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RENEWABLE ENERGY

Lighting R&D Program:

L-Prize® Launch Roundtable on Lighting Innovation, Workforce Development, and Partnership

October 2021

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Disclaimer

DOE Lighting R&D Program, "L-Prize Roundtable," October 2021

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Lighting R&D Program
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Comments

The Department of Energy is interested in feedback or comments on the materials presented in this document. Please write to Brian Walker, Lighting Program Manager:

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Kelly Gordon, Advanced Lighting Program Manager, Pacific Northwest National Laboratory

Monica Hansen, Principal, LED Lighting Advisors

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Introduction

On May 18, 2021, Department of Energy (DOE) leadership and lighting industry thought leaders gathered at a virtual roundtable to discuss lighting innovation, workforce development, and partnership. The event highlighted DOE partnerships with manufacturers, national laboratories, technical societies, and market transformation organizations.

The impetus for the roundtable was the new L-Prize® competition, launched on May 17 at DOE's 2021 Better Buildings, Better Plants leadership symposium by Secretary of Energy Jennifer M. Granholm. The L-Prize competition is primed to unlock the full potential of LED (light-emitting diode) technology—to combine high efficiency with exceptional lighting quality, data-driven control and functionality, and innovative design, construction, and grid flexibility in a winning product that will redefine the future of illumination in commercial and institutional buildings. The competition supports the Biden Administration's priorities to push the frontiers of science and engineering and catalyze clean energy technologies and jobs, helping America lead the transition to a sustainable, equitable, and inclusive global clean energy economy.

A decade ago, the first L-Prize was awarded by DOE, recognizing breakthrough performance in an LED replacement for the common 60-watt light bulb. Since then, LED technology has continued to advance, and the impact has been nothing short of revolutionary. Each year, LEDs help the United States avoid 98 million metric tons of carbon emissions—equivalent to reducing our driving by 243 billion miles per year. LEDs also save U.S. households about $225 per year in energy costs, and commercial buildings that have switched to LED lighting save $5.1 billion per year. Yet, much technology headroom remains for efficiency, quality of light, connectivity, and overall environmental footprint. The new L-Prize competition aims to close this gap.

The roundtable provided an opportunity for attendees to learn more about the new L-Prize competition and to exchange ideas for continued innovation in LED lighting by leveraging partnerships and increasing workforce development. This report summarizes that discussion.

Opening Remarks

Brian Walker, manager for lighting research and development in the Building Technologies Office (BTO) within the Office of Energy Efficiency and Renewable Energy (EERE), facilitated attendee introductions and acknowledgements. He began by thanking the invited speakers: Kelly Speakes-Backman, Acting Assistant Secretary, EERE; Karen Willis, Industry Director, Lighting Systems Division, National Electrical Manufacturers Association; Christina Halfpenny, Executive Director, DesignLights Consortium (DLC); Bernadette Boudreaux, Associate Director of Operations, DLC; Brian Liebel, Director of Standards and Research, Illuminating Engineering Society (IES); Mark Lien, Industry Relations Manager, IES; Chris Wolgamott, Senior Product Manager, Commercial Lighting, Northwest Energy Efficiency Alliance; Kelly Gordon, Advanced Lighting Program Manager, Pacific Northwest National Laboratory (PNNL); and Monica Hansen, Principal, LED Lighting Advisors.

Walker acknowledged the leadership and support of EERE in the development and launch of the L-Prize, thanking Kelly Speakes-Backman, Shara Mohtadi, Annamaria Garcia, Rob Sandoli, Ashley Armstrong, Dylan Jones, and Jay Nathwani, as well as BTO colleagues David Nemtzow, Lucy deButts, Mary Hubbard, Cedar Blazek, Erika Gupta, and Monica Neukomm for their essential support. He also acknowledged the hard work of the L-Prize team that developed the broad strokes and fine details of the prize: Gabe Arnold, Kelly Gordon, Kate Hickcox, and Sergey Gorbatyuk from PNNL; Debbie Brodt-Giles, Rebecca Bennett, and Emily Evans from National Renewable Energy Laboratory; and Karen Marchese, Amy Oriss, and Wendy Graves from Akoya.

