BPA E3T 2012 LED Technical Advisory Group

Final Report

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WSU Energy Program

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Preface

This report covers the 2012 cycle of the Energy Efficiency Emerging Technology (E3T) program's second Lighting Technical Advisory Group (TAG), focusing on light-emitting diode (LED) applications and technologies, from its conception in late 2011 to its final meeting in June 2012. The TAG is known as the 2012 LED TAG. This report summarizes key events during the LED TAG and includes specific recommendations for four technologies the TAG scored.

The complete LED TAG report and appendices include:

- Narrative putting the 2012 LED TAG in context with previous work
- Summaries of key stages of the 2012 LED TAG cycle
- Graphics detailing ranking and scoring surveys results
- TAG Recommendations for four selected LED technologies (Appendix A)
- A list of TAG members, partners and participants (Appendix B)
- Notes on earlier TAG cycles (Appendix C)
- Detail on survey language and guidance used for this TAG (Appendix D)

The purpose of this report is to provide a distillation of events, processes and results of the TAG to put the core product – the recommendations – in context. This report also summarily addresses the question, "How did we get there?" Beyond the ranks and scores depicted and the recommendations themselves, the report is not intended to detail the emerging technologies considered by the TAG. More detailed documentation of individual technologies and solutions examined during the TAG cycle can be found at E3TNW.org, which serves as the official repository for information gathered during the E3T process.

This report uses the terms "emerging technology," "technology," "application," "potential measure" and even "item" to denote the individual technologies considered by the TAG. Additionally, the official names used to refer to the individual technologies are in some cases modified as a result of TAG work. Lists, tables and graphs in those reports may use components developed at different stages of the TAG cycle and, thus, some names vary within this report. For example, TAG members changed the title of emerging technology #395 from its original "Outdoor Wall Packs" to "Outdoor Wall-Mounted Luminaires" for clarity. The database reference numbers do not change, which can help resolve potential confusion caused by the evolution of technology titles.

Introduction

The E3T program was designed to evaluate energy efficiency technologies that are commercially available or nearly ready to come to market and could be deployed in the Pacific Northwest to acquire conservation resources. This work reflects cross-disciplinary collaboration and stakeholder engagement in a streamlined process that establishes a system for strategically identifying potential measures for implementation within BPA's service territory.

Decision makers from different BPA departments were involved early in this process. The TAG process is related to E3T's Technology Roadmapping, which focuses on energy efficiency technologies that are not yet commercially available.

TAGs are a part of the E3T Framework, which states as a goal "for BPA to engage in an ongoing collaborative effort to 'fill the pipeline' with innovative energy efficiency strategies and technologies that promise significant region-wide energy savings."

Previous TAG Cycles

This group's work followed four previous E3T TAG cycles:

- The first focused on all lighting technologies beginning in early 2009
- The following two focused on heating, ventilation and air conditioning (HVAC) in 2009 and 2010
- The last was an Energy Management TAG in 2011

During these TAG cycles, operational details of the E3T TAG process were developed and refined, and recommendations for 17 promising technologies were drafted. Brief summaries of these past TAGs are available in Appendix C. Final reports were completed for each of those TAGs and are available at the E3TNW.org website.

2012 LED TAG Timeline

In late 2011, as the Energy Management TAG was concluding, discussions among staff began to suggest that a lighting TAG specific to light-emitting diode (LED) technology and applications be convened in the first half of 2012. Background material was researched and summarized in January and February, largely by BPA staff under a new agreement with the Washington State University (WSU) Energy Program. After this step was complete, the E3T team developed a working definition for the chosen focus area and defined the TAG scope. Recruitment for the TAG began in late February and a list of selected TAG members was drafted in mid-March.

On March 20, the LED TAG was launched as members, staff, and guests were asked to register for the first meeting of the 2012 E3T LED TAG. This meeting was held on April 5, 2012 via online webinar and in person in the WSU Energy Program offices in Olympia. In April and May, four working groups, each with four to seven TAG members and staff, began their task of examining a single LED application. These working groups each met several times and also communicated between their meetings using listservs established exclusively for their work to prepare presentations and draft recommendations.

Subsequent all-TAG meetings were held on May 3, 17, and 31 and on June 7, when TAG members representing each working group made presentations on individual LED applications which had ranked highly in member surveys that inquired about their readiness and suitability for promulgation through

utility programs. A final all-TAG meeting was held June 21, 2012 to review information gathered for recommendations specific to each LED application. Staff completed drafting those recommendations by the end of June.

2012 LED TAG Stages and Meetings

Planning, Definition, and Recruitment

The LED TAG was new but had deep roots. In October 2010, preliminary plans were made to re-convene members of the 2009 Lighting TAG, with a suggestion that it would focus exclusively on Light Emitting Diode applications. Around the same time, a "re-visioning" of the entire E3T program was underway, based in part on a needs assessment which surveyed key stakeholders. Pending a plan to implement program-wide modifications, TAGs were suspended. Plans again emerged to convene a Lighting TAG focusing on LED applications late in 2011.

Staff discussions included many ideas on how to modify the TAG process during this cycle to meet needs identified internally at BPA. Key drivers for change included a desire to have a shorter TAG cycle with fewer hours in all-TAG meetings and to share more context and information with TAG members early on to yield recommendations that better addressed key Programs needs and concerns. Also stressed was a re-invigorated intent to nominate TAG members from across the professional spectrum – distributors, designers and installers, and national and regional efficiency experts – while also ensuring that utility staff were well-represented on the TAG because they are key to the ultimate promulgation of BPA energy efficiency programs. Added staff at BPA were able to review literature and assemble available information and presenting on program directions and to share in advance Program considerations and perspectives. Thus this TAG was able to go "from 2 to 12, instead of 0 to 10" in the words of one staff member.

BPA staff originally wanted the TAG to produce an LED strategy that would go beyond identifying specific emerging technologies and develop an integrated strategy that defined the role BPA should play in guiding use of LEDs in the region. It was determined that this additional task would detract from TAG members' core role. A working definition of the TAG was developed in late March.

Ultimately, the 2012 E3T LED TAG comprised 29 members from 22 organizations, five states and one Canadian province across five time zones, supported by five WSU Energy Program staff members, two BPA E3T staff, the BPA lighting program manager, and the BPA lighting technical manager.

Identification and Ranking

In past TAG cycles, identification and ranking tasks were accomplished during separate meetings. In the 2012 LED TAG, we combined the stages into a single meeting, with staff reviewing several LED technologies in advance of the TAG launch. As TAG members were confirmed, they were informed of prospective LED technologies the TAG was poised to review and asked to add to the list of "emerging lighting technologies that might successfully compete with the items [already] listed, whether they utilize LED or other technology, and additional LED applications that you believe are equally or more promising."

The initial LED TAG meeting on April 5 provided an introduction to E3T and the TAG process, a final opportunity to suggest additional technologies, and time for TAG members to complete the ranking survey, effectively merging the identification and ranking meetings of past TAGs.

During the lunch break of the initial meeting, members were asked to rate the 10 technologies using an online survey. In a departure from previous TAGs, members were also asked to characterize the readiness of each proposed LED application before rating their overall support for the listed technologies.

After indicating readiness, the survey asked members to give an overall rating to each of the 10 technologies, which facilitated ranking the technologies and selecting the top four. The survey used language distinct from that used in previous TAGs. Survey questions and guidance are included in Appendix D.

Members' ratings were compiled during the meeting and the results were conveyed using the screen-sharing capabilities of the webinar software. Prior to the end of the first meeting, the first of two surveys that TAG members were asked to take was complete, and the technologies that would be the focus of the TAG's remaining work were known.

Ranking results are depicted in Figures 1 and 2.

