ET 2017 Residential Lighting Technical Advisory Group (TAG #14) Final Report

March 2018

ENERGY EFFICIENCY
EMERGING TECHNOLOGIES

A Report of BPA's Emerging Technologies Initiative

Prepared for

Bonneville Power Administration

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POWER ADMINISTRATION

Contents

Executive Summary

Efficient lighting has provided over 40% of the energy savings for the Residential portfolio for BPA. Starting in late 2016, the BPA Energy Efficiency team realized that dramatic changes were in store for the Residential Lighting program. Given anticipated changes in the Residential Lighting baselines driven by the rapid growth of LED, lighting energy savings were expected to rapidly decline over the next 18 months. Following extensive analysis, it was determined that savings might decline up to 60%.

In response, Energy Efficiency Planning, Programs and Engineering team members launched a strategic planning initiative to revamp the Residential Lighting Program to ensure future energy savings for the region. To support this strategy development, the Emerging Technology team agreed to launch a Technical Advisory Group (TAG) to identify and prioritize new measures for Residential Lighting. The TAG, made up of national and regional lighting experts, would focus on finding new technologies for lamps, fixtures, and lighting controls both as standalone solutions as well as part of home automation technologies. BPA was particularly interested in defining recommendations for hard-to-reach markets such as low-income and multifamily housing.

Work began in September to recruit lighting experts to participate on the TAG. Twenty-seven individuals representing 23 organizations volunteered to participate. A kick off meeting occurred in October and five meetings were held and the TAG wrapped up in mid-December. During the TAG, experts brainstormed potential lighting technology solutions. They prioritized 52 technologies including 10 new technologies and recommended seven technologies for further exploration. These recommendations included:

- Specialty LED Lamps
- Linear LEDs Lamps
- Higher Efficacy Lamps
- Lighting Controls for Lamps
- Exterior Lighting with Controls
- MF Bi-Level Lighting Controls
- Lighting Controls through Home Automation Systems

TAG members divided the recommendations into two categories (lamps and lighting controls). A series of presentations given by lighting experts via public webinars provided further information. Following these presentations and discussion, each technology was scored using the following criteria: potential energy savings; non-energy benefits; product performance; market/commercial readiness; program readiness; ease of adoption, and; value. A summary of the scores and recommendations for Lamps and Controls follows.

Rating Summary for Lamps

Rating – 1st, 2nd, or 3rd (last)

	Specialty Lamps	Linear LEDs (TLEDs)	Higher Efficacy LED Lamps
ENERGY SAVINGS	1	3	2
NON-ENERGY BENEFITS	1	3	2
PRODUCT PERFORMANCE	1	2	3
MARKET/COMMERCIAL READINESS	1	2	3
PROGRAM READINESS	1	2	3
EASE OF ADOPTION	1	3	2
VALUE	1	3	2
TOTAL	1	**3**	**2**

* For total average score, a higher number is more favorable.

Specialty lamps include most residential lamps other than A-lamps and linear fluorescent lamps. In ten years of implementing TAGs, no technology has ever been ranked in first place for all criteria as specialty lamps has done here. This technology has strong energy savings as well as non-energy benefits. Adoption is quite straightforward with hundreds of products readily available. Utility programs, including at BPA, are well developed. Overall, their value to consumers and utilities is excellent.

Linear LED lamp products, markets, and programs were judged to have solid readiness. There are good products, well proven and available, and BPA provides incentives. Energy savings was rated lower largely due to lower hours of use and partly because the simplest type of linear LED lamp to install has lower energy savings due to ballast losses (there are three types of linear LEDs with different power architectures). Non-energy benefits are lower mostly because they are installed in low use areas (e.g. garages and laundry rooms). The ease of adoption was also rated lower due to the complexities of selecting the appropriate type of power architecture for the application.

Higher efficacy lamps have the inverse of the scores for linear LED lamps. Energy savings and non-energy benefits are better, as is ease of adoption and overall value. However, the technology readiness is not as strong. There are fewer products available, fewer incentives in the market, and utilities do not incentivize these products, possibly due to lack of clarity in defining what would qualify as “higher efficacy”.

Rating Summary for Controls

Rating – 1st, 2nd, 3rd, or 4th (last)

	SF Exterior Sensors	MF Bi-level Controls	Lighting with Controls	Lighting with Home Automation Systems
ENERGY SAVINGS	2	1	3	4
NON-ENERGY BENEFITS	2	2	4	1
PRODUCT PERFORMANCE	2	1	3	4
MARKET/COMMERCIAL READINESS	1	2	2	4
PROGRAM READINESS	1	2	3	4
EASE OF ADOPTION	1	2	3	4
VALUE	2	1	3	4
TOTAL	**2**	**1**	**3**	**4**

* For total average score, a higher number is more favorable.

Exterior lighting controls, such as porch and security fixtures with simple photo/motion sensors for single-family homes, had an overall score just a little below multifamily bi-level controls. Ratings for these two technologies are roughly the inverse of each other. Compared with the bi-level controls, single-family fixtures were seen as having greater readiness of markets and programs as well as easier adoptability, but with lower savings, non-energy benefits, and product performance. The overall value was therefore judged to be lower than for bi-level controls.

Bi-level control products are available, but markets and programs have not yet adopted them in the Northwest as they have in California. Energy savings was rated higher for bi-level controls, even though they only dim lamps during periods of vacancy rather than turn them all the way off. This could reflect concerns of a lack of potential adoption of single-family controls due to homeowners' security concerns regarding dark yards.

Interior lighting controls received poor scores – a reflection of their limitations in residential settings. Energy savings are lower partly due to smaller hours of baseline operation. While they are well developed, replacing current lamps and fixtures with individual controls may not gain much in savings or convenience.

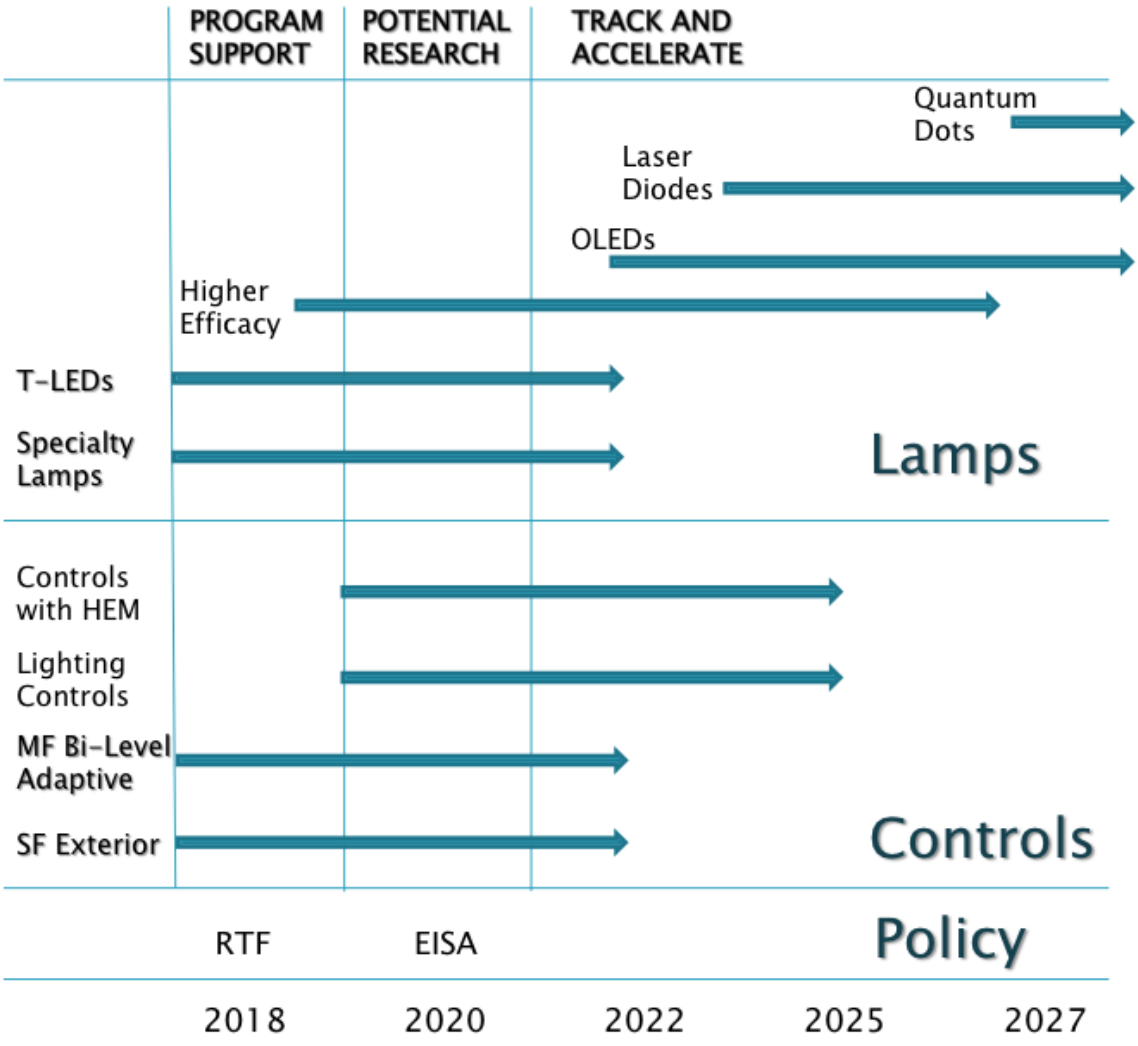
Lower scores for controlling lighting through home automation indicate that this technology seems promising, but not quite mature yet, with technical and programmatic hurdles to adoption. However, TAG members believe it will offer an extensive collection of non-energy benefits to spur adoption.

Based on the TAG recommendations, the TAG Steering Committee, made up of members of EE Programs, Planning and Engineering, developed action plans which summarized next steps for each of the recommendations. These action plans have been included in the appendix of this document. A summary of activities for each recommendation follows:

Recommendations	Action Plan Summary
Specialty Lamps	Major focus for Residential Programs for greatest savings before EISA 2020. Consider splitting up incentives for specialty lamps into subcategories. Use market data to prioritize lamps with the most potential.
Linear LEDs	Target Multifamily common areas and leverage measures including O&M savings. May bundle with other recommendations. Explore bulk direct install programs. Consider running pilots to test direct install programs.
High Efficacy	Consider a tiered incentive for high efficacy lamps with a list of qualified products or specifications. Filament lamps may be part of this category. CEE and DLC have already adopted the use of tiers.
SF Exterior Controls	Support measures for Exterior Lighting Controls and fixtures. Modify the existing incentive for LED exterior lamps and fixtures to include additional rebates for motion and sensor controls. Offer upstream incentives for stocking and promoting exterior lights with controls.
MF Bi-Level Adaptive Controls	Support measures for Multifamily Bi-Level Lighting fixtures with controls including motion, photo and occupancy sensors. Consider bundling measures for Multifamily and conducting pilots to validate savings and cost effectiveness. Track TIP 391 results.
Lighting Controls for Lamps	Explore research pilots to validate energy savings and cost effectiveness. Track commercial sector research to see what may be applicable.
Lighting Controls through Home Automation	Explore pilots or assessments opportunities to determine savings and cost effectiveness for different technologies. Determine methods to estimate energy savings and cost allocation across multiple functionalities. Identify other research questions.