Kelly Speakes-Backman, EERE acting assistant secretary, began the roundtable by reiterating President Biden's goal of a net-zero economy by 2050. Buildings are key to decarbonizing the U.S. economy; the nation's building stock currently accounts for over a third of our carbon emissions, 40% of our energy use, and 75% of the electricity that Americans consume. Driving advances in control technologies and connected lighting systems in commercial buildings where long operation hours, controllability, and network capabilities will offer the greatest opportunity for energy cost and carbon savings.

The L-Prize, Speakes-Backman said, is designed to spur groundbreaking innovation and transformative product design of LED lighting. It aims to manufacture these products in the United States and install right away to deliver benefits even before the competition ends. And, it includes incentives for innovation in diversity, equity, and inclusion in how these lighting systems are designed, produced, and installed.

Speakes-Backman stated that DOE has worked for years to research, develop, and deploy technologies to make buildings more efficient and emphasized more can be done. She expressed her eagerness to hear attendees' thoughts on how they and DOE can partner in new ways to achieve both groups' common goals.

The New L-Prize

Brian Walker presented a brief synopsis of the L-Prize and the genesis of the new competition. He began with the nature of the "problem." Despite LED lighting's significant progress in the last decade—resulting in strong energy savings—the progress has not been uniform. Some applications are approaching total adoption. Others—such as A-lamps, the target of the first L-Prize—are nearing 50%. Across all segments, the average adoption of LED lighting today is 30%. But adoption especially lags for connected lighting systems in commercial buildings, which will be so important for the integration of lighting with other building energy loads and with the grid. Thus, Walker stated, the time is right for another L-Prize.

Walker outlined the phases of the new L-Prize competition:

- The Concept Phase aims to spark, encourage, and provide feedback on new ideas. The phase will be open for nine months in the hopes of attracting broad participation from students, designers, researchers, and lighting innovators.
- The Prototype Phase seeks prototype products that go beyond the forms, materials, and functions commonly available in commercial lighting today. At the same time, the Pacific Northwest National Laboratory will issue a request for information in the online forum as a means for any interested competitor to find teaming opportunities in the final phases of the competition. This phase will be open for 12 months.
- The Manufacturing and Installation Phase rewards installation of real products that meet the L-Prize's rigorous technical requirements with incentives for U.S. assembly and manufactured content. This phase will be open for 20 months.

