding is the progress that LED lighting is expected to make in the next five years. LED technology is poised to overtake a program staple, linear fluorescent, as the most frequently installed sold lighting technology in non-residential applications. Our panelists predict LED will achieve cost-parity with other general illumination technologies (namely linear fluorescent) as early as 2015 and they expect to be selling, specifying and installing LED more often than linear fluorescent five years from now. This finding has major implications for energy efficiency programs.

Wisconsin's robust and long-running energy efficiency initiatives have transformed markets in the state. Focus on Energy's Commercial and Industrial programs have undergone changes in recent years including adding some design-based and market segment-specific offerings. According to our research Retail, Light Industry, Heavy Industry and Office represent the next best opportunities for program intervention. Additionally the Outdoor and Restaurant sectors are going to be somewhat harder to reach and have unique barriers that need to be addressed. Restaurants often survive on thin profit margins, and do not have the capital available to larger firms to invest in new lighting and they tend to base lighting decisions on aesthetics. Panelists believe that because outdoor projects

¹⁸ Wisconsin Focus on Energy program data.

tend to be more expensive, the added cost of efficient lighting can be a barrier. Additionally, outdoor components of larger projects are often overlooked, and opportunities are missed.

Our panel also reported working primarily on design projects and reported that only 25% of their projects represent one-for-one replacement. These findings align with the 2010 potential study mentioned earlier and indicate significant program savings could be achieved through design. Of those projects that require a design-based solution, panelists report designing above code in about 70% of their projects. At the same time, however they report only receiving incentives for 36% of those projects.

KEY TERMS

The following definitions come from the from the ENERGY STAR Building Manual (October 2008 revision).¹⁹ Key terms presented here represent a subset of terms from that glossary that are most applicable to the subject matter. Additional terms can be found in the full glossary.

Accent lighting *Directional lighting used to emphasize or draw attention to an object or area.*

Ambient lighting *Lighting throughout an area that produces general illumination.*

Ballast *An electrical device designed to control the current delivered to a fluorescent or High Intensity Discharge (HID) lamp. Most ballasts also convert the line voltage into the proper voltage and waveform needed to start and operate the lamp.*

Ballast efficacy factor (BEF) *The ratio of the ballast factor, specified as a percentage, to the ballast input power in watts. Ballast efficacy factor is only meaningful when used to compare ballasts operating the same type and number of lamps. Also called the ballast efficiency factor.*

Ballast factor (BF) *The luminous flux of a fluorescent or HID lamp (or lamps) operated on a ballast divided by the luminous flux of the same lamp when operated on the standard (reference) ballast specified for rating lamp lumens.*

Dimmer *A device used to control the intensity of a lamp's emitted light by controlling the voltage or current available to power the lamp.*

Downlight *A small direct-lighting unit that directs the light downward and can be recessed, surface-mounted, or suspended.*

Efficacy *The total luminous flux emitted by a lamp divided by the total lamp power input, expressed in lumens per watt.*

Electronic ballast *Device using solid-state components to provide power to a discharge lamp at high frequency (typically 25,000 to 100,000 cycles per second, but sometimes as high as 2,500,000 cycles per second).*

Fluorescent lamp *A low-pressure mercury electric-discharge lamp in which a fluorescent coating (phosphor) transforms some of the ultraviolet energy generated by the discharge into light.*

High-bay lighting *Interior lighting where the roof truss or ceiling height is greater than approximately 7.6 meters (25 feet) above the floor.*

High-intensity discharge (HID) *A type of electric-discharge lamp in which the light-producing arc is stabilized by wall temperature and the arc tube has a bulb wall loading in*

¹⁹ United States Environmental Protection Agency. Office of Air and Radiation. ENERGY STAR Building Upgrade Manual. 2008 Edition. http://www.energystar.gov/ia/business/EPA_BUM_Full.pdf

excess of 3 watts per square centimeter. HID lamps include groups of lamps known as high-pressure mercury, metal halide, and high-pressure sodium.

High-pressure sodium (HPS) A high-intensity discharge lamp in which light is produced by radiation from sodium vapor operating at a partial pressure of about 1.33×10^4 Pascal's (100 torr). Includes clear and diffuse-coated lamps.

Light-emitting diode A solid-state device that generates light by the recombination of electrons and holes in the junction between two different semiconductor materials.

Magnetic ballast Power circuit consisting of one or more magnetic coils and optional capacitors, designed to limit current and provide necessary starting voltage for discharge lamps.

Metal halide (MH) A high-intensity discharge lamp in which the major portion of the light is produced by radiation of metals that are the product of dissociation of metal halides in the arc discharge. Includes clear and phosphor-coated lamps.

T# A designation of lamp type, as in T8, T12, and so on. T stands for tubular; the number describes lamp diameter in one-eighth-inch increments. A T8 lamp is eight-eighths of an inch (or 1 inch) in diameter; a T12 is twelve-eighths of an inch (or 1 and one-half inches) in diameter.

Task-ambient lighting Task lighting and ambient lighting combined in an area in such a way that the general level of ambient lighting is lower than and complementary to the task lighting.