Based on input from the TAG, the BPA team was able to develop a proposed Technology Pipeline which provided insights into how Residential Lighting technologies might evolve across three timeframes: short term (less than two years); midterm (2 – 5 years); and long term (over 5 years). This pipeline is designed to guide research for the technologies over all the coming years. The technology pipeline includes new emerging technologies that are not expected for another 5 – 10 years. These technologies will be tracked and if possible accelerated for market adoption through strategic partnerships. The technology pipeline is summarized below:

Residential Lighting Technology Pipeline
Three Stages – Now, Next, and Future



In addition to scoring technologies for Lamps and Controls, the TAG members also prioritized and reviewed programmatic initiatives for further review. These three programmatic initiatives are consumer education, hard to reach markets, and non-energy benefits. These programmatic priorities were addressed via a panel discussion at the final meeting. Results from this discussion are summarized.

Next Steps

Work is continuing to develop BPA's future residential lighting program. The results of the TAG will be incorporated into BPA's Residential Lighting Strategy to shape both short and long term energy savings for the region. The new strategy will be unveiled later in 2018.

TAG Background

Technical Advisory Groups (TAGs) are used by the Bonneville Power Administration (BPA) to help scan, screen, and prioritize promising energy efficient technologies, which may be assessed by BPA to develop new measures for future energy savings. The objective of the TAGs is to leverage industry experts and utility program managers to choose technologies for utility conservation programs which may eventually become incentivized measures for BPA's customers – publicly owned utilities throughout the Pacific Northwest region. The Washington State University Energy Program (WSU) manages TAGs in support of BPA.

Over the past seven years, BPA and WSU have conducted 14 TAGs covering a variety of topics including: Lighting, HVAC, Energy Management, LED Lighting, Advanced Lighting Controls, Information Technology/Data Centers, Commercial Building, Residential Building, Commercial HVAC and Multifamily. TAG members have been responsible for helping BPA identify, screen and select 72 technologies for further assessment and research. Of these, BPA has researched sixteen technologies resulting in seven new measures and lighting measures for the regional lighting calculator.

Participation in the TAG is voluntary and involves a commitment of approximately 10 – 15 hours over the course of three months. Meetings are held via online webinars and included presentations of top rated technologies. The following describes the implementation process steps for each TAG. This report provides highlights from each stage of the Residential Lighting TAG.

TAG Planning: Chose topics and selected Steering Committee.

TAG Steering Committee Kickoff: Planned activities to design the scope of the TAG to meet the needs of the BPA Technical and Sector Leads.

TAG Recruitment: Identified and recruited the technical experts to help identify and evaluate emerging technologies and strategies

Initial TAG Meeting with Brainstorming: The TAG members identified emerging technologies and strategies related to the subject matter for further evaluation.

Ranking: TAG members rated emerging technologies so that they could be ranked, from which 6 – 8 are selected by the Steering Committee for further exploration.

Showcase Webinars: TAG subject matter experts presented information regarding the prioritized emerging technologies and strategies via webinars.

Scoring ETs: The TAG members scored the emerging technologies as well as valuable comments and recommendations.

Final TAG Meeting: The TAG members reviewed the TAG scores and provided final comments and recommendations.

TAG Action Plan: BPA met to create an Action Plan for TAG Recommendations.

TAG Final Report: WSU created a final report.

2017 Residential Lighting TAG

Residential lighting is an important source of energy savings for BPA and the region. There are over 300 million lamps in Pacific Northwest Homes. Lighting is the 3rd largest residential end use representing approximately 6% of the total regional energy use across all sectors. More than 40% of BPA's residential conservation program savings have been driven by lighting.

However, since 2009 there has been a 39% decline in lighting consumption in the region. Savings have dropped due to the introduction of comprehensive conservation programs and technological advances including the phasing out of incandescent lighting and the introduction of more efficient lighting alternatives including CFLs and LEDs. The longer life expectancy of CFLs and LEDs is expected to continue this downward trend because bulbs will not need to be replaced as frequently.

With the continued decline of lighting savings, BPA selected residential lighting as the topic for the 2017 TAG with the objective of finding new residential lighting measures to ensure future energy savings for the region. The TAG focused on new technologies for lamps, fixtures, and lighting controls both as standalone solutions as well as part of home automation technologies. The BPA staff was particularly interested in defining recommendations for solutions in hard-to-reach markets such as low-income and multifamily housing.

Highlights from the 2017 Residential Lighting TAG included:

- Recruitment of 27 national experts with deep expertise and decades of relevant experience.
- Fifty-two (52) technologies were rated by the TAG including 10 new technologies.
- More than 20 TAG members participated at each meeting and response rate for scoring exercises were between 58-67%.
- Seven (7) technologies were recommended for further evaluation.
    - Specialty LED Lamps
    - Linear LEDs
    - Higher Efficacy Lamps
    - Lighting Controls for Lamps
    - Exterior Lighting with Controls
    - MF Bi-Level Lighting Controls
    - Lighting Controls through Home Automation Systems

The following document provides details about the results of the 2017 Residential Lighting TAG.

TAG Steering Committee

To support the TAG implementation, BPA created a steering committee comprised of staff members from BPA Programs, the Energy Efficiency Emerging Technology (E3T) team, BPA Planning, and PEJD Engineering Services. Steering committee members are shown below:

Residential Programs	Planning	Residential Technical Support	Marketing	E3T Program
Dave Murphy Gary Smith Maitri Dirmeyer	Jessica Aiona Philip Kelsven	Robert Weber Janice Peterson	Boyd Wilson	Keshmira McVey Debra Bristow

The steering committee guided the TAG process to ensure end results would address the needs of BPA's customer utilities and advance the plans of the BPA Programs team. The TAG steering committee serves a number of functions:

- Guides the development of the TAG's scope to meet the needs of BPA's customer utilities
- Nominates prospective TAG members
- Selects the technologies rated by the TAG to be researched and scored
- Reviews and approves the final ranking and scoring results by TAG members
- Develops next steps to implement TAG recommendations

The TAG steering committee chose a broad scope for the TAG:

- New construction and retrofit solutions
- Single family and low-, medium-, and high-rise multifamily buildings applications
- Technologies and strategies for the following:
    - Lamps and fixtures
    - Controls
    - Integration with connected homes

TAG Membership

Twenty-seven (27) efficiency experts from 23 organizations volunteered to participate on the TAG. These senior-level decision makers from top regional and national research organizations, utilities, and private companies provided expertise for lighting emerging efficiency technologies. An overview of the makeup of the TAG members is summarized below in Tables 1 and 2:

Table 1. Types of Organizations Represented by TAG Members

6 regional utilities	2 consulting firms
3 regional state / regional energy efficiency organizations	1 government agency
1 non-NW utility	1 non-profit organization
7 research organizations	2 equipment distributors

Table 2. Organizations Represented by TAG Members

Avista Utilities	LEDVance	Mary Matteson-Bryan
Benton REA	Lighting Research Center	Regional Technical Forum
California Lighting Technology Center	National Renewable Energy Laboratory	Sacramento Municipal Utility District
Clark PUD	Natural Resources Defense Council	Seattle City Light
CLEAResult	Northeast Energy Efficiency Partnerships	Snohomish PUD
Electric Power Research Institute	Northwest Energy Efficiency Alliance	US EPA ENERGY STAR
Energy Trust of Oregon	Pacific Lamp Supply Company	WSU Energy Program
Franklin PUD	Pacific Northwest National Laboratory	

TAG Kickoff Meeting

Kickoff meetings introduce participants to the TAG process and lay the foundation for identifying and prioritizing technologies. The BPA staff provides background about the role of TAGs in building the BPA emerging technology program as well as defining the scope and expectations for the current TAG. This information is designed to define the parameters for the brainstorming and educational steps which follow.

The 2017 E3T Residential Lighting TAG was convened on October 18, 2017. Attendees included 22 TAG members in addition to BPA Steering Committee and staff members and two WSU staff members. This initial meeting included an overview of the objectives of the TAG, an introduction to WSU and the BPA Steering Committee, and a brainstorming session to expand the initial list of emerging technologies for further exploration. The following presentations were made to set the stage for TAG members to engage in the process.

Kickoff Presentations

- Keshmira McVey, BPA E3T Program Manager, provided an overview of BPA's E3T program, including the TAG process, and the contributions of previous TAGs – 73 TAG recommendations that led to five measures, 22 research projects, and 15 Lighting Calculator candidates.
- Dave Murphy, Residential Program Manager for Lighting, discussed BPA's residential lighting program background and future challenges and explained how the BPA team hoped to use the TAG output.

Rob Penney, WSU Senior Energy Engineer, facilitated the group discussion to ensure a common understanding of the technologies to be rated and solicited input on additional technologies. The TAG was also given the following definition for emerging technologies to guide their recommendations. Nominated technologies:

- Are commercially available or new concepts
- Offer potential electrical energy savings
- Provide non-energy benefits
- Show promise for cost effectiveness
- Provide opportunities for adoption in the NW

Beginning with a list of 42 technologies assembled by WSU with input from TAG members prior to the meeting, and approved by the steering committee, TAG members brainstormed to expand that list to 52.

Ranking the Technologies

Following the kickoff meeting, Steering Committee members reviewed the list of technologies to screen suggestions before asking TAG members to rate them. This ensured that the significant effort to research, present, discuss, and score would be applied to technologies BPA believed would provide the best value to the region.

Not all suggestions were technologies, some were programmatic or strategies. The E3T and WSU staff split the items into technologies and programmatic categories, with the intention

that items in each category be rated against others in the same category. The final count for the rating survey was 30 technologies and 22 programmatic/strategy elements.

TAG members were asked to rate these using the following scoring system:

- I do not support this technology
- I support this technology with significant reservations
- I mildly support this technology
- I support this technology
- I strongly support this technology
- My support for this technology is enthusiastic and unqualified

From the TAG member ratings, a ranked list of each group was assembled. The final ratings may be seen in Appendix A.

After reviewing the rating results and TAG member comments, the TAG Steering Committee selected six technologies to move forward in the process. The six technologies were grouped into two categories: lamps and controls, as shown below:

Lamps:

- Linear fluorescent lamps
- Specialty lamps
- High efficacy lamps

Controls:

- Exterior lighting
- Exterior lighting with bi-level adaptive controls
- Connected lighting-only controls
- Connected controls integrated with a home automation system

The programmatic initiatives and strategies were prioritized separately and addressed through a panel discussion at the final meeting.

Scoring the Recommendations

The final stage of the TAG process asks members to prioritize the recommendations for future assessment. Members are asked to participate in Showcase Webinars to learn as much about the recommendations as possible before participating in a final scoring process. The presentations focus on providing information on eight selection criteria: (1) energy savings potential; (2) non-energy benefits; (3) technology readiness; (4) ease of adoption; (5) value/cost-effectiveness; (6) market and commercial readiness; (7) product performance; and (8) program readiness. TAG members were recruited to make presentations to introduce the seven selected technologies over the course of two webinars to help educate TAG members. Video archives of each of these presentations are available on the TAG Portal on E3TNW.org.

Showcase Webinars

Webinars are the primary way for TAG members to learn about new technologies before offering feedback to BPA. The webinars are part of the regular Showcase Webinar series, which are open to the public. Each webinar ran one hour, followed by ½ hour of discussion by TAG members and BPA staff only. The webinars were held on November 29 and December 7. Eighteen (18) TAG members and four BPA staff attended the November 29 lamp webinar, along with 37 other participants. There were 19 TAG members, seven BPA staff, and 59 others attending the December 7 controls webinar. The following provides an overview of the topics and presenters for the two Showcase Webinars: Lamps on November 29 and Controls on December 7:

Lamps - November 29, 2017

Highlights from this webinar included: All LEDs have some inherent benefits, including longer life, better cold-weather performance, dimming capacity, better optical control, and variable color. ENERGY STAR certification is advisable to ensure quality products in this price-sensitive market. (Insert hyperlinks?)