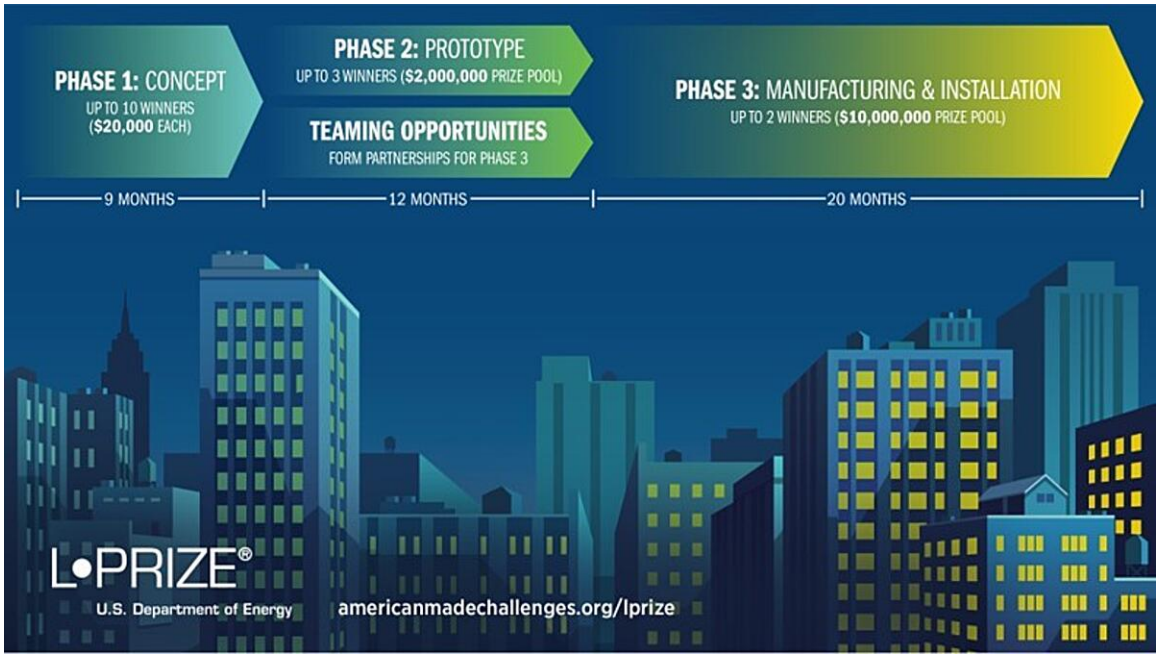
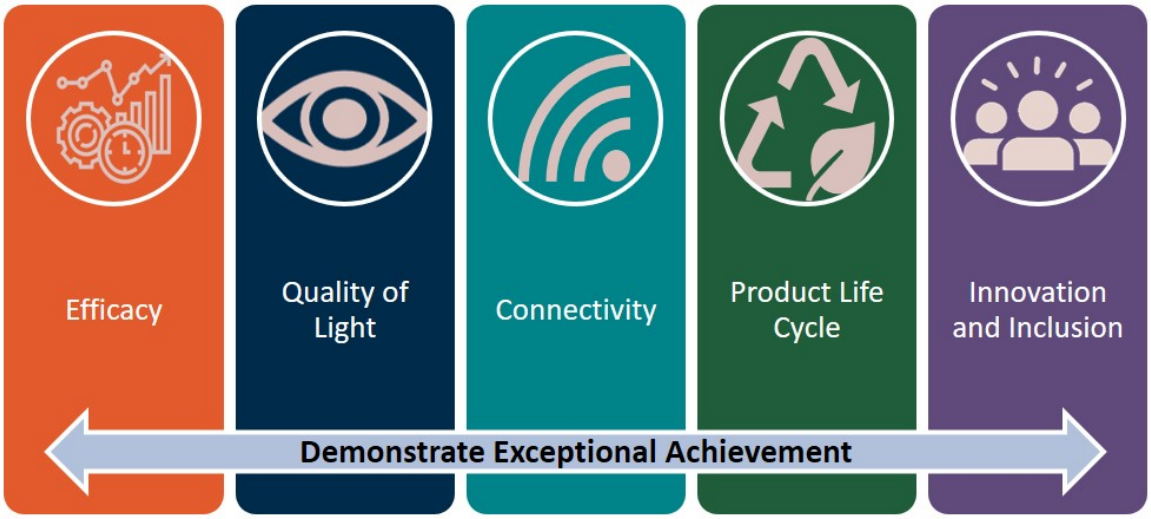


Figure 1: L-Prize phases, timeline, and prize information.

Walker highlighted the competition's five innovation focus areas, which align with DOE's goals and are underpinned by very specific technical requirements. Some are mandatory and, in some cases, competitors can earn points for exceeding minimums. He emphasized innovation and inclusion are a core part of the L-Prize, and DOE wants to make sure it is part of every stage of the competition. He concluded with a plug for a June 10 informational webinar and encouraged attendees to share the L-Prize website (www.herox.com/lprize) with their stakeholders and networks.



Participant Remarks

Karen Willis, Industry Director, Lighting Systems Division, National Electrical Manufacturers Association

Karen Willis attended the roundtable as a representative of both the National Electrical Manufacturers Association (NEMA) and the Next Generation Lighting Industry Alliance, a group of for-profit U.S. companies formed to accelerate U.S. solid-state lighting development and commercialization through government-industry partnership. She congratulated DOE on the launch of the L-Prize as part of the American-Made Challenges series.

Willis stated there is great opportunity for DOE to work with industry to define the role of lighting equipment and lighting systems in the larger ecosystem of efficiency as it evolves toward interactive lighting systems, high-performance buildings, and renewable and grid interaction initiatives. Future success will depend on collaboratively creating an evaluation framework that not only inspires the blue-sky thinking associated with the L-Prize, but also emphasizes achievable results in that area.