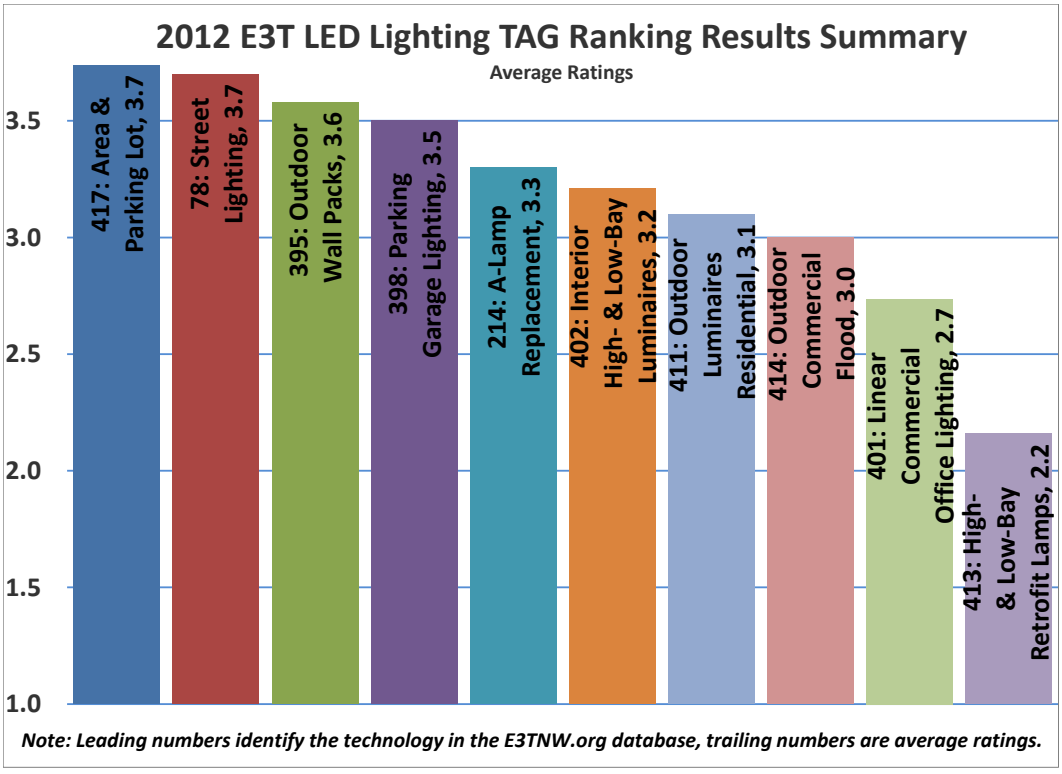

Figure 1. Graphical Representation of 2012 LED TAG Ranking Results

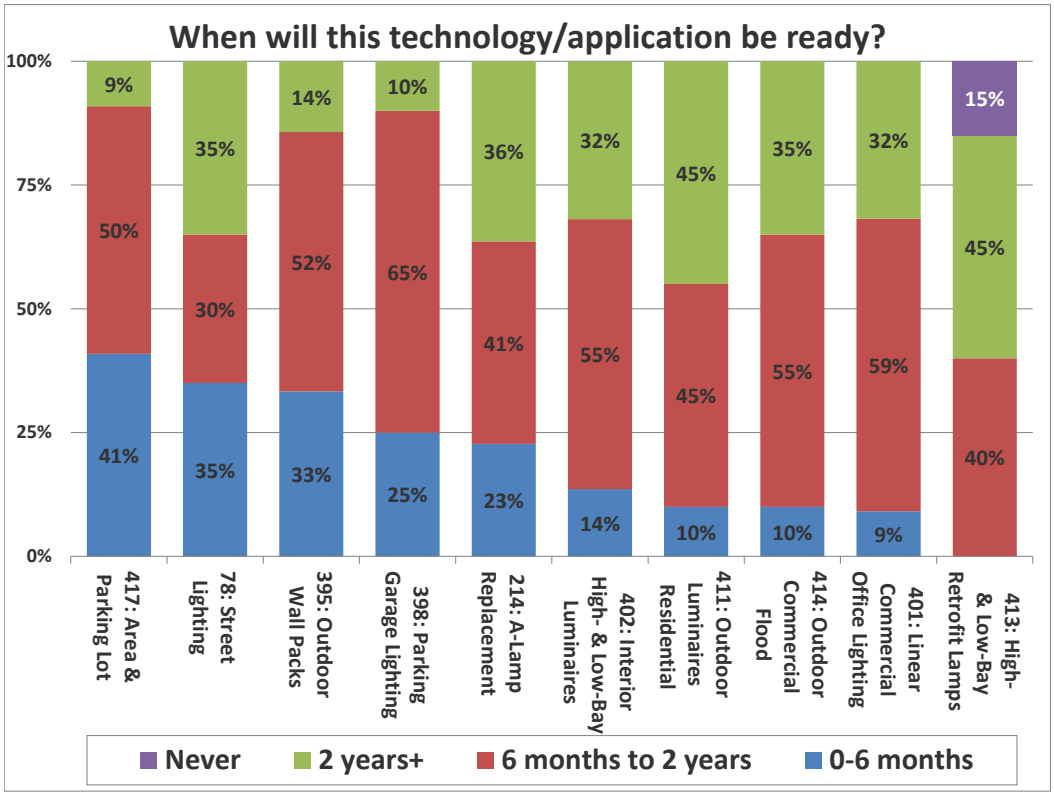

Figure 2. Graphical Representation of 2012 LED TAG Readiness Results

Working Groups

Working groups were established at the end of the first LED TAG meeting to concentrate on each top-ranked technology. Members were invited to join one of four groups to research and discuss these technologies in more depth, develop presentations, and draft recommendations for scoring meetings of the full TAG. For each working group, a convener was designated and a suggested presenter was named, with the understanding that the group would ultimately determine these roles. In addition to presenting technical aspects of each technology, working groups were able to consider how to promote the emerging technologies. Each group included E3T staff from BPA and used a dedicated listserv to facilitate ongoing exchanges.

Working groups grew out of reflections on previous presentation planning. Typically, a TAG member worked alone or with one other member or staff person to prepare presentations focused primarily on technical aspects of the item under review. Content for recommendations was winnowed from the presentation and subsequent discussion during the scoring session, and staff completed a draft set of recommendations after the meeting.

However, TAG participants have always been interested in discussing TAG outcomes, including recommendations, at greater length than time allowed in previous scoring sessions, during which all of the top-ranked technologies were reviewed in a single meeting. Staff preparing the recommendations

afterwards also needed to consult with the presenters and other TAG members to clarify information and to draw out implications for actions that BPA and others could take. When Jack Callahan, senior staff for the E3T project at BPA, suggested the idea of working groups during the Energy Management TAG in 2011, this idea resonated as a potential solution.

For the 2012 LED TAG, the working groups were composed of the following members:

	LED Area and Parking Lot Lighting	LED Outdoor Wall-Mounted Luminaires	LED Linear Commercial Office Lighting (includes troffers and pendants)	LED Street Lighting
Convener	Jennifer Williamson	Jon Linn	Stan Walerczyk	Levin Nock
BPA Staff	Jennifer Williamson	Jennifer Williamson	Levin Nock	Levin Nock
Presenter	Kurt Nielsen	Eric Strandberg	Stan Walerczyk	Edward Smalley
	Craig Ciranny	Irina Rasputnis	David Kunesh	Ira Krepchin
	Dave Hunt	Joe Vaccher	Connie Samla	Mark Rehley
			Naomi Miller	Mary Matteson Bryan
			Doug Oppedal	
			Cindy Wills	

Scoring Meetings

To keep scoring meetings short, each presentation was featured during a separate presentation and scoring meeting. Each meeting allowed about 30 minutes for the working group presentation, followed by about an hour of discussion and revision of recommendations. Each group met on the same day of the week at the same time, a minor change from previous TAGs that seemed to be well received. Toward the end of each meeting, TAG members were asked to complete the scoring survey. The meeting dates and topics were as follows:

- May 3: Area and Parking Lot Lighting presentation by Kurt Nielsen
- May 17: Outdoor Wall-Mounted Luminaires presentation by Eric Strandberg
- May 31: Linear Commercial Office Lighting presentation by Stan Walerczyk
- June 7: Street Lighting presentation by Edward Smalley

Results

The final results of the scoring are provided below. The technologies are listed in order of the average overall score, based on the 1 to 5 ratings of each technology on the five criteria listed in Appendix D.

Emerging Technology	Average Score
#395: LED Outdoor Wall-Mounted Area Luminaires	**3.9**
#78: LED Street Lighting	**3.9**
#417: LED Area and Parking Lot Lighting	**3.5**
#401: LED Linear Commercial Office Lighting	**3.1**

More detailed results are provided in Figures 3 and 4. Scored technologies are also ranked in aggregate and by characteristic, as shown in Figure 4.