Residential Lighting: Higher Efficacy LED Lamps

- **Jeff Quinlan, VP of Engineering and Illumination at Acuity and Chairman of Next Generation Lighting Industrial Alliance**

Lamp efficiency continues to improve, up from about 50 lm/W in 2005 to over 150 lm/W now, with an ultimate theoretical maximum of 250-350 lm/W. Models are available with warm dimming for most lamp types and a wide range of color temperatures. The exact efficacy is a function of light distribution, which can range from 15 (highest efficacy) to 55 degrees (lowest efficacy). Higher efficacy lamps can be smaller, facilitate more creative applications and provide better optics.

Specialty Bulbs: The Opportunity for Savings

- **Taylor Jantz-Sell, ENERGY STAR Lighting Program Manager at US EPA**

LED specialty lamps can cut energy use by 90%. With lamp retail cost ranging from $3-16, payback can be as short as a few months. The energy savings potential for upgrading specialty lamps in the US is large—702 TBtu (see the table at right). Dimming is a key feature for specialty lamps, and NEMA's SSL 7A standard for dimmer/lamp compatibility coming out in 2018 will help ensure better quality to increase customer satisfaction. Amber tint, filament style, and warm dimming are additional attractive features that are now available. Efficacy can be as high as 120 Lm/W and is expected to continue to increase. One filament lamp not yet available in the US is already delivering 200 lm/W.

	% of installed base	Units installed (millions)	Energy Savings potential (tBtu)
A type	13.5%	436	491
Decorative	6.7%	58.9	283
Directional	15.3%	82.4	129
Small Directional	47.6%	21	58.9
Downlighting	19.8%	137	231

Source: Taylor Jantz-Sell, U.S. EPA ENERGY STAR

Linear LED Replacement Lamps

- **Nicole Graeber, Senior Development Engineer at the California Lighting Technology Center**

There are over five linear lamps per US household. Replacing five fluorescent lamps with LEDs can reduce total energy use by 70W. These lamps are typically in applications with low hours of use, such as garages, laundry/utility rooms, and some multifamily parking garages and common areas. Replacements with linear LEDs offer a typical energy savings of 44%. However LED replacement lamps typically have 29% lower light output and may be only appropriate in spaces that are currently over-lit. There are three types of power architecture for these lamps: Type A uses ballast power, Type B uses line voltage, and Type C uses an external driver. It is critical to purchase and install these with a clear understanding of these types of linear LEDs to capture savings and avoid hazards.

Controls - December 7, 2017

Adaptive Lighting in Residential Exterior Applications

- **Michael Siminovitch, UC Davis Rosenfeld Chair in Energy Efficiency and Director of the California Lighting Technology Center**

Adding the combination of photocell and motion sensor to exterior lighting can significantly reduce energy use. This can include porch lights and security lighting as well as pathway, area, and parking lot or garage lighting in multifamily facilities. These are now available in a wide variety of styles, although more so in California than the Northwest. Having bi-level lighting rather than on/off is generally preferred by occupants, who may feel less secure in the dark. It is less economical though, especially for porch lighting, which can have a payback of five years. Bi-level lighting is well established in California. However, in the Northwest it is only used in some commercial applications, not residential. LED bi-level systems replacing high-pressure sodium or fluorescent lamps can typically saving 50-70% of energy use.

Residential Connected Lighting

- **Chris Wolgamott, Senior Product Manager at NEEA**

Connected lighting can include dimming for daylighting or mood, occupancy sensing, color tuning, smart phone remote control, and energy use reporting. Some connected lamps need a hub, while others can work directly with a phone app. Different manufacturers use different communication strategies and protocols – it is not clear at this time which will dominate. DOE estimates energy savings from connected lighting in the US as 1,020-1,140 TBtu by 2035. One potential obstacle to energy savings is the attribution of the increased standby loads (energy used 24/7 for connected controls) that come with smart lamps that may provide lighting as well as entertainment, security, health, and other benefits.

Scoring Emerging Technologies

Following each webinar, TAG members were asked to provide five separate criteria scores for each of the technologies, using a scale from 1 to 5, where 5 are the best. The criteria are:

- **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 products 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 the costs and benefits, how good a buy is this technology for the owners?
- **Market/Commercial Readiness**: How available is it from how many manufacturers in the Northwest?
- **Product Performance**: How thoroughly has the technology been assessed?
- **Program Readiness**: How cost effective is it and how developed are utility programs promoting it?

The following tables provide a summary of the scores of the technologies in each of the criteria listed above. The colors and numbers indicate ranking so readers can easily get a sense of the relative strengths and weaknesses of each technology. Average scores are provided at the bottom. Note that for the colored ranking, a lower number is more favorable (e.g., 1 is the best out of 3), while a higher number is more favorable on the scoring scale.

Lamps

Total average scores on a scale of 1 (lowest) to 5 (highest)

	Specialty Lamps	Linear LEDs (TLEDs)	Higher Efficacy LED Lamps
ENERGY SAVINGS	4.10	3.10	3.75
NON-ENERGY BENEFITS	3.30	2.45	2.50
PRODUCT PERFORMANCE	3.95	3.65	3.26
MARKET/COMMERCIAL READINESS	4.58	4.33	3.38
PROGRAM READINESS	4.65	3.61	3.27
EASE OF ADOPTION	4.00	2.90	3.65
VALUE	4.10	2.85	3.45
TOTAL	**4.10**	**3.27**	**3.32**

Rating – 1st, 2nd, or 3rd (last)

	Specialty Lamps	Linear LEDs (TLEDs)	Higher Efficacy LED Lamps
ENERGY SAVINGS	1	3	2
NON-ENERGY BENEFITS	1	3	2
PRODUCT PERFORMANCE	1	2	3
MARKET/COMMERCIAL READINESS	1	2	3
PROGRAM READINESS	1	2	3
EASE OF ADOPTION	1	3	2
VALUE	1	3	2
TOTAL	**1**	**3**	**2**

* For total average score, a higher number is more favorable.

Specialty lamps include most residential lamps other than A-lamps and linear fluorescent lamps. In ten years of implementing TAGs, no technology has ever been ranked in first place for all criteria as specialty lamps has done here. Unlike some technologies, they have strong energy savings as well as non-energy benefits. Adoption is quite straightforward, and hundreds of products are readily available. Not surprising, utility programs—including at BPA, are well developed. Overall, their value to consumers and utilities is excellent.

Linear LED lamp products, markets, and programs were judged to have solid readiness. There are good products well proven and available and BPA offers an incentive. However, energy savings was rated lower largely due to lower hours of use and partly because the simplest power architecture to install has lower energy savings due to ballast losses. Non-energy benefits are lower mostly due to the typically utilitarian applications (e.g. garages and laundry rooms). The ease of adoption was also rated lower due to the complexities of selecting the appropriate type of power architecture for the application. Overall, value is good but not as good as either of the other two lamp technologies.

It is interesting to see that ratings for higher efficacy lamps are the inverse of the scores for linear LED lamps. Energy savings and non-energy benefits are better, as is ease of adoption and overall value, but the readiness of the technology is not as good. There are fewer products available, less incentive in the market, and utilities don't incentivize it, possibly due to lack of clarity in defining what would qualify as "higher efficacy". A definition of "higher efficacy" would be needed to establish a potential tiered incentive based on efficacy.

Controls

Average scores on a scale of 1 (lowest) to 5 (highest)

	SF Exterior Sensors	MF Bi-level Controls	Lighting with Controls	Lighting with Home Automation Systems
ENERGY SAVINGS	3.38	3.62	2.95	2.42
NON-ENERGY BENEFITS	3.00	3.00	2.95	3.76
PRODUCT PERFORMANCE	3.80	4.11	3.56	3.05
MARKET/COMMERCIAL READINESS	4.11	4.06	4.06	3.89
PROGRAM READINESS	4.06	3.88	3.18	2.06
EASE OF ADOPTION	3.58	3.52	2.95	2.74
VALUE	3.33	3.55	3.00	2.52
TOTAL	**3.61**	**3.68**	**3.24**	**2.92**

Rating – 1st, 2nd, 3rd, or 4th (last)

	SF Exterior Sensors	MF Bi-level Controls	Lighting with Controls	Lighting with Home Automation Systems
ENERGY SAVINGS	2	**1**	3	4
NON-ENERGY BENEFITS	2	2	4	**1**
PRODUCT PERFORMANCE	2	**1**	3	4
MARKET/COMMERCIAL READINESS	**1**	2	2	4
PROGRAM READINESS	**1**	2	3	4
EASE OF ADOPTION	**1**	2	3	4
VALUE	2	**1**	3	4
TOTAL	**2**	**1**	**3**	**4**

* For total average score, a higher number is more favorable.

Exterior lighting controls, such as porch and security fixtures with simple photo/motion sensors for single-family homes, had an overall score just a little below multifamily bi-level controls. Ratings for these two technologies are roughly the inverse of each other. Compared with the bi-level controls, single-family fixtures were seen as having greater readiness of markets and programs as well as easier adoptability, but lower savings, non-energy benefits, and product performance. The overall value was therefore judged to be lower than for bi-level controls. For bi-level controls, products are available, but markets and programs have not yet adopted them as they have in California. Interestingly, energy savings was rated higher for bi-level controls, even though they only dim lamps during periods of vacancy rather than turn them all the way off, as is done by single-family controls. This could reflect concerns of a lack of potential adoption of single-family controls due to homeowners' security concerns regarding dark yards.

Interior lighting controls received poor scores – a reflection of their limitations in residential settings. Energy savings are lower partly due to smaller hours of baseline operation.

While they are well developed, replacing current lamps and fixtures with individual controls may not gain much in savings or convenience. All TAG members seemed to agree that controlling lighting through home automation is not yet ready. The technology seems exciting and promising, but not quite mature, with technical and programmatic hurdles to adoption. However, when the time comes, it will offer an extensive collection of non-energy benefits to spur adoption.

Highlights of TAG Recommendations

In addition to scores, TAG members provided useful comments about the pros and cons of these lighting technologies and their potential for adoption and delivery of reliable and persistent energy savings. These are listed in the Appendix. During the scoring process, TAG members also offered specific recommendations many of which provided better understanding regarding the energy-saving potential of the technologies and/or ways to develop the technologies into utility measures.

Highlights from these recommendations are as follows. Bolded text indicates recommendations that are directly related to BPA's proposed next steps which are summarized in Action Plans (These appear in the Appendix). The fact that so many of the TAG's recommendations are directly reflected in the Action Plan shows the value placed on the TAG input in shaping future conservation programs and how much BPA appreciates the time and effort expended by the TAG members.

Lamps

Specialty Lamps

- Since they will likely be covered by federal regulations in 2020, invest less for incentives or just promote non-energy benefits
- **Compare cost effectiveness of delivery channels**
- **Provide consumer purchase guidance**
- **Consider making rebate upstream instead of downstream to lower product retail costs and reduce hassle factor for consumers**
- Promote non-energy benefits to consumers
- Specify ENERGY STAR certification for rebates
- **Move forward with implementing Specialty Lamps Incentives**
- Provide a short window for generating savings before EISA 2020

Linear LED Lamps

- **Focus on multifamily rather than single-family applications**
- **Focus on multifamily building managers who are much more likely to have the expertise needed to adopt these safely and effectively and possibly bundle these lamps with other**

measures targeting the sector. Also provide guidance for tenants and condo owners wanting to purchase and install these lamps themselves.