Addressing lighting's future workforce, Willis said manufacturers have immediate challenges on two fronts, beginning with the struggle to find qualified technical workers and facilities. High

school and college-age potential hires often associate lighting manufacturing as an old or lackluster industry. There is also a drastic labor shortage in the electrical trades. The second challenge involves the increasing complexity of today's lighting systems. Lighting system installers and facilities in general have an increasing need to understand system complexity instead of individual devices. New systems often require software for commissioning, maintenance, and troubleshooting and, again, qualified electricians and technicians for these systems are hard to find. The lighting workforce needs to recognize that every lighting application is different depending on occupant preference and space use. There is no one-size-fits-all product quality evaluation, and manufacturers are going to have to be flexible for more customized products. Lighting specifiers will need to be familiar with far more product capabilities, and lighting installers will need to be updated more frequently with the latest technologies.

NGLIA and NEMA, Willis added, are perfectly positioned to partner with DOE and share their diverse expertise. Manufacturers want to engage and want to be active stakeholders with DOE.

The L-Prize, she concluded, is a bold statement that is extremely important for the industry and is a destructive enabler for the industry to move forward.

Christina Halfpenny, Executive Director, DesignLights Consortium

Tina Halfpenny of the DesignLights Consortium (DLC) stated the future of lighting could be the gateway to the smart digital building. The smart building can improve building operations in the indoor environment and is also the key to energy and carbon reduction. However, she cautioned, there is an economic reality that puts this technology evolution at risk.

Today, Halfpenny said, cheap lamps and luminaires can already deliver energy savings. But integrated controls can do more: they can help mitigate problems like light pollution and help create better indoor environments. Halfpenny emphasized that connected, interoperable lighting should be the future, to enable load shedding and demand response in key areas (e.g., the lighting load can be substantial when aggregated across a geographic area such as an urban zone).

Based on DOE projections for installations, Halfpenny noted, indoor networked lighting controls could displace 5% of the generating capacity of the entire fleet of U.S. fossil fuel power plants because of its overlap with peak demand. Connected lighting can integrate with building systems, and with better sensing technology it has the potential to optimize energy loads with HVAC in energy management systems. Interoperability must become a priority.

A partnership with DOE, DLC, and others, Halfpenny added, starts with a collective action plan that identifies critical standards and timelines, so market-based collaborations can work together towards a shared vision. With over 1,800 manufacturer stakeholders and 75 energy efficiency administrators, the DLC can partner with regional energy efficiency organizations and others to create the specifications and tools to simplify program design. DLC's Qualified Products List

also can promote and incentivize smart lighting. Advanced sensors, software solutions, and user interfaces need innovation, and Halfpenny said she believed the L-Prize will be very helpful when it comes to those kinds of technology innovations.

In conclusion, Halfpenny said, if more connected lighting is not installed in the next five years, we could lose 10 years of energy savings and innovation gains. To increase visibility and impact of our joint efforts, we should talk not only about net zero but also about connected smart lighting. And, when we talk about peak demand and load management in grid-enabled buildings, we should also talk about smart connected lighting.

Bernadette Boudreaux, Associate Director of Operations, DesignLights Consortium

Bernadette Boudreaux of the DesignLights Consortium provided perspective wearing both her engineering hat and her citizen's hat. Boudreaux said she sees the future of lighting representing the diverse community that it will be designed to serve. This future includes a more diverse workforce and more education and information available and targeted to groups in areas that have previously been underrepresented or underexposed to the lighting industry, its opportunities, its benefits, and its impact on the community, health, and the environment.

Boudreaux said she believes that through engagement, underrepresented communities will become more trusting of solutions and actually implement solutions that involve more diversity, and we can ensure that smart building technologies address some of the environmental health concerns highly present in some of these communities. With standards, pilots, and prizes such as the L-Prize, DOE can recommend and dictate projects or targets. Implementation via mentoring and education at community-based centers, such as YMCAs or Boys and Girls Clubs, can address concerns and lead to acceptance of these emerging technologies.

