TO:	Tiffany Miller, Manager, Outdoor Lighting and Smart Cities Leslie Downey and Susan Rivera, Outdoor Lighting Program Coordinators
CC:	Local government elected officials, planners, and managers
FROM:	Virginia Responsible Streetlighting Coalition
RE:	Requested attention to LED streetlight conversions: best practices and standards to mitigate light pollution and support community well-being
DATE:	January 22, 2025

INTRODUCTION

The advent of solid-state Light Emitting Diode (LED) technology promised dramatic gains in energy efficiency for municipal and commercial outdoor lighting applications. However, a narrow focus on efficiency and efficacy, a "cookie cutter" approach to applications that ignores unique features of LED technology, and the false assumption that "brighter is better" have led to ever-increasing light pollution. More than 99 percent of the U.S. population now lives beneath light polluted skies and in Virginia even the most remote, rural areas have degraded night sky quality.

Sky glow, high artificial light levels at night, glare, and light trespass are forms of environmental pollution that degrade ecosystems and habitat and pose harm to human health, safety, and well-being. Virginians are increasingly concerned about the effects of light pollution on their communities and neighborhoods; many are experiencing light pollution most directly through LED streetlight conversions.

Nationwide, streetlight conversions over the past fifteen years have brought attention to the challenges and missed opportunities of LED conversion. The transition to LED lighting too often has failed to address the unique attributes of technology that produces light with electroluminescence through a semiconductor device rather than with incandescence through a filament, in the form of a diode array rather than a bulb.

Increased glare, light trespass, and excessive brightness have generated community backlash while decision makers have neglected LED's great advantage of adaptive control to reduce both greenhouse gas emissions and light pollution. As "lessons learned" accumulate, some localities have changed course. Yet most LED lighting continues to fall short of the technology's capabilities to revolutionize outdoor lighting in beneficial ways.

In Virginia, Dominion Energy is uniquely positioned to show leadership in smart lighting. Light pollution is neither smart nor sustainable. A comprehensive approach prioritizes visibility, protects visual function, minimizes harm to quality of life and the environment,

and reduces greenhouse gas emissions through efficiency, appropriate light levels, and timing. By informing its practices with up-to-date science and design, Dominion can correct the most problematic aspects of LED conversion. Responsiveness to customers, alignment with responsible outdoor lighting standards, and use of technological advances would serve both economic efficiency and community needs while fulfilling the commitments in Dominion's own Environmental Policy Statement.

This memorandum concludes with specific recommendations for changes to Dominion's luminaire supply and streetlighting practices.

BACKGROUND: light pollution and its consequences

Measurable global light pollution has increased since the advent of LED technology.

- The night sky is artificially bright for eighty percent of the world's population. While the average increase in light pollution was estimated at two percent annually in the early 21st century, recent research using ground-based visual estimates indicates a global average increase of about ten percent annually.
- LED lighting, which now accounts for nearly 50 percent of lighting sales, has likely contributed to the increase. White LED emits a larger proportion of its energy in short-wavelength ("blue") light than other technologies; as early as 2010, the scientific community recognized that blue-rich light sources increase detectable sky glow by fifteen to twenty percent because it scatters farther in the atmosphere.
- LED lighting is most likely also contributing to expanded and amplified sky glow through overall increases in the use and brightness of lighting as a reaction to its cheaper operating costs.

Artificial light at night is a form of pollution that degrades ecosystems, harms wildlife, and is increasingly linked to adverse human health outcomes.

- All life on earth evolved over billions of years according to consistent, cyclical patterns of light and dark with the night illuminated only by starlight and moonlight. Natural light levels and photoperiod (seasonal changes in daylength) are the primary cues for the biology, behavior, and life cycle functions of all species.
- Research has found harmful effects from artificial light at night at both the individual and population levels for birds, fishes, amphibians, reptiles, mammals, insects and other invertebrates, and plants. For example, light pollution is implicated in the annual mortality rate of migratory birds and research increasingly identifies light pollution as a contributor to the decline in insect populations, including pollinators.

- Scientific evidence establishes a connection between artificial light at night and harm to human health through the biological role that light and dark play in the regulation of the circadian 'master clock' that in turn governs body organs and systems. The secretion of melatonin (suppressed by light, triggered by dark) features strongly in the possible link between exposure to artificial night at light and certain cancers. Sensitivity is greatest to short wavelengths; therefore "blue light" is most disruptive. While research design is challenging and results must be cautiously interpreted, frequent exposure to excessive light at night also may be a contributing factor to obesity, diabetes, cardiovascular disease, endocrine disorders, dementias, and developmental disorders.

Efficiency alone does not fulfill promises of "sustainability." Wasted light is wasted energy.

