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LED Lighting and Neurological Disability

Reconsidering Lighting Policy Through an Accessibility and Public Health Lens

Executive Summary

Federal energy-efficiency law has restructured the U.S. lighting market faster than public health research has kept pace with it. Since July 25, 2022, general-service lamps failing to reach 45 lumens per watt (a floor conventional incandescent bulbs generally cannot clear) have been prohibited from sale. A 2024 DOE rule raises that floor past 120 lm/W for lamps manufactured or imported after July 25, 2028, locking in an LED-dominant marketplace for the foreseeable future.

Energy efficiency is a legitimate policy goal. But lighting is also a neurological exposure, and for a substantial share of the population it is not a neutral one. Traumatic brain injury produces photophobia in roughly 30.5% of patients one week after injury, persisting in a meaningful subset for months (a 75-publication meta-analysis, Truong et al., *Optometry and Vision Science*, 2021), a population that includes an estimated 533,519 U.S. service members diagnosed with TBI since 2000. Migraine, estimated to affect 12–15% of American adults, involves documented light sensitivity through retinal and trigeminovascular pathways. Autism research finds lighting sensitivity across a majority of the higher-quality studies reviewed, with one study reporting 45.8% of respondents very or somewhat sensitive to light. Photosensitive epilepsy affects roughly 3% of people with epilepsy, with flicker in the 3–65 Hz range (peak sensitivity around 15–25 Hz) the most consistent trigger.

LED lighting complicates this further rather than settling it. Pacific Northwest National Laboratory's flicker research finds that LED systems, depending on the LED, driver, and dimmer, can produce temporal light modulation causing severe unwanted effects, while other LED systems produce none, with sensitive individuals more prone to eyestrain, headaches, and migraines. The claim here is not that LEDs are categorically harmful. It is that policy eliminated practical access to an alternative technology some sensitive individuals tolerate better, without ever accounting for that population.

DOE has already shown this kind of accommodation is administratively workable. Effective May 6, 2025, it announced enforcement discretion declining to enforce the 45 lm/W sales prohibition against lamps marketed exclusively for the health and care of reptiles, amphibians, and other small animals. *If federal lighting policy can flex for animal health, it should be able to flex for documented human neurological disability.*

This paper recommends preserving affordable incandescent access for disability-related needs, recognizing lighting modification as a disability accommodation in schools, workplaces, and public facilities, developing neurologically informed lighting standards, and studying sensitive populations directly. It is written at a high level so that narrower, agency-specific papers can be drafted from it, for example a companion paper on lighting accommodations under IEPs and Section 504 plans for the U.S. Department of Education.

I. How We Got Here: Energy Policy Changed the Lighting Marketplace

The shift from incandescent to LED lighting did not happen through consumer preference alone.

Congress established increasingly stringent lighting-efficiency requirements through the Energy Independence and Security Act of 2007 and subsequent DOE rulemaking. DOE codified the general-service lamp (GSL) efficacy floor in May 2022; the resulting sales prohibition (no GSL below 45 lumens per watt) took effect July 25, 2022. Conventional general-service incandescent bulbs generally cannot meet that floor.[1]

DOE's April 2024 final rule adopts a still higher standard (Trial Standard Level 6), requiring most common general-service lamps manufactured or imported on or after July 25, 2028 to exceed roughly 120 lumens per watt. DOE projects the rule will save consumers an estimated $27 billion in utility costs over 30 years and describes it as reinforcing the ongoing transition to LED technology.[1] That savings estimate is a legitimate policy achievement; it is also a measure of how completely the marketplace has been redirected toward a single technology.

The result is an American lighting marketplace in which conventional incandescent bulbs, once inexpensive and available in nearly every grocery, hardware, and general-merchandise store, are no longer a realistic general consumer option.

Yet federal law already recognizes that one lighting technology does not serve every application. DOE regulations exclude numerous incandescent lamp categories from the general-service definition altogether, including appliance lamps, infrared lamps, marine lamps, plant lights, sign-service lamps, showcase lamps, and traffic-signal lamps, among others.[7]

An even more significant example arrived in 2025, discussed in Section VI: DOE's decision to decline enforcement of the sales prohibition for lamps marketed exclusively for reptile, amphibian, and small-animal care. DOE has therefore already demonstrated that the federal lighting framework can accommodate specialized lighting needs. The question for policymakers

is whether comparable flexibility should exist when human neurological disability creates a comparable need.

II. Neurological Light Sensitivity Is Not One Condition

Neurological light sensitivity spans multiple populations, and it does not present identically in each one.