- **Revisit the assumptions of use in residential spaces within the BPA TLED measure that impact cost effectiveness**
- **Encourage homeowners to:**
  - **Replace all linear lamps at once**
  - **Not use old ballasts to improve savings and avoid ballast failure**
  - **Use new fixtures or retrofit kits rather than TLEDs**
  - **Pay close attention to architecture type and check ballast for compatibility (not easy) to avoid equipment damage or hazard**
  - **Check DLC for performance before selecting a product**

Higher Efficacy LED Lamps

- **Consider reducing the size of BPA's "lumen bin" method of assigning savings and its impact on use of higher efficacy lamps**
- **Specify ENERGY STAR (900 lamps are 100+ Lm/W) and maybe encourage ENERGY STAR to raise minimum efficacy**
- **Partner with a lighting lab to check these for glare and heat issues**
- Consider not supporting this directly If potential cons seem to outweigh the potential pros

Controls

Single-family Exterior Lights

- **Modify the existing incentive for LED porch lights to include additional rebates for having motion and photo sensors**
- **Determine potential energy savings and cost effectiveness**
- **Provide outreach through utilities on the potential impacts on security**
- Offer an upstream incentive for stocking and promoting smarter porch lights locally

Multifamily Bi-level Controls

- **Focus on multifamily applications**
- **Make sure the non-technical side of application is well understood by all parties, particularly perspectives on the impacts of these controls on security**
- Work with rural utilities who may have limited opportunities for this measure

Indoor Lighting with Controls

- **Quantify energy savings and cost effectiveness**
- **Clarify what types of lighting controls are most likely to deliver energy savings and a positive customer experience**
- **Target new construction and codes**
- Support fixture-integrated controls that offer energy savings without additional installation cost and eliminate lamp-dimmer compatibility issues

Indoor Lighting with Home Automation

- **Collaborate with NEEP, CEE, EPRI, CLTC, and California utilities on studies and monitoring/influencing development. Some NW utilities are currently working with NEEA on home automation hubs.**
- Try to maintain "a seat at the table" to at least monitor technology and product development, even though it is currently rated lower. Energy efficiency is not a development driver, although NW utilities had success with upstream incentives for the 80 Plus power supplies so some influence may be possible, at least regarding data and communications. Impacting standby loads will be harder, although some manufacturers are already reducing them to move toward battery-powered wireless operation. It may help to target more "green" manufacturers.
- Target populations such as seniors for these more complex controls that may better meet their special needs.
- **Promote these for primary lights and not for lamps infrequently used, to minimize standby loads**
- **Keep up on technology and product developments; touch base with LRC, Efficiency Vermont, NRCanada, NEEP, LEDVANCE**
- Perform more assessments prior to pilot projects, including exploration of standby load containment and attribution among uses

Final Meeting

The final step in the process fulfills BPA's commitment to promote Technology Transfer among industry stakeholders. A final meeting is designed to share results of the scoring process with TAG members to ensure that participants and their constituents benefit from this collaborative effort. This meeting also encourages feedback about the scores to allow TAG members to provide additional valuable input regarding final recommendations.

This TAG's final meeting was on December 14, 2017. Attendees included 15 TAG members in addition to seven staff members from BPA and WSU staff. The purpose of the final meeting was two-fold:

1) Review the final scoring results with TAG members and seek additional input; and
2) Present a panel discussion on programmatic strategies for residential lighting efficiency

Review of Residential Lighting Technologies Scores and Recommendations

Rob Penney from WSU presented a summary of technology scores and rankings, and led a group discussion that provided additional comments and recommendations. Highlights from this discussion are included in the Scoring Emerging Technologies section above.

Programmatic Strategies for Residential Lighting

Of the final list of technologies from the kick-off meeting, 42% were programmatic strategies rather than technologies. The Steering Committee decided to dedicate the third TAG webinar to a panel discussion of some of the higher rated topics which included how to:

- Educate the consumer and retail staff about the benefits and proper applications of LEDs
- Promote non-energy benefits to accelerate LED adoption, and
- Increase LED use in large but hard-to-reach markets such as low income and multifamily

The key theme for the panel was "How do we continue building market adoption for residential lighting". The discussion was facilitated by Keshmira McVey. A video archive of the presentations is available on the TAG portal at: http://e3tnw.org/TAGPortal/2017ResidentialLightingTAG(14).aspx#Announcements-55.

Presentations

- **Lighting Patterns for Homes: Consumer Education**
  Jeremy Snyder, Energy Program Director at the Lighting Research Center

The Lighting Research Center (LRC) at Rensselaer Polytechnic Institute created a publication, sponsored by BPA among others, called "The Lighting Pattern Book for Homes" in 1993. The book, designed in the tradition of architectural pattern books, provides a way to design, plan, and create good residential lighting based on energy conservation.

In 2013, LRC published a website (www.lrc.rpi.edu/patternbook) based on the publication with updated prices and wattages. A video series was added in 2015.

Mr. Snyder provided an overview of the website, which is intended for use by consumers, point-of-sale staff, builders, and efficiency contractors. Guiding principles included no identification of specific brands or products, use of neutral lighting patterns that matched or exceeded baseline lighting quality, and use of lay-terminology. Users can begin designing by selecting a type of room, types of equipment such as under-cabinet or sensors, or techniques such as daylighting or task lighting. It also includes guidelines on selecting products and performing calculations.

The website is professionally produced, accurate, comprehensive, and user-friendly. It offers an excellent model of a powerful information resource for consumer and trade ally education that could be updated to reflect the rapid advancement of LED technologies.

The last part of the presentation included educational ideas for accelerating adoption of LEDs. These included:

- Homeowner education online and at point-of-sale, including understanding product labeling
- Training of efficiency contractors, builders, retail sales staff, and electricians
- Increasing consumer confidence in products, such as with ENERGY STAR and clearer warranties
- Model homes, showrooms, and in-home demonstrations to showcase LEDs

- **Non-energy Benefits**
  Doug Dickson, Residential Energy Services Manager at Snohomish PUD

Identification of non-energy benefits (NEBs) of lighting systems can accelerate adoption. It can also increase cost effectiveness if the NEB's are monetized. However, monetization is not common practice and many organizations lack the skills and willingness to attempt it. With increased efficiency of baseline energy use due to adoption of LEDs in recent years, this may be more important to maintain claimable savings for utilities. Customer NEBs include improvements in lighting quality, maintenance, convenience, lamp appearance, security, cold-weather performance, and health. There are also NEBs for utilities, including demand reduction, fewer high bill complaints or shut-offs notices (and thus better customer relations).

- **Increase Adoption in Hard-to-Reach Markets: Low Income and Multifamily**
  Connie Samla, Sacramento Municipal Utility District

There is a large opportunity to increase energy savings, as well as comfort and health for low-income residences through LED lighting. Providing customers with a single point of contact, streamlined access to programs, and incentive for bundles of measures with direct install can increase impact. Multifamily, which has a substantial overlap with low-income customers, is also a large and rapidly growing sector with opportunity for lighting retrofits, and the proportion of families who rent rather than own their home is increasing; a third of US households now rent. Tailoring and targeting programs to building owners and managers is important. For both sectors, partnering with community organizations (housing trade associations, trade allies, food banks, low-income schools, etc.) and promoting non-energy benefits (for both tenants and building owners) with outreach tailored for target audiences can accelerate adoption. There may be great untapped savings potential in these; many programs serve less than 1% of multifamily customers while some serve up to 26%.

Discussion

Discussion points of the presentations include:

- SMUD used direct mailing of up to ten lamps to low-income neighborhoods. Lamps include general, night-lights, and fanlights. Their study, due mid-2018, shows some energy savings. Customers need to register, and later get an audit. They reach roughly 2,000 customers annually. There were some language barriers, so not all customers understood that the lamps would save energy.
- LED lamps actually contain no lead or mercury as long as lead-free solder is used.
- Non-energy benefits can outweigh the value of energy savings. For example, even a 2% improvement in worker or student productivity could dwarf energy savings. SMUD values the increased customer satisfaction as well as time-of-day benefit and minimizing reliance on low-income subsidies--even without energy savings.
- Education can help customers trying to make a purchasing decision by training store staff, simplifying labeling, and helping them to understand labels—which is easiest if they can just look for a graphic that shows approval, such as ENERGY STAR. Most people are unaware that lighting labels cover far more than energy savings, including color, dimming range, lamp life, flicker, and more. However, ENERGY STAR allows a range of CCTs so it may

be worth developing a new logo. However, adding another logo to those already on packaging (ENERGY STAR, California's more aggressive energy efficiency certification, Lighting Facts, and NEMA's new SSL-7A dimmer compatibility logo) could result in logo overload for customers.

- Some product enhancements result in their losing their ENERGY STAR ratings. For example, this could be due to increased standby losses (which ENERGY STAR limits to 0.5W) or to the lack of an ENERGY STAR category for color-changing lamps.

In all, TAG members expressed the importance of these three topics – education, reaching hard-to-reach markets, and using non-energy benefits – to increase adoption of residential lighting market adoption.