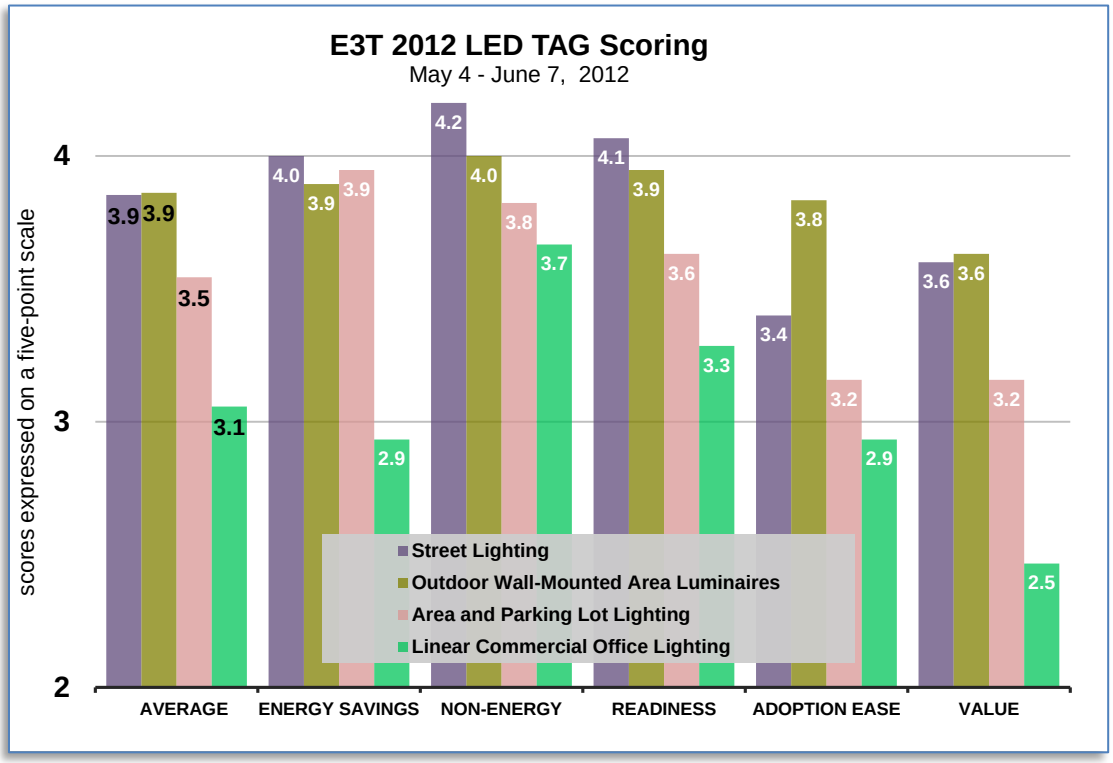

Figure 3. Graphical Representation of 2012 LED TAG Scoring

SCORES	Area and Parking Lot Lighting	Outdoor Wall-Mounted Area Luminaires	Linear Commercial Office Lighting	Street Lighting
AVERAGE	3.5	3.9	3.1	3.9
ENERGY SAVINGS	3.9	3.9	2.9	**4.0**
NON-ENERGY	3.8	**4.0**	3.7	**4.2**
READINESS	3.6	3.9	3.3	**4.1**
ADOPTION EASE	3.2	3.8	*2.9*	3.4
VALUE	3.2	3.6	*2.5*	3.6

scores are all expressed on a five-point scale
4 or above **bold;** 3 or below *italic*

		Area and Parking Lot Lighting	Outdoor Wall-Mounted Area Luminaires	Linear Commercial Office Lighting	Street Lighting
RANKS	OVERALL	3	1	4	1
	ENERGY SAVINGS	2	3	4	1
	NON-ENERGY	3	2	4	1
	READINESS	3	2	4	1
	ADOPTION EASE	3	1	4	2
	VALUE	3	1	4	2
	Legend >>>	blue = 1st place	red = 2nd place	white = 3rd place	*<<< Legend*

Figure 4. 2012 LED TAG Scoring Detail and Ranks

Traditionally, TAG scores above approximately 2.9 constitute a technology that the TAG recommends to move forward into utility programs. All four of these technologies scored above 2.9 so, as confirmed by the TAG dialog, all four of these technologies are recommended to move forward into utility programs. The Outdoor Wall-Mounted Luminaires, Area and Parking Lot Lighting and Linear Commercial Lighting are already in the lighting calculator, but the TAG suggested several actions to refine the level of incentives and additional strategies to encourage their use in the region. Those recommendations are included in Appendix A.

In general, the TAG felt confident that the Outdoor Wall-Mounted Luminaires and the Area and Parking Lot Lighting were technologically and economically ready for deployment, especially for new installations. Street Lighting is also technologically and economically ready for deployment, but the TAG acknowledged that it poses some additional programmatic challenges for BPA in implementation because of rate structure and billing issues.

The TAG acknowledged that Linear Commercial Lighting is potentially a huge opportunity because it comprises such a large percentage of the lighting load in the region. However, the value proposition of the incumbent technology – linear fluorescent lighting – is so compelling that implementing this technology in the very near future poses significant challenges to make this an economically viable conservation resource. The Linear Commercial Office Lighting, however, should be considered for new installations.

Recommendations Confirmation Meeting

Draft recommendations from working groups came in variety of formats, with differing emphases on research and programmatic aspects. Following the final presentation and scoring session on June 7, Jack Zeiger, the WSU Energy Program lead technical E3T staff, put each set of recommendations into a consistent format and identified remaining gaps. BPA reviewed the recommendations in advance of the meeting to identify clarifications and questions that needed to be addressed in order for the recommendations to be actionable for BPA.

In the last all-TAG meeting held June 21, following a review of side-by-side scoring results, each set of recommendations was opened for final comment from TAG members and staff present. Between 30 and 45 minutes of discussion was allotted to each. Following the meeting, staff noted that, although we spilt presentations into individual meetings, the TAG reviewed all recommendations in a single meeting. In subsequent TAGs, it may be beneficial to schedule separate short meetings for each set of recommendations. This would allow more time for members to review and comment in advance of each meeting and would still provide some of the same benefits that the individual presentations on technologies offered.

Recommendations represent the core product of each TAG cycle. Recommendations from the E3T 2012 LED TAG follow in Appendix A.

Appendix A: 2012 LED Lighting TAG Recommendations

The following recommendations were developed by the 2012 LED Lighting Technical Advisory Group in May-June of 2012.

LED Outdoor Wall-Mounted Luminaires – #395 Exterior wall-mounted LED walkway or security lights	**Overall Score: 3.9**

Note: this technology is already in the BPA Lighting Calculator and, therefore, eligible for BPA incentives.

Summary

The TAG consensus is that LEDs in this application are appropriate for BPA to support. We are comfortable that performance is good enough, and consumer benefits significant enough to encourage full deployment. The main issue is first cost.

LED outdoor lighting is becoming a more common product. A contractor in the group mentioned that most of his customers are now requesting at least one LED option in proposals. A distributor said he is now selling LED products frequently. Some customers are deterred by first costs. LEDs provide a lot of benefits over conventional lighting in this application, and this application is the simplest of the four TAG topics, from the perspective of lighting design (fixture placement, light distribution, etc).

The Scoring Meeting presentation outlines many specifics (such as advantages and disadvantages, approved products lists, etc.), and this document outlines the TAG's recommendations for research or program design.

Research Recommendations

- **Case Studies**
    - Collect information on existing installations. The main purpose is to identify potential problems, such as early failures. Another value could be to provide examples for customers to observe if they are considering a similar installation. Beware that because product designs are changing so rapidly, information gathered on a product in place more than 6 months will be generally useful for the purposes outlined above, but it is likely that the specific model will no longer be on the market, and will have evolved into a new model at that point. The intent is that these "case studies" will not be in-depth analysis and reporting of each site, but rather a brief overview of approximately 10 installations in the region.
    - Consider compiling a list of complaints in order to identify trends (e.g. particular problem manufacturers).
- **Secondary Research**

  Perform additional secondary research. We should gather the available research by DOE and California, etc., and summarize the relevant conclusions.

Programmatic Recommendations

- **Naming**
  Consider dropping the terms "wall pack" and "sconce," and adopting the term used by DLC – "LED Outdoor Wall-Mounted Luminaires." The DLC is undertaking a review of their naming conventions and categories in the next few months, and the changes are expected to be effective in approximately nine months.

- **Structure of Incentive**
  - Create multiple categories based on size of bulbs so that it can be recognized that larger wattage bulbs will save more energy and therefore deserve higher incentives. For example, the incentive for a 100 watt lamp may be $50 (based on 75% wattage reduction and $.15/kWh) and the incentive for a 400 watt fixture could be $198.
  - Structure incentives to acknowledge that it is typical for wall packs to reduce wattage by 65%, which is greater than the 50% BPA currently requires. Examples of these situations are illustrated in the presentation in the table column titled "standard practice."
- **Qualified Products Lists**
  Consider accepting everything on the DLC Qualified Products List (QPL) for ease of understanding and less administrative hassle. Address the differences between various lists (DLC, LDL, etc.), and move toward fewer lists. Note that the DLC list does not currently cover flood lights, which can be a good alternative to other types of wall-mounted luminaires, but these can be tested at Lighting Design Lab and accepted by BPA even without that as a non-standard project.
- **Lifetime**
  - Consider requiring a minimum warranty period for utility incentives. There was some disagreement about what length of warranty should be required. Some members felt that five years was adequate, while others felt the warranty should be as long as the product is rated for (12-15 years for outdoor lighting rated at 50,000 hours and operating 4,000 hours per year). Decide how warranty issues should be enforced.
  - Consider using lumen maintenance as a surrogate for lifetime (a practice many utilities currently follow).
  - Beware that product "innovations" could lead to shorter lives (if the manufacturer is trying to cut costs and therefore cuts quality).
- **Retrofit Kits**
  Consider taking a position on retrofit kits. The TAG discussed retrofit kits at length and did not reach a consensus. Many members felt that BPA should not provide incentives for retrofit kits because so few of them really worked well, concerns about putting a retrofit kit in an old fixture, warranty issues, water leakage, and the fact that UL listing is only valid if the retrofit kit is UL-approved to fit in a specific UL-approved fixture. Others felt that some reputable manufacturers have developed retrofit kits specifically designed for certain of their fixtures that work well and that they should be supported. Retrofit kits provide potential for cost savings as well. The DLC list does include retrofit kits, so consider influencing their policy and relying on their list.
- **Controls**
  Consider providing a bonus incentive for fixtures that have bi-level controls or are at least "controls-ready"; work with CLTC to define that term.