DOE, DLC, and other groups, Boudreaux added, have varied stakeholders, and partnering to support individual diversity efforts will gain more traction and increase overall visibility and impact. She would like to see all groups engage more at the youth level, emerging professional level, and university level to establish strategic programs that ensure continued and measurable progress. Establishing and nurturing these relationships will lead to a more diverse workforce and more exposure in the community at a grassroots level.

As a group, she concluded, we need to promote the idea that lighting is an industry young people and emerging professionals should want to be a part of as they grow in developing their careers, with concerted effort focused on youth, diversity, and underrepresented communities.

Brian Liebel, Director of Standards and Research, Illuminating Engineering Society

Brian Liebel from the Illuminating Engineering Society (IES) echoed Boudreaux's statements, especially about youth engagement, stating that IES struggles to determine where the next generation of lighting engineers and practitioners will come from.

IES's mission, Liebel said, is to improve the quality of life through quality lighting. With advancements made over this last decade, we can do almost anything with the lighting that we have today (e.g., control it, make different color spectra, vary it throughout the day). However, he asked, how do we take that ability and create a better quality of lighting — beyond how it looks — that, in fact, improves the quality of life? For example, Liebel said, if we can improve a hospital condition that reduces the stay of patients or reduces medical error rates, that's an improvement to life that lighting can provide.

Liebel said today, industry looks at research to see how we can effectively use new technologies, many supported through DOE efforts, and take them to the next step. Part of that, he said, is recalibrating lighting metrics, knowing that today's metrics are well over a century old and have not been fundamentally changed to accommodate for the new knowledge and understanding that would lead to improved, quality lighting and more energy efficiency. IES, Liebel said, is focused on new metrics and how to evaluate lighting's benefits to make consumers understand its value and how it affects them.

Liebel's final comments addressed lighting education and breaking through the barriers of fear and unfamiliarity that consumers—and contractors—have with new products and systems. If we as a group, he advocated, can do a better job educating on the benefits these products have and how to use them, then we will create a more educated workforce that is less resistant to change. He added that the IES's relationship with DOE has always been strong, and he anticipates working together to develop more strategies and initiatives that work toward these key areas of metrics, economics, and impediments to adoption.

Mark Lien, Industry Relations Manager, Illuminating Engineering Society

Mark Lien of the Illuminating Engineering Society said there is still a lot of work to do to squeeze out more energy savings from lighting, and it is becoming more difficult as complexity increases. He stated the need for a brightness metric and the need for clarity on the health effects of light, which are inextricably linked to energy savings.

Lien reiterated that there is a lag in LED market penetration, citing a December 2019 DOE report that projected 35% in 2020 but is currently at 30%. Clearly, Lien said, the market needs to be incentivized and moved, and the L-Prize will do that. It will lay out the guide rails for the next phase of product characteristics and performance that can lead us to the integration we know we need.

Interconnected lighting, Lien said, is inevitable, and DOE can guide that transition to accelerate the process and improve the result, which will translate to greater energy savings and quality of the built environment. He added there is a lot of work to do yet on controls, specifically ease of use (apps are slower than switches) and voice activation.

In terms of partnering, Lien said there are over 100 organizations directly involved in the lighting community, and their cumulative outreach extends well beyond the walls of the lighting community. Many of these organizations cross trades and engage in social media and communication at a level outside of the ability of the lighting industry. In conclusion, Lien said, if you want to go fast, go alone; if you want to go far, go together. The L-Prize is the unified message we need to embrace and convey.

Chris Wolgamott, Senior Product Manager, Commercial Lighting, Northwest Energy Efficiency Alliance

Chris Wolgamott of the Northwest Energy Efficiency Alliance (NEEA) began by stating that quality lighting will be key to market transformation. Efficiency is still very important, he said, but there has never been a more efficient light source than LEDs, and we may reach a point where gains in efficiency lead to diminished quality, which will not make consumers want to use the products.

Wolgamott agreed with Brian Liebel that new metrics for LEDs may be needed; perhaps lumens are not the best measurement anymore. He emphasized that the industry should look at the entire lighting picture and not just efficiency, which has been the focus for so long (e.g., look at how lighting affects health and well-being, how people use lighting to work in a building, how they feel when they are in the lighted space). It's exciting, he said, that the L-Prize has more of these elements in it.