Traumatic Brain Injury and Post-Concussion Syndrome

Photophobia is a well-documented consequence of traumatic brain injury. A systematic review and meta-analysis of 75 publications found photophobia in approximately 30.5% of patients one week after TBI; prevalence declined over the following months but persisted in a meaningful subset later in recovery.[2]

This is not an abstract population. DoD data show 533,519 cumulative TBI diagnoses among U.S. service members from 2000 through the third quarter of 2025, the large majority classified as mild, the category most associated with persistent post-concussive photophobia.[14] For veterans and civilians alike with persistent post-concussive symptoms, light sensitivity can interfere with reading, screen use, concentration, driving, mobility, employment, and the ability to remain in brightly lit spaces at all.

Migraine

Light sensitivity is a defining feature of migraine, which affects an estimated 12–15% of American adults.[3] Migraine-related visual discomfort is more complex than simple brightness aversion: patients can experience discomfort from flicker, pattern, color, and specific wavelengths. Researchers have identified neurological pathways involving retinal signaling and the trigeminovascular system that help explain the relationship between light exposure and headache pain.[3][9]

This matters for lighting policy because two sources producing similar quantities of visible light do not necessarily produce identical neurological experiences.

Autism and Sensory Processing

Lighting is also a significant environmental factor for autistic individuals. A 2026 systematic review screened 11 original studies and narrowed that group to seven meeting quality criteria; five of those seven identified meaningful lighting sensitivity. One underlying study found 45.8% of respondents are very, or somewhat sensitive to light, and reviewers repeatedly flagged fluorescent lighting, flicker, glare, brightness, and window glare as triggers.[4]

The review's most important finding for policymakers may be its limitation, not its result: it found no study that precisely and objectively measured the lighting parameters involved, making it

impossible to say exactly which intensity, spectrum, or flicker characteristics trigger reactions.[4] LED technology has been deployed extensively in classrooms, homes, offices, and public buildings even though research has not yet established lighting specifications tolerable for every autistic or sensory-sensitive individual. Policy should preserve the ability to individualize the environment rather than assume a lighting system suitable for most occupants will be suitable for everyone.

Epilepsy and Photosensitivity

The relationship between flickering light and photosensitive epilepsy has long been recognized; roughly 3% of people with epilepsy are photosensitive.[15] A 2026 focused review of temporal light modulation and seizure risk found the strongest evidence for visible flicker in the approximately 3–65 Hz range, with the greatest sensitivity around 15–25 Hz. The authors caution that this established relationship does not prove that typical high-frequency, imperceptible modulation from LED lighting causes seizures; direct evidence connecting ordinary LED modulation to seizure incidence remains limited.[5]

That distinction matters for credible policy. The conclusion is not that LEDs generally cause seizures. It is that lighting standards affecting a neurologically susceptible population should account for temporal light modulation, waveform, modulation depth, and individual susceptibility rather than assume that all sources producing equivalent illumination are neurologically equivalent.

III. Why LED Lighting Can Be Different

"LED lighting" is not one uniform exposure.

LED products vary in spectral distribution, color temperature, brightness, glare, driver electronics, dimming behavior, waveform, and temporal light modulation (TLM): rapid fluctuation in light output that is often invisible to conscious perception but not necessarily to the nervous system.

Pacific Northwest National Laboratory, conducting lighting research supported by DOE's Solid-State Lighting program, has extensively studied TLM. Its research states plainly that "LED systems, including the LED, driver, and control, can result in TLM that causes severe unwanted effects, while others may exhibit TLM producing no unwanted effects at all."[6] Driver design and the interaction between drivers and dimmers substantially affect the outcome; pulse-width modulation, a common LED dimming technique, can increase unwanted responses "especially among more sensitive individuals, who are more likely to experience eyestrain, headaches, or migraines in their daily activities."[6]

That is the paper's central point, and the one most easily misread. The claim is not that LEDs are inherently worse than incandescent lighting. It is that the two technologies produce light through fundamentally different physical processes, a heated filament versus a semiconductor

device and electronic driver, and that difference in mechanism produces a difference in variability. Conventional incandescent lighting can also exhibit modulation, but its physical and electrical characteristics differ from an LED driver's, and it does not carry the same driver-dependent range of outcomes.[10]

Consequently, the policy question should not become a contest over whether incandescent or LED lighting is universally "healthy." There is no universal neurological response to either technology. The appropriate question is narrower: whether public policy should eliminate practical access to a lighting technology that remains, for some individuals with neurological disabilities, significantly more tolerable, and whether LED specification and procurement standards should begin accounting for TLM the way they already account for lumens per watt.

IV. There Is Increasingly No Place to Avoid the Exposure

The scale of the lighting transition makes neurological sensitivity difficult to accommodate. An individual may retain meaningful control over lighting inside a private home. That control narrows sharply the moment they leave it.