  The consensus was that it would not be appropriate to require wall luminaires to be "controls-ready" for dimming at this time. ("Controls ready" was defined as being able to accept a 24 volt input to the fixture, and having a 0-10 volt dimmable driver.) The current extra BPA incentive for occupancy controls is sufficient. Consider requiring at least a bi-level control capability, but beware that dimmable drivers increase costs.

- **Education**

  Publish informational fact sheets, application and purchasing guidelines, and advice, and provide training for end-use customers, utility staff, contractors, specifiers, distributors and others. Target audiences could include:

  - **Customers**
    - Demand lighting that will meet their needs. On a large project, encourage customers to try a pilot installation to ensure satisfaction before installing a large number of fixtures
    - Ask about and consider if replacement components will be available for the life of the product.
    - Consider **disposal/recycling issues.**
  - **Utility staff**
    - How to analyze claims from manufacturers and contractors
    - How to advise customers
  - **Contractors, specifiers and distributors**
    - Develop appropriate curriculum

Product Availability

- The DLC QPL currently lists over 120 qualifying products in the category called “Outdoor Wall-Mounted Area Luminaire” (counting only the parent product, not variations of model numbers representing colors, etc.), including 43 brands from 36 different manufacturers. Efficacy ranges from 59 to 103 lumens per watt.

LED Street Lighting #78 Street lighting fixtures employing light-emitting diode (LED) technology	**Overall Score: 3.9**

Summary

The TAG gave LED Street Lighting high marks on technical performance and availability. As with other LED technologies, the prices are still high but coming down. The biggest remaining barriers for street lighting center on programmatic changes, and particularly issues having to do with the fact that street lighting is seldom metered. Designing rate schedules that provide savings to the customers and provide load savings to BPA that remain relatively simple and do not require metering would go a long ways to making this technology viable for BPA programs. Other utilities are doing this successfully, so it would be worthwhile studying their models.

Since public safety is at stake and these products last for so long, it is also important for each jurisdiction to have competent technical advice on how best to light their streets efficiently while providing adequate safety and aesthetics.

Research Recommendations

- **Glare**
  Develop draft specifications or incentive requirements limiting allowable glare of LED street lights.
- **Health impacts:** Encourage and possibly support deep secondary research or primary research on the potential health impacts of higher color temperature street lighting on humans and animals. In a Seattle survey, participants preferred LED street lights at 4,000 or 4,500^{o}K, similar to moonlight, compared to higher CCT's. At present, the DLC acceptable range is 2,900 to 5,900^{o}K.
- **High-wattage fixtures:** Investigate the current cost effectiveness of replacements for existing fixtures above 400 watts. Most TAG members feel that LED technology is currently not cost-effective for these applications, but is becoming so quickly.
- **Longevity**
  Develop draft specifications for photocell longevity. To take full advantage of the relatively long life of LED technology, other components, such as the drivers and photocells, must have a commensurate life expectancy. Consider providing an incentive for long-life photocells such as Tyco 2000 series and Sun-Tech TRS. Encourage or perform research to identify what aspects of photocells are causing early failure and share this information with manufacturers to help them make more robust sensors. Consider adding this task to the Energy Efficiency R&D roadmap.

Programmatic Recommendations

- **Rate Structures**
  Provide model language and/or tools to customer utilities for modifying their rate schedules to accommodate LED street light performance. Street lighting poses a unique rate schedule issue; most jurisdictions do not meter their street lights, but are billed according to the known wattage of the lamps and the expected run time.

  - Others have tackled this issue, including Pacific Gas and Electric (PG&E), the Sacramento Municipal Utility District (SMUD) and Efficiency Vermont. It would be efficient to review rate schedules they developed, investigate the approaches they tried and find out how well these approaches are working. Build on these successes to come up with a workable strategy or strategies.
  - Encourage the development of rate schedules that accommodate the variability in wattages of LED

street lights. Incumbent technologies have distinct lamp sizes and corresponding wattages, so rate schedules are relatively simple. For example, PG&E's tariff includes 5-watt increments for LED lamp wattages.

  - Come up with a cost-effective method of metering for utilities that choose to monitor actual street lighting energy use. Investigate the accuracy requirements for electric meters; using utility-grade meters can increase the costs.

- **Group Purchases**
  Consider encouraging group purchasing with multiple jurisdictions to achieve quantity discounts. Note that the City of Portland is buying some streetlights through Seattle City Light's contract, and other northwest utilities could also buy through Seattle City Light.
  - Consider offering turnkey installations such as those offered by PG&E.
  - Often, each jurisdiction can make its own choices from a family of products, and still be considered part of a group purchase.
  - NEEA may be in a good position to help utilities with this.

- **Technical Support**
  Offer technical support as part of incentive programs, possibly including help with modeling performance and product selection.
  - Encourage use of the Municipal Solid-State Street Lighting Consortium (MSSLC) model specification (http://www1.eere.energy.gov/buildings/ssl/specification.html) to aid jurisdictions in expediting their purchasing and ensuring they select quality products.
  - At a minimum, utilities should direct end users to information resources and consultants. Ideally, the utility would provide some direct on-site technical support, including the MSSLC checklist of what to consider. This is especially important early in the purchasing process to ensure that jurisdictions install products they are happy with and the technology does not get a bad reputation. Consider providing this information through regional partners such as the Northwest Trade Ally Network.
  - Consider forming a street lighting users group, , where end users share their experiences with others. This could be a group of municipalities, such as the successful group formed by SMUD, and/or a group of utilities.
  - Contact Mark Ledbetter at PNNL for additional suggestions for effective technical support.

- **Incentive Structures**
  Use incentive structures that assure savings; review incentive structures developed by others (PG&E, SMUD, Efficiency Vermont and Seattle City Light).
  - Design a prescriptive program, if possible. This could be based on PG&E's model, which specifies maximum LED wattage allowed for each application, such as arterials and neighborhood streets.
  - Set savings targets at a reasonable but aggressive level. Seattle is currently saving 62% on arterials and 50% on surface streets that have LED street lights. Maybe 40% to 50% is a good target today, but may be too low a year from now. These targets should be reviewed regularly (annually may be sufficient).
  - Consider requiring that products include certain features before providing an incentive. Alternately,

provide additional incentives for non-energy benefits such as extended warranties and particularly robust photocell sensors.

- **Retrofit Kits**
  Develop a position on retrofit kits. At this time, most TAG members did not feel that there are enough good retrofit kits that meet the requirements for lighting performance and heat management, and they are not comfortable supporting their use. At most, allow kits that have demonstrated (to a credible third-party organization) thermal management and optical performance with the specific fixture they're used in. In most cases, retrofit kits would be installed in fixtures that are over 20 years old, so maybe it is time to replace them anyway. Check with Ed Smalley for additional input.

- **Health Impacts**
  Consider encouraging or requiring that street lighting have a color temperature lower than 4,200^{o}K to mitigate potential health impacts of humans and wildlife. (See related recommendation under Research above.)

Product Availability

1. The DLC QPL currently lists over 400 qualifying products in all categories including "Pole Mounted" in the name (counting only the parent product, not variations of model numbers representing colors, etc.), including over 70 manufacturers. These figures include approximately 40 retrofit kits. Efficacy ranges from 41 to 100 lumens per watt. This is one of the largest product categories currently included in on the DLC QPL.

2. Most of the products that show promise in actual conditions are designed to replace HID lighting of 250 watts or less.

3. Some products are available for 320 to 400 watt HID replacement but there are fewer options in that range.

LED Area and Parking Lot Lighting – #417 Outdoor area and parking lot lighting employing LED technology	**Overall Score: 3.5**

Note: this technology is already in the BPA Lighting Calculator and, therefore, eligible for BPA incentives.

Summary

The TAG consensus is that LEDs in this application are appropriate for BPA to support. We are comfortable that performance is good enough, and consumer benefits are significant enough, to encourage full deployment. The main issue is first cost.