- As lighting has become more efficient and less expensive, the world has consumed more of it. Using more and brighter lighting where and when it is not needed has eroded much of the potential for energy savings and emissions reductions.
- Unshielded fixtures, light directed horizontally and upward, unnecessarily intense illumination levels, and all-night lighting at full output when it does not serve a purpose all contribute to energy waste and climate change.

Public health and safety are better served by less light pollution.

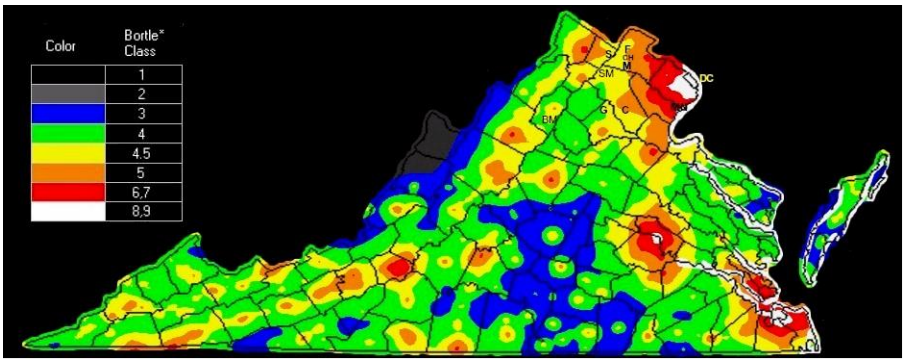
- Scientific evidence does not support the belief or practice that more lighting and brighter lighting universally increases safety and security.
- In a 1997 report to Congress, the National Institute of Justice noted that "We may speculate that lighting is effective in some places, ineffective in others, and counter-productive in still other circumstances. . . . offenders need lighting to detect potential targets and low-risk situations." In 2000, an increase in alley lighting in Chicago resulted in an increase in reported crimes in all categories. Reductions in streetlighting in the U.S. and the U.K. have not resulted in increases in crime and accidents.
- Poor lighting design that produces glare and reduces contrast degrades rather than enhances visibility and impairs vision. Short wavelength blue light produces more glare and negatively affects vision because it disproportionately constricts pupil size and hinders visual adaptation to changing light levels. The hazards of glare, particularly to older drivers, was a primary reason the American Medical Association began calling for action on light pollution in 2009.
- Clanton and Associates, a national leader in lighting research and design, had concluded by 2013 in a study with Virginia Tech Transportation Institute that lighting

level is “the worst predictor for visibility” and that “quality of light – good optical design” is essential to visibility.

- The organization Crime Prevention Through Environmental Design (CPTED) states that lighting systems should “minimize glare, shadow, light pollution, and light trespass.” The U.S. CPTED Association and DarkSky International have developed shared goals that prioritize “lighting for safety and sustainability; environmental and community impact; and aesthetic and functional harmony.”

Virginia suffers from polluted night skies even as its dark sky tourism sector seeks expansion and Virginians advocate for more responsible lighting and a reduction in light pollution. Generations of Virginians are growing up without experiencing a starry night sky.

The astronomical Bortle Scale ranks the most pristinely dark skies as a “1” and the most polluted as a “9”. Virginia’s darkest skies according to the most current data fall short of a “1” and most of the commonwealth ranks at or above a “4”.



https://www.novac.com/wp/observing/bortle-scale/

- Virginia is home to five Dark Sky Parks designated by DarkSky International since 2015; that status depends on community commitment to reversing light pollution. Others are in an exploratory or early development phase.
- The Virginia Department of Conservation and Recreation’s Virginia Outdoors Plan has since 2018 recognized night skies as a scenic resource to be conserved.
- Regional and local advocacy and organizing in Northern Virginia, the central Piedmont, Hampton Roads and Norfolk, the Shenandoah Valley and the Allegheny Highlands reflect Virginians’ frustration with growing light pollution, particularly from LED streetlight conversions, and its detrimental impacts on their communities and Virginia’s environment. This includes campaigns in northern Virginia and eastern Virginia to address light pollution’s impact on the bird migration Atlantic Flyway.

EXPLANATIONS: A better future for LED lighting

The lighting industry supports and defines responsible outdoor lighting standards.

- The Illuminating Engineering Society (IES) jointly published with DarkSky International the Five Principles of Responsible Outdoor Lighting in 2020. The principles specify that lighting should be: 1) used only if it has a justified purpose; 2) shielded and aimed to contain illumination to its target; 3) no brighter than necessary; 4) used only when needed, through adaptive controls; and 5) 'warm' in color correlated temperature (CCT) with minimal blue spectrum wavelengths.