Another area for market transformation, Wolgamott added, is using lighting as the backbone for energy efficiency of the entire building system. He said that NEEA pushes hard for luminaire-level lighting controls, where sensors in every building, in every fixture, provide the data you need to make your building more efficient. If you can use your lighting as the backbone for the entire system, you will gain efficiency in other areas like HVAC, which will be more economical as well. He agreed with Tina Halfpenny that if we don't start installing connected systems in buildings now, it will be 10 or 15 years before the opportunity comes again. Changing lights in a building is expensive and not done often. It's not like an A-lamp, like the subject of the original L-Prize.

Finally, Wolgamott echoed the previous participants regarding workforce. At a basic level, he said, we need to overcome the stigma associated with working in the trades. While we should work with colleges and universities, young people should also know college is not the only path; trade skills are valuable and also offer the potential to make a very good living. The skilled electricians Wolgamott has observed in his own building, for example, have reminded him of the need to push for more people to enter the electrical trade and train them on these new and increasingly complex lighting systems.

Kelly Gordon, Advanced Lighting Program Manager, Pacific Northwest National Laboratory

Kelly Gordon of Pacific Northwest National Laboratory (PNNL) and her team of lighting experts have worked with DOE extensively over the last year to develop the technical framework and specifications for the new L-Prize. She said the team is honored to be a part of this competition again, 10 years after fulfilling the same role in the first L-Prize.

The new L-Prize, Gordon said, is a whole new ballgame. It synthesizes some key attributes of advanced LED-based lighting technology that the lighting research community and the industry have been working toward for two decades. The competition asks for a lot from lighting innovators: very high efficiency, beautiful appearance and light quality, advanced controls, data conductivity, grid interaction, sustainable design features, and realization of U.S. economic benefits from domestic manufacturing content and real installations. At the same time, the L-Prize rules give innovators some options and flexibility in competing to bring forward breakthrough lighting system innovations.

Gordon said as a DOE national laboratory, PNNL conducts science and technology research leading to national benefits. In the case of lighting research, the PNNL team focuses on both understanding and quantifying potential benefits and addressing problems that inhibit the full potential of energy efficient lighting technology. Most importantly, she said, they value communication with partners across the lighting industry along with standards organizations and other lighting researchers, sharing research and listening to others to better understand real-world challenges and opportunities.

PNNL's research has revealed some enticing benefits of LED-based lighting systems, Gordon said, from being able to tune the light spectrum to align with human visual preferences, to improved sleep quality for senior care residents and better control over the classroom environment for teachers, to the potential for lighting systems to respond to grid signals and report and regulate their own energy use. PNNL research also has revealed significant hiccups in the implementation of advanced lighting systems, with frustrating controls configuration, commissioning, and integration problems in field installations. It's time, Gordon said, to break through these barriers now.

Gordon concluded by repeating PNNL's belief that lighting technology can effect positive changes, benefiting people and improving the value of our built environment. The L-Prize, she said, stands ready to encourage and reward those innovators who are ready to take lighting systems to the next level of performance.

Monica Hansen, Principal, LED Lighting Advisors

Monica Hansen of LED Lighting Advisors said for lighting to save the most energy, it needs to be application specific and dynamic. Different buildings have different lighting needs for their

occupants, which can change during the day, the week, and so on. Customizable lighting solutions that provide needed light output, spectral content for health and productivity, and connected features are the best way to put the ideal light where and when you need it. Customized solutions are also best manufactured close to the end user, which, Hansen added, can help strengthen U.S. manufacturing.

Hansen said transformative R&D paths to create customizable, print-on-demand lighting can leapfrog beyond our existing approaches of improving LED lighting in legacy form factors. Such a model allows you to specify the needed performance features for your light and then design a lighting-integrated circuit or a lighting system on a chip to provide the desired performance, and then you can print it in a wafer fabrication (fab) plant.

Hansen listed several manufacturing R&D opportunities for the United States to support a print-on-demand lighting infrastructure. The first is factory automation for wafer fabs to print customized, integrated lighting solutions. Generally, she said, U.S. compound semiconductor fabs, like those for gallium nitride, have lacked the automated infrastructure of silicon wafer fabs, like those that Intel uses domestically. While this automation can be associated with a loss of jobs, in the LED industry these jobs are already in Asia. Improved fab automation is an opportunity to create high-tech jobs in the United States and enable new technology platforms currently not available with lighting.