LED outdoor lighting is becoming a mainstream product. A contractor in the group mentioned that most of his customers are now requesting at least one LED option in proposals. A distributor said he is now selling LED products frequently. Some customers are deterred by first costs. LEDs have a lot of benefits over conventional lighting in this application.

The Scoring Meeting presentation outlines many specifics (such as advantages and disadvantages, approved products lists, etc.), and this document outlines the TAG's recommendations for research or program design.

Research Recommendations

- **Light Levels**

  Consider conducting research on the relationship between light levels/controls and safety. Customers and public safety organizations have expressed concern about safety impacts of reducing light levels overall, and of adaptive lighting control strategies. Is there a possibility that dimming lights causes safety concerns in some circumstances? Might it actually increase security by alerting security personnel and others that someone is in the area when the lights come on to full brightness? The California Lighting Technology Center may have some relevant research.

- **Secondary Research**

  Do deeper secondary research on area and parking lot lighting. We should gather the available research by DOE and California, etc., and summarize the relevant conclusions. Also gather lessons from other utilities currently operating LED lighting programs. The purpose is to learn from others' experience, and in part this type of information is more pertinent for LED issues than traditional sources of lighting information because the technology is changing so quickly that traditional sources of direction, such as IES, are not able to keep abreast of the changes.

- **Controls**

  - Consider co-sponsoring research to overcome hurdles such as occupancy sensor placement that has blind spots and pole spacing too great for effective occupancy performance.
  - Sensors and network protocols are limitations for effective adaptive lighting. California is currently conducting research relating to networked solutions, looking to create a standard relating to control protocols and performance specifications (controls and efficacy) for parking lots. Recent innovations in occupancy sensors include the Wattstopper FSP-211 PIR sensor configurable for pole heights of 8 to 40 feet, and the Lighting Science Group PixelView image sensor.

Programmatic Recommendations

- **Incentives**

  Incentives do not need to favor LEDs above other best practices (i.e., they do not need to be structured to cover a higher percentage of the cost just to make them more attractive), but incentives could be structured to better acknowledge savings from higher wattage bulbs. For example, BPA could create multiple categories based on size of bulbs so it can be recognized that larger wattage bulbs will save more energy and, therefore, deserve higher incentives. For example, the incentive for a 100 watt lamp may be $50 (based on 75% wattage reduction and $.15/kWh) and the incentive for a 400 watt fixture could be $198.

- **Lighting Design Credit**

  If the current space is overlit, more wattage reduction is feasible. To the extent possible, allow full credit for kWh saved, such as the "non-standard" approach, rather than a prescriptive incentive based solely on one-for-one replacements of a specific technology. This would encourage end users to maximize savings by giving them full credit for all energy saved. In addition, it allows more flexibility in design to achieve energy savings. Prescriptive incentives giving a fixed incentive per fixture, for instance, encourage the customer to meet only the minimum requirements for the incentive, with the maximum number of fixtures allowed. This may not be the optimal design.

- **Qualified Products Lists**

  Consider accepting everything on the DLC Qualified Products List (QPL) for ease of understanding and less administrative hassle, or accepting it with a minor modification or two, such as requiring a higher minimum efficacy to qualify for an incentive. Address the differences between various lists (DLC, LDL, etc.), and move toward fewer lists.

- **Controls**

  Consider aggressive support for controls

  - Do not require occupancy controls. In area lighting applications, occupancy sensors must be designed carefully to avoid dead spots where an occupant will not be sensed. Other viable controls include an integrated unit that is able to dim based on time of day.
  - Require bi-level parking lot and area lights that dim to a lower level rather than turning completely off.
  - Co-sponsor training on parking and area lighting controls, possibly with assistance from CLTC.
  - Consider offering greater incentives for parking lot and area lighting systems, including controls that exceed code requirements for power density by at least 10%.
  - Focus on supporting fixture level dimming (i.e., integrated controls within luminaires) instead of network level controls (via wireless, BACnet or other protocol).
  - Encourage the use of controls, or at least controls-ready fixtures. It is becoming common for fixtures to come with an integrated dimmable driver (0-10 volt dimming capability). Fixtures that do not have this capability may have multi-level step-dimming as a standard feature, with continuous dimming available for an incremental cost under $25. Consider paying a bonus incentive for "controls-ready," meaning they have the 0-10 volt driver. Currently available controls and any

anticipated future controls should be able to use this feature to employ dimming strategies. However, some products such as the Leotek Ecobra-head can be easily retrofitted for controls, even though they have no 0-10 volt input. Some members of the TAG felt that predicting what features would be useful to future controls designs would be problematic enough that they questioned the value of encouraging "controls-ready" fixtures. CLTC, however, has developed specifications for controls-ready fixtures, and they should be considered.

- California's next energy code (effective 2014) will mandate bi-level controls (occupancy controls) for most 12 to 25 foot poles (not only for LEDs). LEDs are well suited to comply with these controls. The TAG does not recommend that BPA incorporate this into their programs at this time.

- **Case Studies**

  Encourage or sponsor local case studies and demonstrations. This will increase the perception that this technology is being successfully adopted locally and will provide opportunities for people to see local installations in operation. Identify any installations that are already in the region by contacting utilities and distributors. Write up case studies on these installations to increase customer and utility awareness of them. One of the concerns about area lighting applications is that contractors may be motivated to design under-lit spaces in order to increase the energy savings. The case studies would allow BPA to keep an eye on practices in the field.

- **Education**

  Publish information on the technology, including pros and cons and application guidelines, to help customers make better-informed decisions, and make this information available through co-sponsored trainings through the Trade Ally Network and other organizations. Encourage or sponsor training in the region to help customers learn about how to choose and apply the technology effectively. It is more complicated to design area lighting than wall luminaire lighting because area lighting plans must provide even light distribution, address max/min illumination issues and eliminate hot spots. Consider manufacturer websites as a source of technical information.

- **Retrofit Kits**

  The TAG discussed retrofit kits at length but did not reach a consensus. Many members felt that BPA should not provide incentives for retrofit kits because so few of them worked well, concerns about putting a retrofit kit in an old fixture, warranty issues, heat dissipation and the fact that UL listing is only valid if the retrofit kit is UL-approved to fit in a specific UL-approved fixture. Others felt that some reputable manufacturers have developed retrofit kits specifically designed for their fixtures; these seem to work well and should be supported. Retrofit kits provide potential cost savings as well. The DLC list does include retrofit kits, so consider influencing their policy and relying on their list. Use caution when encouraging the use of retrofit kits. At a minimum, be sure that the retrofit kit is UL listed to work specifically with the UL-listed fixture in which it is being installed. It is also preferable that the kit is made by the same manufacturer as the fixture.

Product Availability

4. The DLC QPL currently lists over 400 qualifying products in all categories including "Pole Mounted" in the name (counting only the parent product, not variations of model numbers representing colors, etc.), including over 70 manufacturers. These figures include approximately 40 retrofit kits. Efficacy ranges from 41 to 100 lumens per watt. This is one of the largest product categories currently included in on

the DLC QPL.

5. Most of the products that show promise in actual conditions are designed to replace HID lighting of 250 watts or less.

6. Some products are available for 320 to 400 watt HID replacement but there are fewer options in that range.

Comments

- One contractor noted that almost every customer asks him to bid LEDs as an alternative, but very few choose to install LEDs. The requirement by many customers of a two-year simple payback currently poses a serious impediment to adoption of this technology.
- In California, new standards effective by 2014 will modify section 130 of Title 24, Part 6 of the California Code of Regulations, and will:
  - Reduce power densities
  - Limit maximum power
  - Require sensors in some applications

These changes will favor LEDs because they are well-suited to unit controls. Performance specifications are key; many will favor LEDs. It is likely that the Northwest will eventually follow California's lead, so BPA will not need to work so hard to encourage adoption of more efficient lighting technologies.

Appendix A: 2012 LED Lighting TAG Recommendations

These are recommendations for technologies presented and scored at the E3T LED Lighting Technical Advisory Group (LED TAG) scoring session on May 31, 2012.

LED Linear Commercial Office Lighting (includes troffers and pendants) – #401 Open area recessed, suspended or surface-mounted fixtures for office lighting, typically in place of fluorescent troffers.	**Overall Score: 3.1**

Note: this technology is already in the BPA Lighting Calculator and, therefore, eligible for BPA incentives.

Summary

Some manufacturers of this technology currently offer quality products with interesting – and sometimes superior – features, such as "Kelvin-changing" lamps. While the opportunity is theoretically huge because there is so much linear commercial lighting installed in the Northwest, the general feeling of the TAG is that the competing technology – high-performance T8 fluorescent lighting – offers a compelling value proposition. At the low Northwest electricity rates, it is difficult to justify the payback on LED products currently available for retrofit applications, although the marginal cost is low enough now that it is worth encouraging for new installations. By the time a utility program can be implemented, performance and pricing are expected to improve enough that LED products will be a serious competitors in the market for new installations. Furthermore, expected energy savings are at least as good as the high-performance T8 systems, so incentives for LED systems should be no more than for those systems, unless it can be justified on the basis of a longer measure life or similar rationale.