Homes

The home should be the environment in which an individual has the greatest ability to control lighting. Federal efficiency requirements have nonetheless sharply reduced ordinary access to conventional incandescent bulbs. For a neurologically sensitive person who tolerates incandescent lighting better than available LEDs, the barrier becomes availability and price: a product once sold inexpensively in nearly every general-merchandise store has become a specialty purchase, and a disability accommodation is of limited practical value if the technology required to create it is unavailable or prohibitively expensive.

Schools

Children have almost no control over institutional lighting. Students spend six or more hours a day under fixtures selected for an entire building or classroom, and for students with TBI, concussion, migraine, autism, epilepsy, visual impairment, or other neurological conditions, that lighting can directly affect concentration, reading endurance, headache frequency, sensory regulation, fatigue, or the ability to remain in the room. Federal disability law already requires public schools to consider reasonable modifications necessary to provide students with disabilities meaningful access to school programs and activities under Section 504 and the IDEA.[11] Lighting should be explicitly recognized as part of that conversation, alongside seating, testing accommodations, and assistive technology; individualized accommodations may include disabling or replacing particular overhead fixtures, alternative task lighting, filters, seating changes, access to daylight, changes in brightness or color temperature, or another lighting technology where medically appropriate.

This issue is especially timely in Washington. The state's Health and Safety Guide for K-12 Schools directs facilities running interior metal halide or mercury vapor lighting to plan replacement with LED lighting, citing available utility rebates and energy, maintenance, and light-quality gains.[12] Those considerations are legitimate; neurological accessibility should be weighed alongside them as replacement plans are drawn up, not retrofitted afterward as a complaint response.

This section is deliberately high level. A fuller companion paper addressed to the Washington Office of Superintendent of Public Instruction and the U.S. Department of Education, covering IEP and Section 504 lighting accommodations specifically, is a natural next output of this project.

Workplaces

The same issue follows adults into employment. A worker with migraine, TBI, visual impairment, or another neurological condition may be fully able to perform a job's essential functions and still struggle to remain productive under a particular lighting system for eight hours. Reasonable accommodations are often simple and inexpensive: alternative task lighting, disabling a fixture over one workstation, adjusting intensity, using filters, relocating a workstation, increasing daylight access, or providing a different lamp technology. Lighting accessibility should not require redesigning an entire building when an individualized solution is sufficient.

Healthcare and Public Buildings

Hospitals, clinics, government offices, stores, libraries, airports, and other public environments present a distinct problem: the person entering usually has no ability to modify the lighting at all. For most people this is unremarkable. For someone with severe neurological light sensitivity, the environment itself can determine how long they can remain in the building, whether symptoms escalate, and whether they can meaningfully access the service being provided. Accessibility policy traditionally asks whether people can physically enter and use a facility. Neurological accessibility should also ask whether the sensory environment unnecessarily prevents some people from using it once they are inside.

V. Streets and Vehicle Headlights

The lighting environment does not end at the building entrance.

LED technology is increasingly present in roadway lighting and vehicle headlights, where the exposed individual has essentially no control over the source. Headlight glare is already a recognized general-population problem, not only a disability issue: a March 2026 AAA survey of 1,092 U.S. drivers found six in ten report struggling with glare after dark, 73% of those affected say the problem has worsened over the past decade, and 92% point to oncoming headlights specifically.[16] That the general driving population is already reporting a worsening problem should heighten, not diminish, concern for neurologically sensitive drivers layered on top of it.

NHTSA research distinguishes disability glare, which reduces visual performance because of scattered light in the eye, from discomfort glare, which causes discomfort from the glare source itself without necessarily impairing vision.[13] Headlight glare is influenced by intensity, optical design, spectral distribution, source size, mounting height, alignment, and other factors; it should not be attributed to LED technology alone.

Nevertheless, neurologically light-sensitive drivers represent an important population for future research. Standards designed primarily around whether the driver using the headlights can adequately see the roadway should also consider the person receiving that light from the opposite direction, particularly where migraine, TBI, or photosensitivity is involved.

The same principle applies to streetlights. Brightness, spectral characteristics, shielding, placement, temporal modulation, and intrusion into homes may matter differently to neurologically sensitive residents than to the general population. Public lighting standards should weigh neurological accessibility alongside energy efficiency, visibility, traffic safety, maintenance, and cost.

VI. The Incandescent Paradox

Federal lighting policy presents an unusual contradiction.