Additive manufacturing, Hansen said, is another opportunity to support a print-on-demand manufacturing model with fewer, lighter-weight, new materials. This type of manufacturing can tie into luminaire assembly automation as well and would require creating new designs that are easier for this automated assembly process. The ability to print close to the customer can mean shorter product lead times and lower inventory levels, and reduce transportation and its environmental footprint to deliver products to the domestic market.

A final opportunity, Hansen said, lies in developing a sustainable materials supply chain for lighting, which includes developing and integrating sustainable materials to displace current processes with a goal of making every component of a lighting system recyclable, reusable, and free of harmful chemicals. Creating a sustainable domestic supply chain can help the United States become a global leader for a sustainable future.

Group Discussion

Assistant Secretary Speakes-Backman kicked off the group discussion with an observation: a predominant theme among the presenters was the trade-off between quality of life through lighting and lighting efficiency. She asked for the participants' perspectives on this trade-off and if a balance between the two is possible.

Brian Liebel said one does not have to be sacrificed for the other; in fact, he said, they should go hand in hand. We can define how to increase and facilitate this quality of life through the LED technologies and the very control technologies that provide the energy efficiency. This means, he said, going back to the basics of lighting and lighting metrics, and how we evaluate them for use. He reiterated that existing lighting metrics are over 100 years old and have not been amplified or augmented to any great extent despite how much we know now about physiological and visual responses to light. Studies in the last decade tell us that we can do so much more with this data, and by controlling the light, and the spectrum, and the time of the day, and the duration, we can do this very well.

Bernadette Boudreaux agreed with Liebel's comments. She added that she is encouraged by hearing more people use the terms "lumen" and "correlated color temperature," indicating they are more aware of what lighting does. She believes, however, we must continue to explain health and environmental aspects in more generic terms so consumers not only understand why they should ask for quality light fixtures that save them money and offer brighter light but also understand the trade-offs and benefits of these technologically advanced systems. People understand smart lights and changing colors of their lights, for example. Do they understand what it really does for them — how it impacts them, their systems, their businesses, their customers, etc.?

Liebel said the broader public is exposed to a lot of misinformation on lighting. There must be an effort to control the "bad" information and to say, "No, that isn't quite right," in response to the misinformation that is out there. Speakes-Backman asked for examples of bad information; Boudreaux cited UV (ultraviolet) lights. Many people understand UV lights kill germs but don't understand the negative impacts. Chris Wolgamott added that there are many types of UV lights, and manufacturers may sell something that doesn't do what you want, or what they say it will do. Liebel said many false claims by manufacturers go unchecked.

Wolgamott commented that from the utility perspective, a barrier he sees firsthand is with incentives. Utilities are beginning to see minimal savings through incentives and may not be able to help move the technology forward as in the past. He said it's important to have a more holistic look at the building or system. Fixtures and controls are still viewed separately, but an integrated fixture at the luminaire level is one system. You can't have the light without the controls, and you can't have the controls without the light.

Monica Hansen highlighted another aspect of the trade-off between efficiency and quality of light and life, noting that the different features of lighting that address human physiological

needs, color quality, and so on reduce the efficacy of the products. It is important to continue to push R&D to drive up efficiency. Some say, "LEDs are really efficient already—why are you still working on that?" But we need to boost the engineering headroom to allow these other features to be integrated while still being efficient. There is still more room to deliver energy savings, and sometimes that gets lost with how efficient LEDs are today. But, she said, the more you want to bring in quality-of-life-type features, the more headroom you need.

Tina Halfpenny said we should think about efficacy and how it can be better managed through control systems. If her soapbox had a label on it, she said, it would say "interoperability," because so much can be done once we start to integrate not only sensors, but other building technologies to make the light more dynamic for whatever the end users or the application calls for. Once the control system is in place, we start to balance the efficiency of the entire system. There is not only the efficacy of a system, she added, but also the efficiency of the system to be designed.

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