The Virginia Department of Transportation's Traffic Engineering Division 2019 memorandum on roadway lighting provides practical guidance. This memo has not been updated and does not reflect further advances in lighting technology.

- VDOT's default position is "no lighting" with a focus on "nodes, not roads." All lighting should be both "warranted and justified" and comply with IES minimum recommendations.
- VDOT policy supports dimming when traffic and activity are below certain thresholds on roadways and at parking facilities.
- VDOT specifies luminaires with "zero uplight" ratings and approves of 2700K luminaires when requested by localities or in historic districts.

The Federal Highway Administration's 2023 Lighting Handbook is an invaluable resource Dominion can use to inform and guide their streetlighting policies and practices.

- This handbook's chapters cover vision and physiology; principles and lighting metrics; lighting considerations; warranting; lighting planning and design process; lighting system selection; environmental impacts and mitigation; and adaptive lighting.
- The FHWA warns against over-lighting: "The benefits of increasing the lighting level reach a plateau beyond which there are diminishing returns."
- The FHWA also cautions that LED lighting is incompatible with one-to-one-replacement: "Luminaires vary greatly in optical efficiency and light distribution from product to product" and assuming that "all products meeting specifications will produce equal results can reduce the overall effectiveness of the lighting system".
- Dominion's luminaire supply and streetlight conversion practices run counter to FHWA expertise and standards.

LED streetlight conversions are evolving to correct for costly mistakes and to keep pace with rapid ongoing technological innovation.

- As early as 2011, the Pittsburgh *Remaking Cities Institute* "LED Streetlight Project" highlighted glare as a problematic feature of LED lighting, specified the discontinuing of acorn luminaires, incorporated adaptive controls, and recommended color range down to 2700K.
- In 2014 the city of Davis, CA halted an LED streetlight conversion following negative public reaction to glare, excessive brightness, and light trespass from 2800 lumen/4,000K luminaires. After a review with improved public participation, the project resumed with 1800 lumen/2700K luminaires with house-side shields. The upfront additional cost of the modifications was $325,000, but the revised installation used 30 percent less energy than the original plan.
- In 2016 Cambridge, MA completed a streetlight conversion that reduced lumens and illumination levels and employs two stages of dimming, down to 35 percent capacity.
- In 2018 the city of Tucson's LED streetlight conversion reduced total lumens by over 60 percent and blue light emissions by over 30 percent while adaptive controls dim streetlighting to 60 percent capacity after midnight.
- Recent streetlighting projects in Virginia reflect a preference for 'warm' lighting below 3,000K and for dimming. An installation in Washington, VA is using 2200K luminaires. A large-scale streetscaping and traffic calming project on State Route 9 in Hillsboro (Loudoun County) selected 2700K, ultimately using 3000K only for reasons of project timeline constraints; that installation dims to 50 percent capacity after 10:00 p.m.
- The Town of Vienna in Fairfax County has hired Clanton and Associates, a national leader in smart lighting design, to develop its new outdoor lighting ordinance, prioritizing a community friendly approach to lighting and a commitment to mitigating light pollution. Clanton and Associates' groundbreaking research with the Virginia Tech Transportation Institute led to new understanding of lighting and visibility ("less light . . . better sight").

REVIEW AND RECOMMENDATIONS

- Dominion needs to substantively address environmental and human health and safety harms of light pollution from poorly designed lighting and shift to standards that address all design aspects of community friendly lighting including smart controls, spectral content, and appropriate lighting levels.

- Dominion's luminaire product list is outdated; it has not kept up with advances in technology and does not reflect lighting design industry best practices.

The following changes are necessary:

- Eliminate the use of term "dark sky friendly" in its product list unless a luminaire is certified by DarkSky International or Community Friendly Lighting Program (Smart Outdoor Lighting Alliance). Over 180 manufacturers participate in DarkSky's approval program with thousands of approved luminaires.
- Follow current Recommended Practices of the Illuminating Engineering Society as they are updated.
- Limit blue spectral content to the greatest extent possible across CCT range.
- Include 2200K, 2400K, and 2700K options in product list with minimal short wavelength blue emissions spectral power distribution (SPD below 530nm of no more than 25 percent).
- Include phosphor-converted amber LED options (explainer attached).
- Utilize only luminaires with uplight ratings of zero and glare ratings of zero or one.
- Make available backlight shields for all residential installations and clearly state availability on Dominion website and in communications with municipality and residents.
- Equip all luminaires with adaptive control capability.
- Discontinue acorn fixtures, which waste approximately 40 percent of their illumination, causing glare, uplight, and trespass.
- Precede streetlight conversions with a public engagement process organized by a lighting consultant that includes surveying a broad cross section of stakeholders through a guided tour of a range of design options with adaptive control to demonstrate varied lighting levels. Residential installations need to include options at least as low as 2700K.