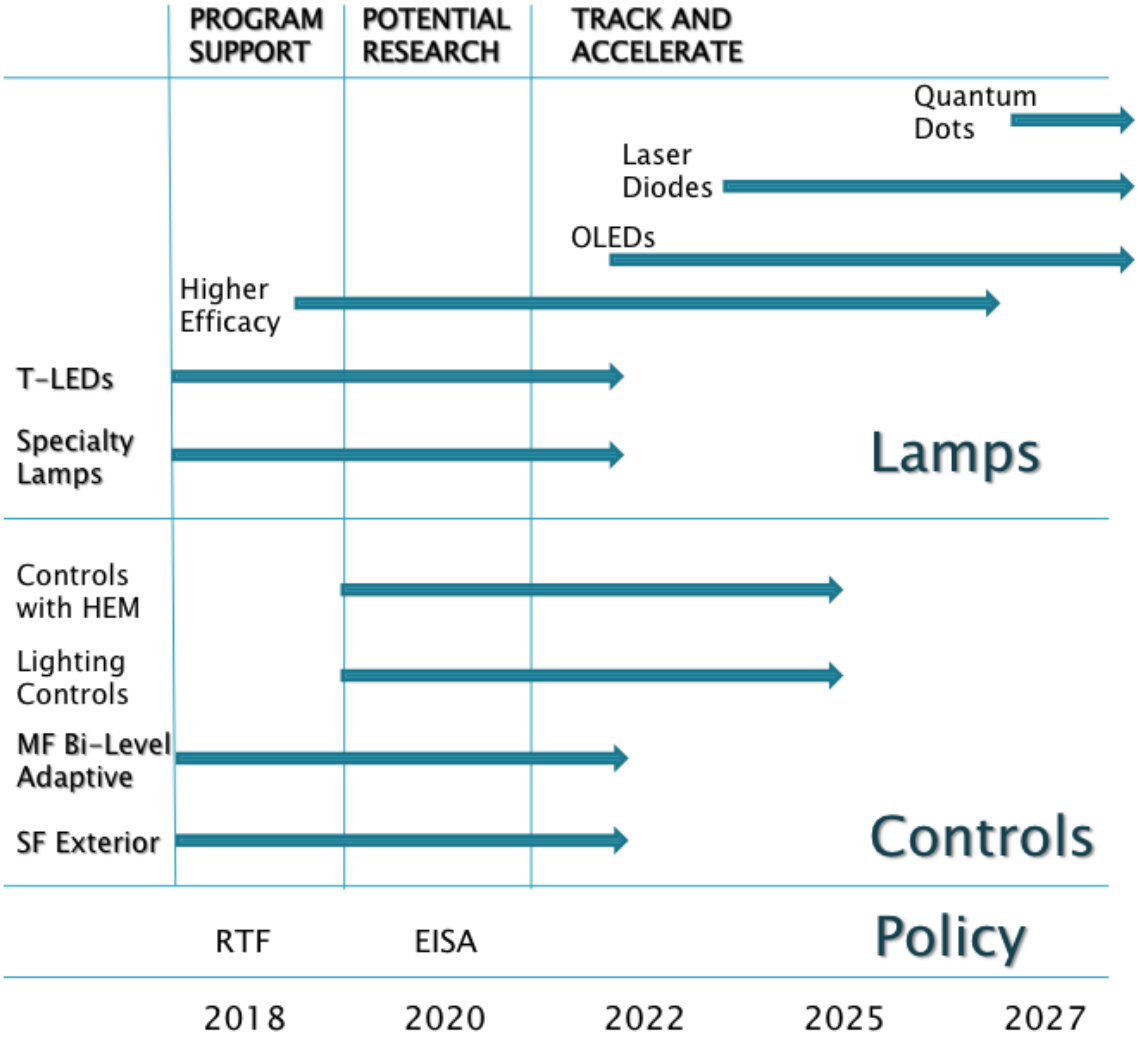
Next Steps for BPA

BPA has found working with the TAG Steering Committee to review, prioritize and develop action plans for the recommendations leads to greater success in implementing results. Steering Committee members met to discuss how to implement the TAG Recommendations and document next steps. Several key work products were developed as part of this phase including: a Technology Pipeline and action plans for each of the TAG recommendations. This section of the report summarizes both.

Technology Pipeline for Residential Lighting

Based on input from the TAG as well as qualitative research completed by the Washington State University Energy Program, the TAG Steering Committee developed a technology pipeline which highlights how new lighting initiatives might unfold over the next 5 – 10 years. The pipeline has three distinct phases of activities including short-term program support (2019 – 2020), mid-term research (2019 – 2021), and long-term tracking/accelerating (2022 – 2027). Technologies in the short term phase will be reviewed by the program team for new measure development including: Specialty lamps, Higher Efficacy Lamps, T-LEDs, Bi-Level Adaptive Lighting for Multifamily and Exterior Lighting Controls for Single Family. Technologies in the Potential Research Phase include Controls for Lamps and for Home Automation Systems. Longer term emerging technologies which BPA will monitor for research partners to complete proof of concept tests include: OLEDs, Laser Diodes, and Quantum Dots. The Technology Pipeline is summarized on the following page.

Residential Lighting Technology Pipeline
Three Stages – Now, Next, and Future



Action Plans for Recommendations

An action plan was developed for each of the seven recommendations summarizing key information and identifying next steps. The action plans document the steps necessary to develop the technology into new measures that capture energy savings. Each plan has eight sections: TAG Action Plan Highlights; Programmatic Elements Summary (Consumer education, Hard to Reach Markets and Non-energy Benefits) and next steps; applications; related BPA existing measures; future research questions; pros and cons; and possible next steps. These detailed action plans appear in the Appendix.

The following tables summarize possible next steps for each of the lamps, controls technologies and three programmatic strategies:

Lamps	Possible Next Steps
Specialty Lamps	• Identify specialty lamps that show the most promise for new incentives using RBSA and CLEAResult data and create subcategories for incentives. • Prepare analyses in case that EISA 2020 is not implemented. • Exploring opportunities for delivery channels including online promotions and under-served markets. • Provide consumer purchase guidance. • Explore opportunities to lower product retail costs and reduce hassle factor for consumers
Linear LEDs	• Determine potential for Linear LEDs in Multifamily. • Explore direct install programs and other targeting approaches for multifamily sector in association with other end uses. • Revisit the assumptions of use in residential spaces within the BPA TLED measure that impact cost effectiveness • Programs might encourage homeowners to: • Replace all linear lamps at once • Not use old ballasts to improve savings and avoid ballast failure • Use new fixtures or retrofit kits rather than TLEDs • Pay close attention to architecture type and check ballast for compatibility (not easy) to avoid equipment damage or hazard • Check DLC for performance before selecting a product
High Efficacy Lamps	• Consider a tiered incentive to encourage higher efficacy lamps if cost effective • Maintain incentives for lamps with 135+ lumens/watt to incent purchase of most energy efficiency LEDs until 2025 • Specify ENERGY STAR (900 lamps are 100+ Lm/W) and may encourage ENERGY STAR to raise minimum efficacy • Partner with a lighting lab to check these for glare and heat issues • Revisit “lumen bin” method of assigning savings and its impact on use of higher efficacy lamps • Explore a variety of incentives to increase availability across a variety of markets • Determine if there are products with higher lumens per watt, which qualify and then develop a strategy for working with the RTF including reviewing cost effectiveness.

Controls	Possible Next Steps
Single Family Exterior Lighting Controls	• Review CA codes and standards • Consider pilots to determine energy savings and cost effectiveness • Modify the existing incentive for LED exterior lights to include additional rebates for having motion photo sensors and/or automatic timers • Provide outreach through utilities on the potential impacts on enhanced security
Multifamily Bi-Level Lighting Controls	• Develop a higher level multifamily strategy • Collaborate with other utilities that have successful programs – i.e. PSE, SCL, ETO, and SCL. • Consider promoting this measure in Multifamily and explore measure bundle • Explore offering a direct install pilot program • Provide outreach on the impacts of adaptive lighting on safety/security; maybe convene discussion with some safety organizations • Target more urban utilities for implementation • Track TIP 391 project results
Indoor Lighting Controls	• Identify pilots and assessments in order to quantify energy savings and cost effectiveness • Clarify what types of lighting controls are most likely to deliver energy savings and a positive customer experience • Target new construction and codes • Create outreach program to promote the NEMA SSL-7A Standard.
Lighting Controls in Home Automation Systems	• Keep up on technology and product developments; collaborate with LRC, Efficiency Vermont, NRCanada, NEEP, LEDVANCE, CLTC • Identify pilots or assessment opportunities to validate energy savings and cost effectiveness for controls • Maybe promote these for primary lights and not for lamps infrequently used, to minimize standby loads

Programmatic Strategies	Possible Next Steps
Consumer Education	• Identify opportunities for consumer education primarily through retail store staff training and displays. CLEAResult maybe able to help. • Develop brochures to share with customer utilities about new measures.
Hard to Reach Markets	• Segment hard to reach markets. Do MF, low income and SSR have the same needs? • Do SSRs need more stock? Access to low cost products? A different delivery mechanism? • Establish a different savings baseline for each of the market segments. • Help utilities identify areas within their service territory with low-income customers. • Leverage different channels – CAP agencies, food banks, etc. • May need different attestation for these. • Utilize CLEAResult utility survey results for hard to reach markets. • Look at lamp sales data for stores more likely to serve low-income populations. • Consider new direct install program with a bundle of measures using the previous approach. • Streamline verification requirements that may leverage 3rd parties to deliver products. • Continue a strong online presence through Amazon, Wal-Mart, Home Depot, and maybe Target. Consider free shipping or store pick up to reduce costs.
Non-energy Impacts	• Develop NEB benefit messaging for each measure; consider monetizing NEBs and discuss with RTF; and encourage NEB field in Lighting Calculator. • NEBs can be used as a marketing measure to push sales • Encourage use of NEB field in Lighting Calculator.

The Emerging Technology team will periodically review the TAG Action Plans to identify next steps. For 2019, the ET team is proposing research for controls for lamps and with home energy management systems (HEM) systems to validate savings and cost effectiveness.

The Value of TAG Members

The contributions that TAG members made include: identifying technologies/best practices/strategies for further exploration; completing technology scores; participating in detailed and insightful discussion; providing on-line comments, and readily sharing information resources. These efforts resulted in BPA finding seven of the technologies worthy of investing time to research, present, and score, which is more than most previous TAGs.

The continued participation of TAG members reflects the favorable reputation that BPA's E3T program has among senior-level efficiency experts and the benefit they derive from the opportunity to interact with their peers around the country to move technology assessments forward.

At times, the BPA and WSU staffs have attempted to quantify the contribution of the TAG to the E3T Emerging Technology program. Although we hesitate to put a dollar value on the contribution of our TAG members because their expertise and support is invaluable, here is our attempt to do so. We estimate that TAG members in total contributed over 300 hours of volunteer time participating in TAG related activities. Assuming a conservative $200/hour consultant rate, their collective contribution can be valued at around $60, 000. This contribution allows BPA to invest in more research projects to secure future energy savings for the region.

BPA and WSU are indebted to the TAG members for helping to build our emerging tech and energy efficiency programs on behalf of the region.

Appendix A

TAG Member Recommendations

As part of the technology scoring process, TAG members identified pros and cons of each technology. There is a strong overlap between these and BPA's Action Plan, which is included in the Appendix D. As with strong uptake of TAG recommendations into the Action Plan, TAG members will appreciate that their insights into pros and cons also reflected in BPA plan for future research and incentives.

Lamps

Specialty Lamps

Pros:

- Ubiquitous lamp type in residential
- As there are fewer CFL specialty lamps, incumbent specialty lamps are mostly incandescent and readily available because they are not yet covered under federal efficiency standards. The high market share (78% of market share for decorative and mini-based lamps according to NEEA) means a relatively large market for adopting LEDs
- Hundreds of products are well-proven, plug-and-play replacements, ENERGY STAR listed, and available
- ENERGY STAR estimates savings at 90%
- Smaller packages with better dimming, light quality, optics, appearance (filament), and life—good for hard-to-reach fixtures

Cons:

- More expensive although great payback unless infrequently used
- RTF is raising baseline of reflector lamps which are now 80% LED cutting claimable savings

Linear LED Lamps

Pros:

- Notably more energy efficient (44% as per CLTC)
- Longer life
- Fewer environmental issues
- Price has dropped 80% since its introduction

Cons:

- More expensive than fluorescent lamps
- While the wattage of these lamps is much lower than for fluorescent lamps, savings are fairly small due to low hours of use.
- It would be hard to get homeowners to opt for early retirement of long-life fluorescents, although some homeowners upgrade because they prefer the look of linear LEDs.
- Typically low usage rates (e.g. garages, shops, laundry rooms) in residential so not cost effective

- Potential equipment failure and hazard if not installed correctly (depends on lamp architecture type)
- Product performance varies much more than new fixtures
- Different LED lamp architectures including ones which have line voltage
- Must have lamp, driver/ballast and dimmer compatibility
- Incumbent technology—fluorescent lamps—has a long life and unlikely to be replaced prior to end of life without a significant incentive

Higher Efficacy LED Lamps

Pros:

- Higher efficacy lamps generate less waste heat, meaning longer lives, better long-term color, and more design freedom due to smaller heat sinks.
- Continues to offer more savings
- Improved optical controllability
- Smaller lamps and fixtures—better for shipping and disposal

Cons:

- Concerns about glare as well as the quality of high-efficacy filament lamps
- More expensive; may not be cost-effective
- Equivalent "lumen bins" may force buying overly bright lamps
- Investing in higher efficacy lamps may be less impactful on lighting energy use than consumer education, quality, etc.
- "Higher efficacy" could be confusing to customers

Controls

Single-family Exterior Lights

Pros:

- kWh savings can be significant; a Navigant research report shows that timers for exterior lighting is the second most cost-effective form of residential controls
- Proven technologies and fixtures widely available in CA (less in NW)
- Sensor reliability may suffer to lower fixture costs
- Easy adoption (swap fixtures)
- Alerts homeowner and neighbors of motion

Cons:

- Homeowners may be uncomfortable with darkness
- RTF raising baseline for reflector lamps in security fixtures

Multifamily Bi-level Controls

Pros:

- The LRC just completed a study of these; savings were good and residents saw them as adding light rather than reducing it. However, with some wall packs some pedestrians had to walk nearer the building to trigger sensor while others were trigged by passing cars; better commissioning is needed. They also have a study with BPA looking at lowest dimmed levels and ramp rates; it will be completed in late 2018.