Research Recommendations

The consensus of the TAG is that little additional primary research needs to be performed (with the exception of the issues of flicker and dimming). They are comfortable that performance of the best available products is good enough to encourage full deployment. The main issue is first cost. This technology may qualify for a form of fast track treatment. However, because the cost-effectiveness is questionable and the marginal savings versus high-performance T8 fluorescent lighting is small, implementing a program rapidly is not a high priority. Full deployment by spring of 2013 (by which time costs will have dropped further) may capture most of the savings nearly as effectively as an earlier deployment. However, some research may be worth considering.

- Conduct a demonstration project and case study on dimming and Kelvin-changing LED troffers and task lights to gauge customer satisfaction with product performance. These additional features available with LEDs are not available or are more challenging with fluorescent lighting. If they prove to be valuable non-energy benefits, these features may help accelerate customer acceptance of LED technology in the marketplace.
- Consider co-sponsoring a systematic analysis of flicker on linear commercial lighting systems with dimming. Some systems have noticeable flicker when dimmed significantly. This is a major concern. In addition, many systems have 120 Hz flicker comparable to, or worse than, early T12s. While this is usually invisible, there are potential health effects. It would be worthwhile to do some deep secondary research to understand the health and lighting-quality issues associated with this, and to encourage or sponsor research to analyze what is causing it, determine how to identify which systems have this problem, and suggest ways to fix it. Consider adding this to the BPA Energy Efficiency R&D Roadmap.

- Co-sponsor research on the longevity of drivers. Most LED systems have rated life based on the LED lamps alone, and do not take into account other key components in a fixture. The TAG does not have confidence that the drivers will last as long as the LED lamps, so the effective life of a fixture may be less than advertised. If this is the case, maybe encourage or sponsor research to identify ways to extend the life of the drivers. Some of the issues besides flicker that could be addressed by research include:
    - Dimming ranges that vary among driver products, even when receiving the same control signal
    - Interchangeability of drivers (how does someone in the field know what driver works with which LEDs?)
    - Total harmonic distortion (THD) and power factor (PF) from drivers, especially when paired with controls. More importantly, do THD and PF matter in typical commercial office buildings? Some measurements indicate that even if you have a high percentage of low PF drivers in a building, there is little change on the whole-building PF.
    - Develop specifications and standardized testing for drivers to ensure the specifications are met.
    - The impact of heat on drivers. What is expected "life" based on different driver designs and thermal conditions?
    - Tradeoffs: Driver design is a balancing act that requires weighing cost and performance implications of various characteristics. What do drivers really have to do, and what do you give up to get that performance at a reasonable price?
- Perform deeper secondary research than what is already on E3TNW.org. We should gather available research by DOE, the state of California, etc., and summarize the relevant information.

Education and Training

- Develop education and training, which could include seminars and informational materials for end-use customers, utility staff, contractors, specifiers, distributors and others. Provide links and easy access to the various educational and training materials for end-use customers, and develop additional documents to fill gaps in available information.
- Publish case studies on some high-profile installations that are easily accessible by the public.
- Many organizations, including DOE, the Lighting Design Lab, Portland General Electric, the Energy Trust of Oregon, Sacramento Municipal Utility District and California investor-owned utilities offer seminars and webinars for free or at small cost. Consider taking advantage of, supporting, or replicating these efforts.
- Consider requiring, encouraging, or providing expert help in designing lighting projects, especially projects that are over a certain size, to encourage high-quality designs that work well for the end user.
    - Contact Efficiency Vermont, which provides customers with access to experts in the field so they can learn from their experience.
    - Energy Trust of Oregon checks plans before installation.
    - Pacific Gas & Electric and other California investor-owned utilities provide free design services.

Incentives

- Look for ways to streamline the process for "non-standard measures" so incentives can more easily be based on kWh saved and de-emphasize the prescriptive approach. Especially with daylight harvesting and occupancy controls, incentives based on actual estimated savings can help encourage more savings, rather than just prompt consumers to meet a prescribed savings level.

  SMUD is starting with all LED projects being non-standard for couple of years, with the idea of allowing more flexibility in the design until they learn more about what the natural approaches will be in the marketplace. They may then move to prescriptive incentives for some of the most common solutions.

- Consider comprehensive whole-building incentives and/or incentives that are based on certain power densities below current applicable energy code or standard, such as ASHRAE, instead of compared to existing wattages.

- Consider ways to allow lower minimum lumen output when it is appropriate. TAG members believe that the minimum lumens required by the DesignLights Consortium (DLC) and the Commercial Building Efficiency Alliance (CBEA) for 2x2, 1x4 and 2x4 troffers are inappropriately high for many applications, especially with good task lights (the DLC may change its minimal lumens this June or later).

- Significantly reduce baseline wattages for fluorescent lighting fixtures. This makes sense now that new ballasts for many T12 lamps need to be electronic and production of most T12 lamps will be stopped in summer 2012. For example, instead of 72W for two 4-foot, bi-pin, T12 lamps and magnetic ballast, the baseline wattage would be 59, which it is for two 32 watt T8 lamps and generic standard ballast factor electronic ballast. This prevents rewarding laggard customers hanging on to older, inefficient lamps and ballasts and encourages more of an improvement in efficiency during the retrofit. Many California investor-owned utilities are doing this or considering it. Below is the link to Pacific Gas & Electric's Appendix B. Southern California Edison and San Diego Gas & Electric have practically identical documents. http://www.pge.com/mybusiness/energysavingsrebates/rebatesincentives/ief/

- Provide an extra incentive if customers show that they have used the services of a qualified lighting designer or other professional in the design of the project

- Develop a separate standard for retrofit kits. Maybe require new optics and certification of performance of kits designed for specific fixtures to qualify for an incentive. The DLC is currently working to define qualification standards for retrofit kits; their results are expected later in 2012. Maybe wait to see if their definitions and qualifications are acceptable before pursuing this.

- Try a pilot rebate program, which could include providing free or subsidized samples to end-use customers and/or using volume discount pricing so customers, especially small companies, can get a price break.

- Offer incentives to customers to do pilot installations before completing a major installation, which could help users find a system that they are happy with.

- Help customers ensure long-term light levels. The incumbent technology – high performance T8 and T5 lamps – only lose up to 10% of initial lumens by end of rated life, which translates into a rating of L90. Most LED troffers and kits are rated at L70, which means that they are considered to be at the end of their useful life when they have lost 30% of initial lumens. For many office, school, and retail applications, most LED troffers will either provide the right amount of light initially and underlight the space at the end of rated life or overlight the space initially and provide the right amount of light at end

of rated life.

Neither of these situations is ideal. Therefore:

- Consider requiring L90 information for LED troffers and retrofit kits. That is, the lighting should give a rating of expected life before it reaches 90% of initial lumens.
- Consider providing an additional incentive for products that maintain constant or nearly constant lumen output throughout their life without compromising longevity.
- Consider sliding bonus rebates for LED troffers and retrofit kits that have 60,000 – 100,000 rated hours at L90 and 6- to 10-year warranties, maybe including a labor credit. That could really help push the industry in a good direction.

- **Qualified Products Lists**

  Consider accepting everything on the DLC Qualified Products List (QPL) for ease of understanding and less administrative hassle, or accepting it with a minor modification or two, such as requiring a higher minimum efficacy to qualify for an incentive. Address the differences between various lists (DLC, LDL, etc.), and move toward fewer lists.

LED T8 Replacement Lamps

- Establish an informed position on if and when LED T8 replacement lamps (as opposed to replacing the whole fixture) will be supported. There was significant disagreement in the TAG about what to do about this technology. In general, members did not think T8 replacements should be supported at this time because of safety and other issues that may be difficult to resolve, and noted that the quality and efficacy for the price is not yet attractive. Supporting this technology could pose significant liability risks for BPA. The consensus at this time is that light bars (bars of LED lights made to replace fluorescent tubular lamps) and retrofit troffer kits are a superior solution in terms of safety, performance, appearance, and efficacy, but BPA should decide whether to support those who prefer to go with the T8 replacements nevertheless. If an incentive is provided, develop guidelines to help customers, vendors, and contractors to select and install the product safely and effectively and discourage the use of existing ballasts.