Conventional incandescent lighting is no longer broadly available as an ordinary consumer product because it cannot satisfy federal general-service efficiency requirements. Yet federal regulations preserve incandescent technology for numerous specialized applications.[7]

And in May 2025, DOE went further. The 45 lm/W general-service lamp sales prohibition applies broadly across the marketplace. But effective May 6, 2025, DOE announced it would exercise enforcement discretion and decline to enforce that prohibition against otherwise noncompliant lamps marketed and sold exclusively for the health and care of reptiles, amphibians, and other small animals, a policy DOE issued in response to the January 2025 executive order "Unleashing American Energy."[8]

This does not constitute a statutory medical exemption for humans, and it should not be characterized as one. It is an exercise of DOE's enforcement discretion, applied to animal husbandry, not human health. But it establishes an important policy precedent: the federal government has already recognized that strict, uniform application of a general lighting-efficiency requirement may not appropriately serve every specialized lighting need, with reptile and amphibian care being one such need DOE was willing to formally carve out.

That raises an obvious question. If federal lighting policy can preserve access to otherwise noncompliant lighting for a specialized animal-health application, should it also preserve affordable access for humans with documented neurological disabilities who require a different lighting environment? The administrative mechanism DOE used for reptile and amphibian lighting, enforcement discretion tied to exclusive marketing for a defined care purpose, is a workable template, not a novel invention, for a parallel human accommodation pathway.

The proposal here is not to eliminate LED lighting or reverse the efficiency gains achieved over the past two decades. It is to restore meaningful choice, using a mechanism the agency has already shown it is willing to use.

VII. Policy Recommendations

Federal and state policymakers should reconsider lighting policy through the added lens of neurological accessibility while retaining appropriate energy-efficiency objectives.

1. **Restore affordable access to incandescent lighting for disability-related needs.** Congress and DOE should examine a medical or disability-related pathway permitting conventional incandescent lamps to be manufactured, distributed, and sold when needed to accommodate neurological or visual disability, modeled on the enforcement-discretion mechanism DOE already used for reptile and amphibian care.
2. **Examine whether broader consumer choice should be preserved.** A medical exemption alone could turn an inexpensive household product into a specialized medical commodity. Policymakers should consider whether a limited category of conventional incandescent lighting should remain available to ordinary consumers generally.
3. **Recognize lighting modification as a disability accommodation.** Schools, government agencies, public facilities, and workplaces should expressly recognize individualized lighting modifications as potential disability accommodations under the ADA, Section 504, and the IDEA when supported by an individual's documented needs.
4. **Develop neurologically informed lighting standards.** Future standards should weigh temporal light modulation, modulation depth, waveform, glare, spectral characteristics, and brightness alongside energy efficiency, and should apply to LED procurement and specification, not only to lumens-per-watt thresholds.
5. **Study sensitive populations directly.** Lighting research used to inform public standards should include people with TBI and post-concussion syndrome, migraine, autism, photosensitive epilepsy, visual impairment, and related neurological conditions, populations current research shows are understudied at the level of precise lighting specification.
6. **Review transportation and public-infrastructure lighting.** NHTSA and relevant federal and state transportation agencies should examine headlights, streetlights, and roadway lighting specifically in neurologically and visually sensitive populations, building on existing general-population glare research.
7. **Protect affordability.** Accessibility should not depend on a person's ability to purchase expensive specialty products. If an inexpensive lighting technology provides a workable accommodation, public policy should not unnecessarily make that accommodation scarce or costly.
8. **Make future lighting policy technology-neutral where possible.** Energy-conservation goals should establish legitimate performance objectives without unnecessarily eliminating technologies that serve distinct medical, disability, safety, or accessibility needs.

Conclusion

America transformed its lighting environment primarily in pursuit of energy efficiency, cost savings, product longevity, and environmental benefit. Those objectives remain legitimate.

But lighting is also part of the human environment. For people with traumatic brain injury, post-concussion syndrome, migraine, autism, photosensitive epilepsy, visual impairment, and other neurological conditions, characteristics of artificial lighting can affect the ability to read, concentrate, learn, work, drive, enter public buildings, and participate in ordinary life, a population that, taken together across these conditions, runs into tens of millions of Americans.

The scientific evidence does not establish that every LED is harmful. It does establish neurological light sensitivity across multiple populations, and it demonstrates that flicker, glare, intensity, spectrum, and individual susceptibility all matter to outcomes. That should be enough to revisit a policy framework that has made one lighting technology overwhelmingly dominant while making a fundamentally different alternative increasingly inaccessible.

The issue is not whether the United States should abandon energy efficiency. The issue is whether achieving it requires eliminating meaningful lighting choice for people with neurological disabilities. Federal policy already accommodates specialized incandescent applications and has exercised enforcement discretion where specialized lighting was judged necessary for animal health and care. Human neurological accessibility deserves the same consideration.

A modern lighting policy should be able to accomplish both objectives at once: conserving energy for the population as a whole while preserving reasonable, affordable alternatives for the people whose neurological conditions require something different.

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