- SMUD engaged law enforcement and homeowner's associations in their market research. They're okay with the bi-level controls, but not the on/off type; darkness is uncomfortable.
- Proven technology and many applications in California
- Good applications include lighting for building exteriors, parking garages, pathways, parking lots, and indoor common spaces such as stairwells and hallways
- Energy savings could be large if baseline is fluorescent fixtures on all night, but are application-dependent
- Mixed perspectives on security impacts, better than on/off
- Generally supported by law enforcement
- Sensors provide sense of security
- This seems like a great extension of adaptive lighting that has successfully been used in stairwells and parking garages.
- Similar to res exterior lighting, this technology is widespread in CA and the NW could piggyback off work done here.
- Good and fairly easy to implement

Cons:

- More expensive
- Outreach is needed for occupants and guests
- Not as applicable to rural utility districts with less multifamily
- Sensors need improvement
- Rural utilities such as Benton County PUD may have limited opportunities for this measure.
- For residential, this (at least the parking lot/street side aspects of it) would be mostly useful for multifamily
- This seems like a good place for the utilities to focus since many of these lights are likely inefficient and left on all the time, so savings from both the lamps and controls.

Indoor Lighting with Controls

Pros:

- Well proven in commercial sector
- Ability to change color and control remotely with more precision
- May preclude need for wall switches, saving on cost
- Self-reporting of energy use and lamp failures can be useful to homeowners and utilities
- It's more cost-effective to integrate controls into fixtures (~$18/fixture), although wall switches will likely still be used, partly because they're needed for vacancy sensors.

Cons:

- Not enough data on energy savings in residential sector, which are dependent on baseline (low if LED) and behavior (EE geek vs. slacker); good to identify good/bad applications
- High-tech controls can be frustrating, may require training
- Tough to justify early retirement of lamps and fixtures
- Addressable devices that install in screw sockets or outlets cost as little as $10
- BPA's commercial sector program is focusing on controls, not as much in residential.

Indoor Lighting with Home Automation

Pros:

- Numerous NEBs for health, mood, security, convenience, etc.—likely drive purchase decisions more than energy savings
- NEBs include: Voice control, energy reporting, improved circadian rhythm, security, and maintenance
- Can share data with other energy systems, such as occupancy status through Nest
- Can change brightness or color to indicate security or CO alerts
- May provide demand response opportunities

Cons:

- Use of a wall switch can decrease standby loads.
- Hard to estimate energy savings due to behavior, baseline, and standby loads that may need to allocated among lighting and other uses and may significantly impact energy savings
- Programming will save more energy but the programming must be easy or it won't happen—as has been the case with thermostats.
- Technology is immature, lacks uniformity, and is expensive
- Some homeowners may enjoy automation but actually increase energy use
- Requires tech-savvy installers and users
- Solutions must be easy for adoption to become widespread

Appendix B

2017 Residential Lighting TAG Members

Agency	TAG Member
Avista Utilities	Tom Lienhard
Benton County PUD	Eric Miller
California Lighting Technology Center	Michael Simonovitch
Clark PUD	Mike Wallace
CLEAResult	James Domanski
CLEAResult	Heather Gates
Electric Power Research Institute	Frank Sharp
Energy Trust of Oregon	Mike Bailey
Energy Trust of Oregon	Ryan Crews
Franklin PUD	Todd Blackman
LEDVance	Chris Lubeck
Lighting Research Center	Jeremy Snyder
National Renewable Energy Laboratory	Jennifer Scheib
Natural Resources Defense Council	Mohit Chabra
Natural Resources Defense Council	David Goldstein
Natural Resources Defense Council	Noah Norowitz
Northeast Energy Efficiency Partnerships	Claire Miziolek
Northwest Energy Efficiency Alliance	Amy Webb-Cabrera
Northwest Energy Efficiency Alliance	Chris Wolgamott
Pacific Lamp Supply Company	John Elias
Pacific Lamp Supply Company	Spencer Miles
Pacific Northwest National Laboratory	Marc Ledbetter
Private Consulting	Mary Matteson-Bryan
Regional Technical Forum	Ryan Firestone
Regional Technical Forum	Tina Jayaweera
Sacramento Municipal Utility District	Connie Samla
Seattle City Light	Victor Couto
Snohomish PUD	Doug Dickson
Snohomish PUD	Hillary Olsen
US EPA	Taylor Jantz-Sell
WSU Energy Program	David Hales

Appendix C

Residential Lighting TAG Ranking Report

Technologies - Controls	Rank	Mean
Adaptive Lighting	2	3.64
Standby Loads for Connected Controls	3	3.62
Exterior Lighting	5	3.41
Smarter Porch Lights - Technologies	7	3.23
Fixture Integrated Connected Controls	8	3.05
Whole-house Light Switch	9	2.82
Integrated Task Lights	10	2.73
Promote Effective Integration of Controls	10	2.73
Auto-Away / Smart Away Control	14	2.55
"Dark Campus" Concept for Homeowners	15	2.5
Self-powering Lighting Controls	17	2.36
Light Dimming for Demand Respond	18	2.27
Invisible Switches	19	2.18
Li-Fi	20	2.05
More Voice Control	22	1.95
Remote Control Table and Floor Lamps	24	1.91
Power Over Ethernet	28	1.5
"Doorbell" Video Products	29	1.45
Technologies - Lamps		
LEDs in Decorative Applications	1	3.86
Filament LEDs	4	3.5
Higher Efficacy LED Lamps	6	3.32
Improved Longevity Testing	10	2.73
Varying Brightness and Color Temperatures in One Lamp	13	2.68
Tubular LEDs in Residential Applications	16	2.45
DC Power Distribution	20	2.05
Solar Tubes	22	1.95
Organic LEDs	25	1.73
Quantum Dots	26	1.68
Laser Diodes	27	1.59
Light Transmissive Carpets	30	1
Programmatic and/or Strategies	Rank	Mean
Focus on Multifamily Sector	1	3.77
Incentives Which Reward Energy Systems Integration	2	3.64
Better Consumer Education and Labeling	3	3.59
Target Low-income Customers	4	3.5

Require ENERGY STAR Certification for Incentives to Ensure Lamp Quality	5	3.45
Strengthen Lighting Codes and Standards	6	3.23
Provide Incentives for ENERGY STAR Products	6	3.23
Improve LED Dimming	8	3.18
Non-energy Benefits	9	2.95
Require Fixtures manufacturers to ship with ENERGY STAR LEDs	10	2.91
Smarter Porch Lights - Programmatic	11	2.82
Open-source Controls for Utility Report and DR	12	2.73
Connected Control Reports for EM&V	13	2.68
Reduce Homeowner Load Building Through Education Programs	14	2.55
Prorated Average Baseline for Energy Savings Calculations	15	2.52
Smart Lighting as Gateway to Other Smart Systems	16	2.5
Promote Better Quality Metrics	16	2.5
Promote Families of Fixtures	18	2.45
More Intuitive Controls	18	2.45
Allocate the Cost and Energy Use of Lamps with Non-light Features by Function	20	2
Reprioritize Resources Dedicated to Utility Residential Lighting Programs to Other Residential Technologies	20	2
Lamps with Battery Backup for DR	22	1.91

Appendix D. Recommendations

TAG Recommendations

	Category	Overall Scores	Pros	Cons
Specialty Lamps	Lamps	4.10	❖ Top scores across all TAG categories ❖ 300+ Energy Star models available	❖ Short window of opportunity prior to EISA 2020 ❖ Limited availability in big box stores ❖ Price
MF Bi-Level Adaptive Lighting	Controls	3.68	❖ Nominated by 3 TAGs ❖ Good Energy Savings, Product Performance and Value ❖ In BPA Lighting Calculator	❖ Hard to serve market ❖ Who do you target for improvements – owner/occupant
SF Exterior Controls	Controls	3.61	❖ Commercial ready, Program Ready and Ease of Adoption	❖ May be security concerns with dark only options ❖ Limited availability in NW market
High Efficacy	Lamps	3.32	❖ More energy savings ❖ Efficacy on track to exceed 200 lumens/watt by 2025	❖ Unproven ❖ Current BPA Lumen Bins needs to be examined ❖ Concerns about glare
T-LEDs	Lamps	3.27	❖ Proven technology ❖ Provides energy savings	❖ Low HOUs ❖ May be too complex for homeowners to install
Lighting with Controls	Controls	3.24	❖ Provides control for homeowners including remote access ❖ Longer bulb life lowers cost for maintenance	❖ Energy savings needs to be validated ❖ Low HOUs may not drive savings ❖ Increased standby loads
Lighting Controls with Home Automation	Controls	2.92	❖ Desired feature ❖ High NEBs ❖ Voice automation key driver ❖ Provides energy management reporting	❖ Energy savings not key driver ❖ How to determine energy savings and cost effectiveness across multiple functionalities

Appendix E. Lamps - Action Plans and Background Information

Specialty Lamps

TAG Action Plan: Major focus for Residential Programs for greatest savings before EISA 2020. Consider splitting up incentives for specialty lamps into subcategories. Use market data to prioritize lamps with the most potential.

Programmatic Element	Proposed Action
Consumer Education	• New training programs for in store staff - CLEAResult
Hard to Reach Markets	• Consider baseline for hard to reach markets • Understand where SSR residents purchase lamps - CLEAResult • Utilize alternative channels – CAP organizations, Food Banks etc. which may require different attestation to verify savings
Non-Energy Benefits	• Promote non-energy benefits to consumers

Applications: Everything except A lamps including: Decorative, Directional, Small Directional, Reflector Lamps, Bathroom lights and fixtures, Globe Lamps, and Outdoor lamps

Existing Measures (73)

Bathroom Vanity Fixture, Decorative Ceiling Flush Mount Fixture, Bi-pin Multifaceted Reflector Lamp, Bi-pin Non-Multifaceted Reflector Lamp, Decorative and Mini-base Lamp, Globe Lamp, Reflectors and Outdoor lamps

Research Questions

- Analyze lamp sales data to identify best alternatives.

Pros	Cons
• Ubiquitous lamp type in residential, a plug-and-play replacement • Hundreds of products are well-proven, ENERGY STAR listed • ENERGY STAR estimates savings at 90% • Few CFL lamps means incumbent lamps mostly incandescent • Smaller packages with better dimming, light quality, optics, appearance (filament), and life—good for hard-to-reach fixtures	• More expensive • RTF is raising baseline of reflector lamps, now 80% LED

Possible Next Steps

- Identify specialty lamps that show the most promise for new incentives using RBSA and CLEAResult data and create subcategories for incentives.
- Prepare analyses in case that EISA 2020 is not implemented.
- Exploring opportunities for delivery channels including online promotions and under served markets.
- Provide consumer purchase guidance.
- Explore opportunities to lower product retail costs and reduce hassle factor for consumers

Linear LEDs or T-LEDs

TAG Action Plan: Target Multifamily common areas and leverage measures including O&M savings. May bundle with other recommendations. Explore bulk direct install programs. Consider running pilots to test direct install programs.