  - Most utility programs around the country have not been supporting this solution. However, there was also an acknowledgement that T8 replacement lamps are beginning to be sold in significant quantities, so it is important for BPA to establish an informed position on this technology.
  - Concerns about this technology include:
    - Currently two types of LED T8 replacement tubes are available, each wired differently. They are not interchangeable. Some of them, placed in the wrong wiring configuration, would fail catastrophically, perhaps causing a safety hazard. Even within a single wiring approach, you need to pay attention to whether the tombstone is shunted or not. There is currently no suggested way to obviously distinguish these different ways of wiring with the matched product to prevent inadvertent incorrect installation. Some solutions use the existing fluorescent ballasts. This makes replacement easy and less costly, but introduces a number of additional maintenance and energy savings issues,

including that it would be easy to remove and replace it with a fluorescent lamp, losing the intended savings.

- Most replacement tubes require using the existing tombstone, but bypassing the ballast. If one failed and someone inadvertently put a fluorescent tube back in its place, it would fail catastrophically, perhaps causing a safety hazard.

Controls

- Re-evaluate the cost-effectiveness of controls now that lighting energy can be so inexpensive. Controls have often been difficult to justify because of their cost. LED lighting is inherently controllable, so the costs of control should be lower than systems to control fluorescent lighting, but with the reduced lighting load, the savings with controls is less. Because many codes are requiring controls, this may bring the costs down even further, and it may again become cost-effective.

LED Task Lights

- Though beyond the scope of this TAG, the members agree with the 2009 Lighting TAG that an effort should be made to encourage good task-ambient strategies in offices, incorporating some of the new LED products that are designed for this purpose.

Product Availability

The DLC QPL currently lists 209 qualifying products total in the categories called “Linear Panels” (1x4, 2x2, and 2x4, including models from 25 different manufacturers. Efficacy ranges from 34 to 110 lumens per watt.

Troffers

Numerous manufacturers currently offer dimming and fixed Kelvin LED 2x4, 2x2 and 1x4 troffers. Below is a very partial listing.

- Acuity
- Cooper
- Cree
- Hubbell
- Philips
- Finelite
- GE
- Lunera
- Maxlite

Acuity, Cooper, Hubbell and Philips are the big four, each with several brands. In addition, more manufacturers in this country and around the world are developing these products. Galaxia, which won a Next Generation Luminaires award at Lightfair 2012, is one manufacturer of dimming and Kelvin-changing LED troffers. The Galaxia troffer, shown at right, is already DLC-approved. Several other manufacturers are developing this kind of troffer.

The number of LED troffers approved by DLC and the Lighting Design Lab (LDL) is currently

limited, but product offerings should significantly increase by the fourth quarter of 2012.

The Cree CS Series A is a new and well-designed LED downlight surface or pendant fixture line. Some offshore and second-tier manufacturers have designed troffers for LED T8s.

Troffer Kits

Although the manufacturers and models of LED troffer kits is currently relatively small, based on what was seen and discussed at Lightfair 2014 and other sources, they will significantly increase. Here is a partial current list.

- Albeo's T8 LED conversion kit
- A.L.P.'s LED version of RDI kit
- Cree's CR troffer kit
- Energy Solutions International
- Energy Planning Associates' (aka Envirobrite's) LED version of Dialite kit
- Harris Lighting's troffer retrofit
- Lithonia's RTLED relight kit
- Philips Powerlux LED Line

Although there are many styles of hard-wired LED troffer kits. The photo at right shows the Albeo lightbar kit.

Some dimming and Kelvin-changing LED troffer kits, which may cost $125 to $150, may be available by early 2013.

Suspended Direct/Indirect LED Fixtures

Since there are so few of these fixtures, and they are expensive, they are only briefly discussed.

Currently, GE and Lunera are known to make edgelit LED suspended direct/indirect fixtures, which do not have very good LPW. The photo at right is of the GE Lumination.

In the future, LED suspended direct/indirect fixtures may become quite popular, because the LEDs and drivers would be in relatively cool conditioned space, instead of the hotter ceiling plenum space.

Comment

- Helping people design for lighting and systems that support human needs is important.

Appendix B: 2012 LED E3T TAG Member List

TAG Members	Company	City	State/ Province
Rick Allen	PlanLED	Everett	WA
Jack Callahan	Bonneville Power Administration	Portland	OR
Craig Ciranny	Bonneville Power Administration	Portland	OR
Larry Giardina	City of Ashland	Ashland	OR
Charlie Grist	Northwest Power and Conservation Council	Portland	OR
David Hunt	Snohomish PUD	Everett	WA
Cori Jackson	California Lighting Technology Center	Davis	CA
Ira Krepchin	E-Source	Boston	MA
David Kunesh	North Coast Electric	Seattle	WA
Marc Ledbetter	Pacific Northwest National Lab	Portland	OR
Jon Linn	Northeast Energy Efficiency Partnerships	Lexington	MA
Vireak Ly	Southern California Edison	Irwindale	CA
Mary Matteson Bryan	Matteson-Bryan Consulting	Bay Area	CA
Naomi Miller	Pacific Northwest National Lab	Portland	OR
Kurt Nielsen	Light Doctor	Mountlake Terrace	WA
Doug Oppedal	Evergreen Consulting Group, Energy Trust of Oregon	Portland	OR
Irina Rasputnis	Northeast Energy Efficiency Partnerships	Lexington	MA
Mark Rehley	Northwest Energy Efficiency Alliance	Portland	OR
Ron Runkles	NEMA	Roslyn	VA
Connie Samla	Sacramento Municipal Utility District	Sacramento	CA
Michael Siminovitch	California Lighting Technology Center	Davis	CA
Edward Smalley	Seattle City Light	Seattle	WA
Eric Strandberg	Lighting Design Lab	Seattle	WA
Cristian Suvagau	BC Hydro	Vancouver	BC
Joe Vaccher	Eugene Water & Electric Board	Eugene	OR
Stan Walerczyk	Lighting Wizards	Walnut Creek	CA
Cindy Wills	WSU Energy Program	Olympia	WA
John Wilson	Bonneville Power Administration	Portland	OR
Jerry Wright	Seattle City Light	Seattle	WA
BPA E3T Staff			
Jennifer Williamson	Bonneville Power Administration	Portland	OR
Levin Nock	Bonneville Power Administration	Portland	OR
Tyler Dillavou	Bonneville Power Administration	Portland	OR
Debra Bristow	Bonneville Power Administration	Portland	OR
WSU E3T Staff			
Jack Zeiger	WSU Energy Program	Olympia	WA
David Shepherd-Gaw	WSU Energy Program	Olympia	WA
Rob Penney	WSU Energy Program	Olympia	WA
Angela Phillips	WSU Energy Program	Olympia	WA
Alan Mountjoy-Venning	WSU Energy Program	Olympia	WA

Appendix C: Previous E3T Technical Advisory Groups

In 2008, the Bonneville Power Administration (BPA) Energy Efficiency Program began a multi-year effort to identify, assess and develop emerging energy efficiency technologies. The main goal of the Energy Efficiency Emerging Technologies (E3T) program is for BPA to engage in an ongoing collaborative effort to "fill the pipeline" with innovative energy efficiency strategies and technologies that promise significant region-wide energy savings.

A framework was developed for the E3T process in the summer of 2009 as both the 2009 Lighting and HVAC Technical Advisory Groups (TAGs) progressed. The framework has guided past TAGs and informs the path emerging technologies take once TAG recommendations are received by BPA. The four TAGs completed before the launch of the 2012 LED TAG in April 2012 are summarized here.

More information on these TAGs is available in their respective progress and final reports, available upon request. The E3T program maintains a database, www.E3TNW.org, which serves as the repository of information collected and developed for hundreds of individual technologies and solutions.

Lighting 2009

In 2009, the E3T Program recruited highly qualified, experienced lighting engineers and specialists to serve as volunteers on the first E3T TAG, focused on lighting. The TAG process included a cycle of meetings to identify, rank, score and develop recommendations for selected emerging technologies. Those basic stages remain the pattern of TAG cycles, although each cycle has introduced significant changes to the timing and duration of meetings and other efforts involved in each stage.

The 2009 Lighting TAG ultimately identified and developed information and recommendations on five technologies:

- Wireless Lighting Controls
- Integrated Classroom Lighting System
- Bi-Level Parking Lighting with Occupancy Sensors
- Bi-Level Stairwell Lighting with Occupancy Sensors
- Bi-Level Office Lighting with Occupancy Sensors

Beyond the technical information garnered from TAG members and staff, perhaps the most important takeaway from the Lighting TAG was an awareness that TAG results need to align with the capability of plans and programs in existence at BPA to foster their adoption, no matter how promising a technology might appear to a diverse group of experts.

A Lighting TAG was planned and readied for launch in the fall of 2010, but was suspended to allow staff to focus on efforts to revisit the E3T framework using input garnered through interviews with key stakeholders.

HVAC 2009

Closely following the start of the 2009 Lighting TAG in March 2009, another TAG was convened in May 2009 focusing on heating, ventilation, and air conditioning technologies (HVAC). This first HVAC TAG

established a pattern of conducting TAG meetings using screen-sharing webinar software and online survey tools, with no major in-person attendance. However, the occasional presence of TAG members in the Olympia office of the WSU Energy Program was deemed to be very helpful and supportive.