Note: *Spectral emission and lighting density (lumens per acre) are recognized as important factors in the overall effect of lighting. Industry standards to incorporate these characteristics into specifications are in development. For example, Scotopic/Photopic (S/P) ratios, which relate to a measure of short wavelength spectral power distribution, will be a more meaningful measure than Kelvins. We expect to follow up on these technical developments as research and industry standards evolve.*

CONCLUSION

Streetlighting's contribution to light pollution varies by location. However, streetlights disproportionately affect individuals and residential areas; they are the most typical source of light trespass into homes and have the most direct effect on visibility and visual comfort and adaptation for motorists. Streetlighting decisions and installations are in the hands of public utilities and governments, both of which have obligations to community residents.

As the energy provider for most of Virginia's population, Dominion Energy has an unrivalled influence and can set an example for truly smart outdoor lighting. Dominion's own "Environmental Policy Statement" aims "*to do what is right for the communities we serve*" and to meet or go "*beyond environmental requirements*." This statement makes a commitment to "*fostering innovation*" and pledges to "*implement sound environmental practices to protect wildlife, conserve habitats, and advance biodiversity.*"

Mitigating light pollution, respecting community character and the inviolability of private homes, and protecting the visual comfort of pedestrians and drivers are how to "do right" and "protect and conserve." "Fostering innovation" demands lighting that lands on the cutting edge rather than lagging far behind it. Dominion has an opportunity to show highly visible environmental leadership for the benefit of Virginia's towns, suburbs, and cities.

# # #

The Virginia Responsible Streetlighting Coalition includes advocates from Northern Virginia, Richmond, Norfolk, the central Piedmont region including Charlottesville, and the central Shenandoah Valley and Allegheny Highlands. Our collective professional experience and expertise includes urban and environmental planning; public policy, management and administration; law practice; education; health/medical practice and policy; military defense; engineering and contracting; lighting design; defense economics and consulting; social work; natural resource management; and public relations. Member organizations are Citizens for Responsible Lighting, Dark Skies Piedmont, DarkSky Virginia, DarkSky NOVA, and BirdSafe Hampton Roads.

Attachments

- VDOT 2019 memorandum on roadway lighting
- Federal Highway Administration 2023 lighting handbook
- Amber Phosphor LED explainer
- Dominion's Environmental Policy Statement

References and resources

- *State of the Science 2024 Report* https://darksky.org/app/uploads/2024/06/ALAN-State-of-the-Science-2024-EN-1.pdf
- *Science* special issue dedicated to light pollution, June 16, 2023 https://www.science.org/toc/science/380/6650
- *Reducing nighttime light exposure in the urban environment to benefit human health and society* https://www.science.org/doi/10.1126/science.adg5277
- *FHWA Lighting Handbook 2023*, Federal Highway Administration https://highways.dot.gov/safety/other/fhwa-lighting-handbook-2023
- Clanton and Associates Lighting Design and Engineering https://www.clantonassociates.com/
    - Presentation for Town of Vienna: https://us02web.zoom.us/rec/play/05vYm19FCsTdD74uafDyuyKEq0aoGgXZyMpENReZXoxTleLbiK2FpOmyg0pCyM2-koH2Q-kCUdoE4jZ4.RY4XRQkpBx7KlS_0
- *Preventing Crime: What Works, What Doesn't, What's Promising* https://www.ncjrs.gov/works/
- *Chicago Alley Lighting Project final report* https://www.ojp.gov/ncjrs/virtual-library/abstracts/chicago-alley-lighting-project-final-evaluation-report#:~:text=The%20Illinois%20Criminal%20Justice%20Information%20Authority%20undertook%20an,were%20most%20likely%20to%20have%20occurred%20in%20alleys
- *A Unified Approach to Safer, Sustainable Communities*, U.S. Crime Prevention Through Environmental Design and DarkSky International https://uscpted.com/dark-sky-international-us-cpted-association/
- *Crime Prevention Through Environmental Design as a Design Tool* https://www.dcjs.virginia.gov/sites/dcjs.virginia.gov/files/training-events/7596/l-1401-cpted-examples.pdf
- *Artificial Night Lighting and Protected Lands: Ecological Effects and Management Approaches* National Park Service https://irma.nps.gov/DataStore/DownloadFile/582058
- *Multi-Sector Campaign for Migratory Birds*, U.S. Fish and Wildlife Service https://www.fws.gov/story/2024-03/multi-sector-summit-address-light-pollution-and-bird-collisions