Programmatic Element	Proposed Action
Consumer Education	• Work with NEEA to identify low income areas for consumer utilities
Hard to Reach Markets	• Consider baseline for hard to reach markets - Multifamily • Consider direct delivery to MF households
Non-Energy Benefits	• Reduced maintenance costs due to longer bulb life

Applications:

- Residential applications: Garages, Laundry/Utility Rooms/Multifamily parking and common areas
- Linear Fluorescent incumbents – T5, T8 and T12
- Average Power Reduction 44% Fluorescent lamp 31/5 W to LED 17.8 W
- 5.1 Linear lamps per US Household

Existing Measures (10)

Linear LED Flush Mount Fixture, LED T LED Lamps

Research Questions

- Check RBSA to estimate regional Technical potential for T12 replacement

Pros	Cons
• Notably more energy efficient (44% per CLTC) • Longer life • Fewer environmental issues	• Typically low hours of use in residential so may not be cost effective • Potential equipment failure and hazard if not installed correctly (depends on lamp architecture type) • Product performance varies much more than new fixtures • Different LED lamp architectures including ones which have line voltage • Must have lamp, driver/ballast and dimmer compatibility

Possible Next Steps

- Determine potential for Linear LEDs in Multifamily.
- Explore direct install programs and other targeting approaches for multifamily sector in association with other end uses.
- Revisit the assumptions of use in residential spaces within the BPA TLED measure that impact cost effectiveness
- Programs might encourage homeowners to:
  - Replace all linear lamps at once
  - Not use old ballasts to improve savings and avoid ballast failure
  - Use new fixtures or retrofit kits rather than TLEDs
  - Pay close attention to architecture type and check ballast for compatibility (not easy) to avoid equipment damage or hazard
  - Check DLC for performance before selecting a product

High Efficacy Lamps

TAG Action Plan: Consider a tiered incentive for high efficacy lamps with a list of qualified products or specifications. Filament lamps may be part of this category. CEE and DLC have already adopted the use of tiers.

Programmatic Element	Proposed Action
Consumer Education	Would have to educate consumers about why it is important to purchase higher efficacy bulbs
Hard to Reach Markets	
Non-Energy Benefits	Small lamp that allows smaller and more creative fixtures.

Applications: Across all LED applications

Existing Measures (0)

Research Questions

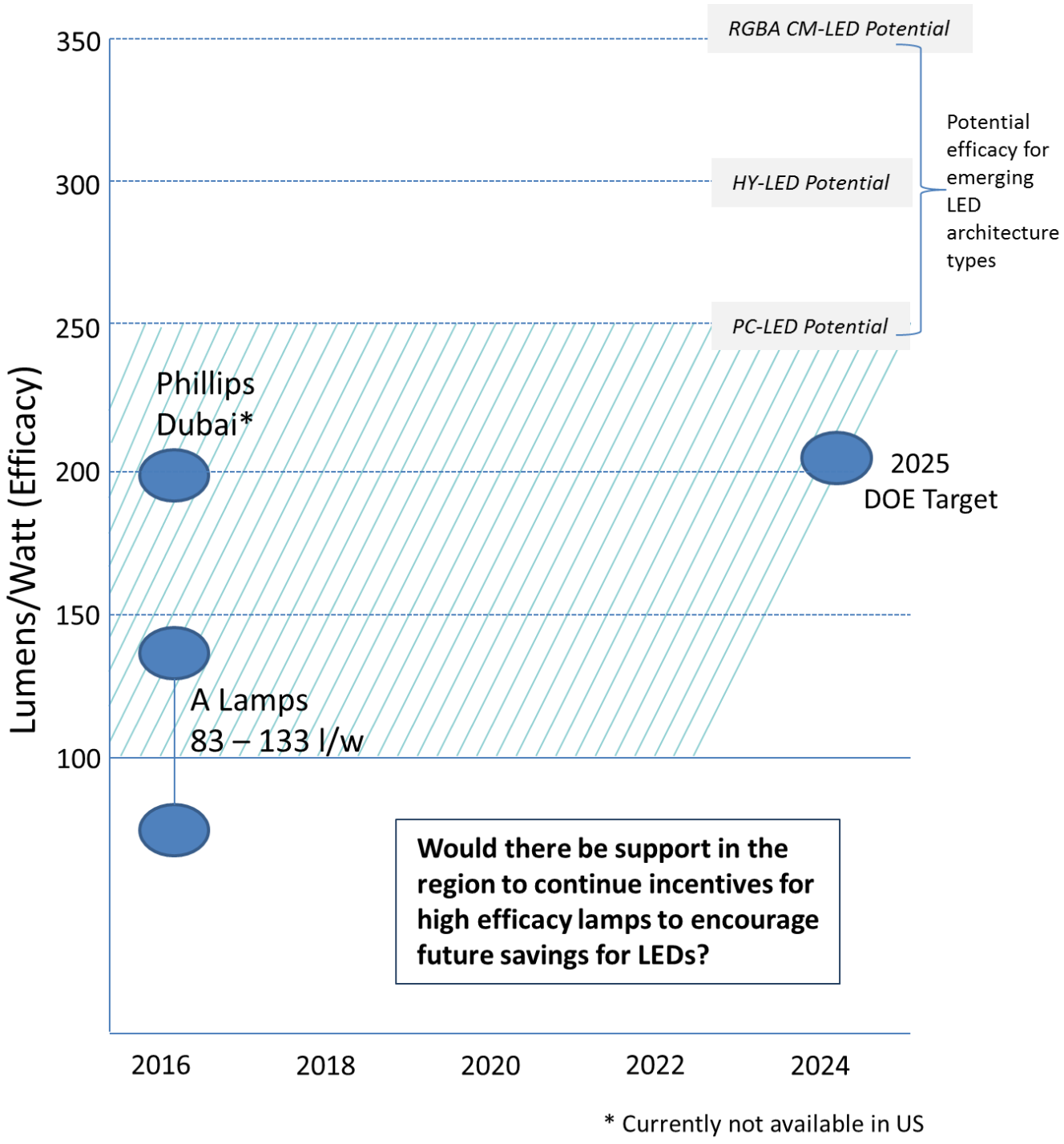
Will the region support a tiered approach to extend program? Where to set the baseline for the tiers? Will these lamps be cost effective? Is there a problem with glare?

Pros	Cons
• Continues to offer more savings • Improved controllability, smaller lamps and fixtures – better for shipping and disposal, and great energy savings	• Requires getting "buy in" for setting up new tiers • Concerns about glare as well as the quality of high-efficacy filament lamps • More expensive; may not be cost-effective • Equivalent "lumen bins" may force buying overly bright lamps • Investing in higher efficacy lamps may be less impactful on lighting energy use than consumer education, quality, etc. • "Higher efficacy" could be confusing to customers

Possible Next Steps

- Consider a tiered incentive to encourage higher efficacy lamps if cost effective
- Maintain incentives for lamps with 135+ lumens/watt to incent purchase of most energy efficiency LEDs until 2025
- Specify ENERGY STAR (900 lamps are 100+ Lm/W) and may encourage ENERGY STAR to raise minimum efficacy
- Partner with a lighting lab to check these for glare and heat issues
- Revisit "lumen bin" method of assigning savings and its impact on use of higher efficacy lamps
- Explore a variety of incentives to increase availability across a variety of markets
- Determine if there are products with higher lumens per watt that qualify and then develop a strategy for working with the RTF including reviewing cost effectiveness.

Higher Efficacy LEDs Tiers



Appendix F. Lighting Controls – Action Plans and Background Information

Single Family Exterior Lighting Controls

TAG Action Plan: Support measures for Exterior Lighting Controls and fixtures. Modify the existing incentive for LED exterior lamps and fixtures to include additional rebates for motion and sensor controls. Offer upstream incentives for stocking and promoting exterior lights with controls.

Programmatic Element	Proposed Action
Consumer Education	Provide information through utilities on the potential benefits for security to address concerns about dark house exteriors.
Hard to Reach Markets	
Non-Energy Benefits	Longer lamp life and lower maintenance costs because the lamps are off much of the time.

Applications: Photocell, motion sensor and/or automatic times for carports, porch lights and other exterior security lighting.

Existing Measures (12)

LED Exterior Light Fixture, LED Security Fixture

Research Questions

- Analyze lamp sales data to identify best alternatives. CLEAResult
- Determine potential energy savings and cost effectiveness
- Identify any barriers to adoption – security concerns i.e. total darkness versus bi level lighting

Pros	Cons
• If dark w/o motion, kWh savings can be significant (baseline) • Proven technologies and fixtures widely available in CA (less in NW) • Easy adoption (swap fixtures) • Alerts homeowner and neighbors of motion	• Homeowners may be uncomfortable with darkness • RTF raising baseline for reflector lamps in security fixtures • Sensor reliability may drop as manufacturers focus on cutting costs

Possible Next Steps

- Review CA codes and standards
- Consider pilots to determine energy savings and cost effectiveness
- Modify the existing incentive for LED exterior lights to include additional rebates for having motion photo sensors and/or automatic timers
- Provide outreach through utilities on the potential impacts on enhanced security

Multi-Family Bi-Level Lighting Controls

TAG Action Plan: Support measures for Multifamily Bi-Level Lighting fixtures with controls including motion, photo and occupancy sensors. Consider bundling measures for Multifamily and conducting pilots to validate savings and cost effectiveness. Track TIP 391 results.

Programmatic Element	Proposed Action
Consumer Education	Provide information to utilities on the potential benefits for security.
Hard to Reach Markets	Consider direct install programs to replace lighting in common areas.
Non-Energy Benefits	Enhanced security, longer lamp life, and lower maintenance costs because lamps are off much of the time.

Applications: Multifamily parking lots, parking garages, patios, pathways, and common areas including stairwells and hallways.

Existing Measures

Bi-Level adaptive lighting controls qualifies for incentives through Commercial Lighting Measures

Research Questions

- Analyze lamp sales data to identify best alternatives. CLEAResult
- Determine potential energy savings and cost effectiveness
- Identify any barriers to adoption – security concerns i.e. total darkness versus bi level lighting

Pros	Cons
• Proven technology and many applications in California • Energy savings could be large if baseline is fluorescent fixtures on all night • Existing lamps are likely less efficient and fully on all night, so saving are from lamps and controls can be significant • Mixed perspectives on security impacts, better than on/off	• More expensive • Outreach is needed for occupants and guests • Overcome challenge of who gets the incentive – owner vs occupant • Not as applicable to rural utility districts with less multifamily • Include commissioning to ensure line-of-sight to target areas and sensitivity to capture motion throughout target area and beyond

Possible Next Steps

- Develop a higher level multifamily strategy
- Collaborate with other utilities that have successful programs – i.e. PSE, SCL, ETO, SCL.
- Consider promoting this measure in Multifamily and explore measure bundle
- Explore offering a direct install pilot program
- Provide outreach on the impacts of adaptive lighting on safety/security; maybe convene discussion with some safety organizations
- Target more urban utilities for implementation
- Track TIP 391 project results

Indoor Lighting with Controls

TAG Action Plan: Explore research pilots to validate energy savings and cost effectiveness. Track commercial sector research to see what may be applicable.