Concluding in February 2010, the 2009 HVAC TAG forwarded recommendations for four technologies:

- Demand Controlled Ventilation for Commercial Kitchens
- Variable Refrigerant Flow Heat Pumps
- Demand Controlled Ventilation
- Indirect-Direct Evaporative Cooling

A key takeaway from the 2009 HVAC TAG was that long intervals between meetings presented challenges to group cohesion. However, the approach of using online tools and holding online meetings provided the basic platform that TAGs continue to operate on, undergirded by the expertise, patience, and professionalism of TAG members.

HVAC 2010

The 2010 cycle of the E3T HVAC TAG was operated on a compressed timeframe, spanning just over three months. The initial Identification Meeting was convened on June 10, 2010. The 2011 TAG cycle concluded with two Recommendations web conferences, the last one held September 16, 2010.

The 2010 HVAC TAG ultimately selected four technologies to advance in the E3T process to steps that will identify and assess their potential in Bonneville Power Administration's service territory, and lay out steps for funding and implementing greater adoption of these technologies.

Those four technologies are:

- Variable Capacity Compressors
- Air-Side Economizers for Data Centers
- Web-Based Small Commercial Thermostat
- Advanced Design Rooftop HVAC Unit

Lessons from the 2010 HVAC TAG included the inverse of the 2009 HVAC TAG – compressed timeframes, particularly in the summer, often run up against member and staff availability issues. Further, staff realized the importance of enhancing the documentation of technologies beyond the short list of those which left the process with recommendations; the overall process is enhanced if more of the technologies in the E3T database are described and detailed enough to potentially suggest synergies with those going forward in the process.

The successes of the 2010 HVAC TAG included a greater awareness of the level of effort needed at different stages to manage a widespread collaborative effort made up of staff and volunteers who include top professionals in their respective fields. It also showed the value of using online resources that minimized the time commitment and travel expected of TAG members.

Appendix C: Previous E3T Technical Advisory Groups

Energy Management 2011

A new focus area, Energy Management (EM), was selected to be the subject of the fourth E3T technical advisory group. Held between late August and early December, the TAG followed the pattern developed in the previous TAGs of four all-TAG meetings – Identification, Ranking Review, Presentations and Scoring, and Recommendations Review, with key online Ranking and Scoring surveys deployed after the first and third meetings, respectively.

Staff developed recommendations for the five technologies presented and scored by TAG members:

- Rooftop Unit Controls with Energy Monitoring and Remote Access
- Building Energy Performance Analytics Software and Service
- Non-Intrusive Load Monitoring
- Low-Cost Energy Management Systems for Small/Medium Buildings
- Innovative Behavior Change Techniques

The EM TAG tried a tiered membership with several categories of people on the TAG, including:

- Ranking members – full members allowed to rate and score emerging technologies
- Corresponding members – members who were invited to events and encouraged to participate in discussions but not given voting privileges, and
- Interested parties – participants who were interested in the topic in general but not in a position to serve as TAG members.

This approach proved to be administratively challenging on tight timelines, and uncertainty arose early about some individuals' status. In addition, this approach necessitated separate communication channels so different conversations could be held with different classes of TAG participants.

By the conclusion of the EM TAG, both the tiered membership approach and the demands of the longest meetings (identification and scoring) were identified as serious challenges to TAG participation as many members stopped actively participating as the TAG progressed.

Appendix D: Survey Language and Narrative Guidance

2012 LED TAG

Each successive E3T TAG benefits from the experience of the previous TAGs, as well as from staff collaboration in the interim. While the basic purpose of each TAG survey remains similar, the questions have been modified over time, as has guidance included in the instructions to those taking the survey.

Because the surveys vary slightly, observers are cautioned against overstating direct comparisons of average scores or ratings across TAGs.

This appendix shows some of the language (*in italics*) used in the two surveys about emerging technologies to which TAG members responded.

Ranking

During the lunch break of the initial meeting, members were asked to rate 10 technologies using an online survey. Those technologies are listed here by their record number in the E3T database and the titles in place at the start of the TAG, followed a short description:

> ***402: LED INTERIOR HIGH- AND LOW-BAY LUMINAIRES****: Pendant or surface-mounted fixtures specifically for commercial and industrial indoor high-ceiling spaces such as warehouses.*
>
> ***401: LED LINEAR COMMERCIAL OFFICE LIGHTING (INCLUDING TROFFERS AND PENDANTS)****: Open area recessed, suspended or surface-mounted fixtures for office lighting, typically to replace fluorescent troffers.*
>
> ***214: LED A-LAMP REPLACEMENT****: While LED lighting has been used for some years, only recently have lamps been developed as direct replacement for conventional incandescent light bulb, officially known as A-lamps.*
>
> ***417: LED AREA AND PARKING LOT LIGHTING****: Outdoor area and parking lot lighting employing LED technology.*
>
> ***413: LED HIGH- AND LOW-BAY RETROFIT LAMPS****: Kits containing LED arrays, drivers, cooling technology and sometimes reflectors to maintain or improve light quality, help achieve energy savings, reduce maintenance over traditional high-pressure sodium (HPS) and metal halide (MH) lighting systems, and allow customers to save money by not purchasing new fixtures and disposing of old ones*
>
> ***411: LED LUMINAIRES, OUTDOOR RESIDENTIAL****: Outdoor LED luminaires designed for residential use. This is functional lighting, as opposed to decorative or landscape lighting.*
>
> ***414: LED OUTDOOR COMMERCIAL FLOOD LIGHTING****: Directional luminaires, sometimes referred to as spot lights or architectural lights, used to light specific outdoor areas like loading docks, signs and billboards, building facades, and walkways next to buildings.*
>
> ***398: LED PARKING GARAGE LIGHTING****: Ceiling-mounted luminaire for parking garage applications, suitable for outdoor and other environments open to the elements.*
>
> ***78: LED STREET LIGHTING****: Street lighting fixtures employing Light Emitting Diode (LED) technology.*
>
> ***395: LED OUTDOOR WALL PACKS****: Exterior wall-mounted LED walkway or security lights.*

Appendix D: Survey Language and Narrative Guidance

In a departure from previous TAGs, the LED TAG members were asked to characterize the readiness of each proposed LED application before rating their overall support for the listed technologies.

> *Please mark your opinion of when each type of LED lighting will meet most or all of the following criteria:*
> *1) Is this LED lighting efficacy comparable to the efficacy of the best practice for that application?*
> *2) Are the products cost-effective?*
> *3) Will customers be happy? (Are LED products technically sound, and do they meet customers' needs?)*
> *4) Can this LED lighting create large regional energy savings? If not, is there a justification to focus on a niche?*
>
> *0 to 6 months 6 months to 2 years 2 years+ Never*

After indicating technology readiness, the survey asked members to give an overall rating to each of the 10 technologies (to facilitate ranking the technologies and selecting the top four) using language distinct from that used in previous TAGs:

> *Please rate each technology on a scale of 0 to 5 to denote your level of confidence in their potential to be successful at the time you suggested in the previous question. For instance, if you said that LED streetlights will be ready in "6 months to 2 years," rate your support for what they will become in "6 months to 2 years" rather than today. In the 0-to-5 key, please consider "I support this technology" to mean that "I believe that LED lighting meets BPA's criteria in this application."*

The same questions for the readiness section were reiterated, followed by language similar to that used in previous TAGs:

> *You may rate as many as you wish, indicating the strength of your support using the scale provided. You do not have to weigh in on items with which you are unfamiliar.*
>
> *0: I do not support this technology.*
> *1: I support this technology with significant reservations.*
> *2: I mildly support this technology.*
> *3: I support this technology.*
> *4: I strongly support this technology.*
> *5: My support for this technology is enthusiastic and unqualified.*

Scoring

Scoring surveys were completed following four presentations on the leading technologies on different dates. The scoring survey had brief instructions and questions regarding five core characteristics:

> *This scorecard is filled out by TAG members to prioritize the emerging technology for consideration. Each technology is scored in a separate survey. More information on the technologies may be found at E3TNW.org – search by record number.*

ENERGY SAVINGS: How significant and reliable are the energy savings per unit?
NON-ENERGY BENEFITS: How great are the non-energy advantages for the end user for adopting this technology
TECHNOLOGY READINESS: How ready are the product(s) and providers to scale up for widespread use in the Pacific Northwest?
EASE OF ADOPTION: How easy is it for the end user to change to the proposed technology?
VALUE: Considering all costs and all benefits, how good of a buy is this technology for the owner?

All five core questions on the scoring survey used the same scale:

1 – Poor 2 – OK 3 – Good 4 – Better 5 – Best

Each began with a technologies title and a short description.

All questions regarding technologies invited open-ended comments in a separate field.