Programmatic Element	Proposed Action
Consumer Education	Raise awareness of lighting control products including the new NEMA SSL-7A standard that ensures compatibility between lamps and dimmers.
Hard to Reach Markets	Low-income apartments may mostly have table and floor lamps and smart lamp bases start at $10-15.
Non-Energy Benefits	Includes remote control, convenience, programmability for security and energy use reporting.

TAG Action Plan: Explore research pilots to validate energy savings and cost effectiveness. Track commercial sector research to see what may be applicable

Applications: Residential Connected Lighting Controls include features in the lamp and/or fixture including: daylighting (dimming); occupancy sensing; color tuning; Smart Phone controls (phone apps); emergency lighting (battery back-up); energy reporting; dimming (self or controlled); and smart lamps or smart lamp bases for table and floor lamps.

Existing Measures (0)

Research Questions

- Quantify energy savings and cost effectiveness
- Clarify what types of lighting controls are most likely to deliver energy savings and a positive customer experience

Pros	Cons
• Well proven in commercial sector. • Ability to change color and control remotely with more precision. • May preclude need for wall switches, saving costs. • Fixture-integrated controls offer energy savings without additional installation cost and eliminate lamp-dimmer compatibility issues. • Smart lamp bases are low-cost additions to table and floor lamps	• Energy savings are not driving decisions as much as convenience. • Not enough data on energy savings in residential sector, which are dependent on baseline (low if LED) and behavior (EE geek vs. slacker); good to identify good/bad applications • High-tech controls can be frustrating, may require training • Tough to justify early retirement of lamps and fixtures

Possible Next Steps

- Identify pilots and assessments in order to quantify energy savings and cost effectiveness
- Clarify what types of lighting controls are most likely to deliver energy savings and a positive customer experience
- Target new construction and codes
- Create outreach program to promote the NEMA SSL-7A Standard.

Lighting Controls with Home Automation

TAG Action Plan: Explore pilots or assessments opportunities to determine savings and cost effectiveness for different technologies. Determine methods to estimate energy savings and cost allocation across multiple functionalities. Identify other research questions.

Programmatic Element	Proposed Action
Consumer Education	
Hard to Reach Markets	
Non-Energy Benefits	Ability to share data with controls for other energy savings, such as Nest thermostats to share occupancy status. See information in Pros section below.

Applications: Home automation systems. Various platforms will deliver lighting controls including Apple, Google and Amazon. Commands will be delivered through different devices SRT and Smart Phones. Voice Control will play a critical role in applications.

Existing Measures (0)

Research Questions

- Do these products provide energy savings?
- Develop methods to estimate energy savings and cost allocation across multiple functionalities
- Clarify what types of lighting controls are most likely to deliver energy savings and a positive customer experience

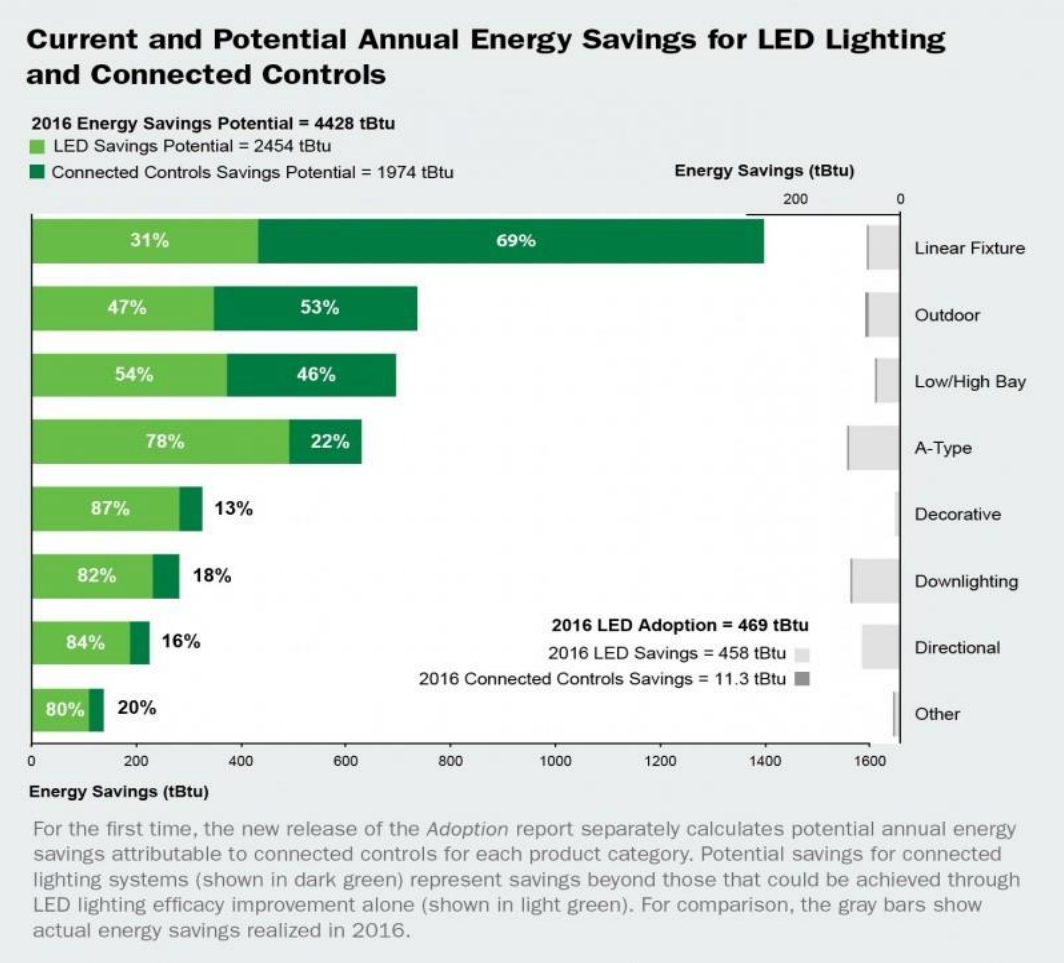
Pros	Cons
• Numerous NEBs for health, mood, security, convenience, etc.—likely drive purchase decisions more than energy savings • NEBs include: Voice Control; Energy Reporting; Improved Circadian rhythm; Security; and Maintenance • Provide Demand Response Opportunities	• Energy savings will not drive purchase decisions. • Hard to estimate energy savings due to behavior, baseline, and standby loads that may need to be allocated among lighting and other uses and may significantly impact energy savings • Need new M&V methodologies to determine energy savings • Technology is immature, lacks uniformity, and is expensive • Requires tech-savvy installers and users

Possible Next Steps

- Keep up on technology and product developments; collaborate with LRC, Efficiency Vermont, NRCanada, NEEP, LEDVANCE, CLTC
- Identify pilots or assessment opportunities to validate energy savings and cost effectiveness for controls
- Maybe promote these for primary lights and not for lamps infrequently used, to minimize standby loads

Annual Energy Savings from LEDs and Connected Controls

"While the energy savings potential for residential lighting controls may be small overall, it varies considerably by lamp type, so controls for some lamp types may make good measures. BPA may want to consider targeting controls with greater potential, shown in dark green and lower adoption rates, shown in gray. For example, residential TLED controls have about 1000 tBtus of potential savings but only about 50 tBtus were realized in 2016. Therefore, targeting motion sensors for TLED could be a measure to consider if it is also shown to be cost-effective."



Source: EPRI Presentation

Appendix G. Recommendation Summaries

Lamp Recommendation Summaries

TAG Recommendation	Potential Next Steps
Specialty Lamps	• Identify specialty lamps that show the most promise for new incentives using RBSA and CLEAResult data. • Prepare in case that EISA 2020 does not go through. • Exploring opportunities for delivery channels including online promotions and under served markets. • Provide consumer purchase guidance • Explore opportunities to lower product retail costs and reduce hassle factor for consumers

Linear LEDs	• Determine potential for Linear LEDs in Multifamily.
	• Explore direct install programs and other targeting approaches for multifamily sector in association with other end uses.
	• Revisit the assumptions of use in residential spaces within the BPA TLED measure that impact cost effectiveness
	• Programs might encourage homeowners to:
	  • Replace all linear lamps at once
	  • Not use old ballasts to improve savings and avoid ballast failure
	  • Use new fixtures or retrofit kits rather than TLEDs
	  • Pay close attention to architecture type and check ballast for compatibility (not easy) to avoid equipment damage or hazard
	  • Check DLC for performance before selecting a product

High Efficacy Lamps	• Consider a tiered incentive to encourage higher efficacy lamps if cost effective • Maintain incentives for lamps with 135+ lumens/watt to incent purchase of most energy efficiency LEDs until 2025 • Specify ENERGY STAR (900 lamps are 100+ Lm/W) and may encourage ENERGY STAR to raise minimum efficacy • Partner with a lighting lab to check these for glare and heat issues • Revisit “lumen bin” method of assigning savings and its impact on use of higher efficacy lamps • Explore a variety of incentives to increase availability across a variety of markets • Determine if there are products with higher lumens per watt which qualify and then develop a strategy for working with the RTF including reviewing cost

Controls Recommendation Summaries

TAG Recommendation	Potential Next Steps
Single Family Exterior Lighting Controls	• Review CA codes and standards • Consider pilots to determine energy savings and cost effectiveness • Modify the existing incentive for LED exterior lights to include additional rebates for having motion photo sensors and/or automatic timers • Provide outreach through utilities on the potential impacts on security
Multifamily Bi-level Lighting Controls	• Develop a higher level multifamily strategy • Collaborate with other utilities that have successful programs – i.e. PSE, SCL, ETO, SCL. • Consider promoting this measure in Multifamily and explore measure bundle • Explore offering a direct install pilot program • Provide outreach on the impacts of adaptive lighting on safety/security; maybe convene discussion with some safety organizations • Target more urban utilities for implementation • Track TIP 391 project results
Indoor Lighting Controls	• Identify pilots and assessments in order to quantify energy savings and cost effectiveness • Clarify what types of lighting controls are most likely to deliver energy savings and a positive customer experience • Target new construction and codes • Create outreach program to promote the NEMA SSL-7A Standard.
Lighting Controls in Home Automation Systems	• Keep up on technology and product developments; collaborate with LRC, Efficiency Vermont, NRCanada, NEEP, LEDVANCE, CLTC • Identify pilots or assessment opportunities to validate energy savings and cost effectiveness for controls • Maybe promote these for primary lights and not for lamps infrequently used, to minimize standby loads

Programmatic Initiative

TAG Priority	Potential Next Steps
Consumer Education	• Identify opportunities for consumer education primarily through retail store staff training and displays. CLEAResult maybe able to help. • Develop brochures to share with customer utilities about new measures.
Hard to Reach Markets	• Segment hard to reach markets. Do MF, low income and SSR have the same needs? • Do SSRs need more stock? Access to low cost products? A different delivery mechanism? • Establish a different savings baseline for each of the market segments. • Help utilities identify areas within their service territory with low-income customers. • Leverage different channels – CAP agencies, food banks, etc. • May need different attestation for these. • Utilize CLEAResult utility survey results for hard to reach markets. • Look at lamp sales data for stores more likely to serve low-income populations. • Consider new direct install program with a bundle of measures using the previous approach. • Streamline verification requirements that may leverage 3rd parties to deliver products. • Continue a strong online presence through Amazon, Wal-Mart, Home Depot, and maybe Target. Consider free shipping or store pick up to reduce costs.
Non-energy Impacts	• Develop NEB benefit messaging for each measure; consider monetizing NEBs and discuss with RTF; and encourage NEB field in Lighting Calculator. • NEBs can be used as a marketing measure to push sales • Encourage use of NEB field in Lighting Calculator.