New ecodesign requirements for lighting products: A consultation on proposed amendments to the minimum energy performance standards for lighting products from late 2023

LightAware Response to the consultation

Submitted by the charity LightAware

31 March 2023

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About LightAware

1. This response to New ecodesign requirements for lighting products: A consultation on proposed amendments to the minimum energy performance standards for lighting products from late 2023. has been prepared by LightAware, a registered charity, SC046160 (www.lightaware.org).

2. LightAware was founded in 2015 to respond to the needs of those whose lives and health have been profoundly affected by the ban on incandescent lighting and the introduction of LED technology. LightAware's charitable objectives are:
    - To raise awareness about the effects of artificial lighting on human health and wellbeing.
    - To stimulate discussion and investigation into the effects of artificial lighting on human health and wellbeing.
    - To promote equality and diversity through encouraging provision of access to civic life for those excluded by sensitivity to artificial lighting.

3. LightAware has recently published 'The story so far' which sets out what we do and the history of the charity, a copy of this document is attached with our response.[1]

About light-sensitivity and light-disability

4. Individuals across the UK (and beyond) have contacted LightAware to complain that modern lighting technologies are causing them ill health and leading to their social isolation. Some individuals have been forced to move home and others have lost their jobs. Almost all their complaints now relate to LED lighting.

5. Many health conditions have some form of sensitivity to light as a recognised medical symptom. These conditions include lupus, autism, migraine, ME and a range of other skin and neurological conditions. People with light sensitivity as a symptom can react to a range of different types of light. Some react to sunlight, some to UV, and some to specific types of artificial light, such as LEDs and some to a mix of these.

6. In addition there is another group of people who have had no previous health issues who start to have health problems when they are exposed to new forms of lighting. Symptoms include eye pain, agonising headaches, skin burning and rashes, dizziness, fainting and vomiting.

7. For both groups, reactions can be extremely severe and debilitating,

8. The EU and subsequently the UK Government in the Eco-Design Regulations (SI 1095/2021) have recognised sensitivity to LEDs as a reason for continued access to non-LED lighting for domestic use.

[1] https://lightaware.org/wp-content/uploads/2023/03/Light-Aware_the_story_so_far.pdf

9. For some sufferers, the severity of their physical reactions to LED lighting means they have to avoid even minimal exposure and the adverse impact on their day-to-day life is extreme and long-lasting, thus reaching the threshold to count as a disability under the Equality Act.

10. They become unable to access much of normal life, including places of employment, recreation, worship, education and healthcare. In some cases, they can no longer access the streets around their home due to the installation of new street lighting or external LED lighting or ad-boards. Some light-disabled people are, in effect, in permanent lockdown. This may result in devastating social exclusion with profound consequences for their mental and physical health. We have included a selection of light-sensitive individuals' experience of the effects on their health of LED lighting at **Appendix 1**.

About our response

11. Because the nature and focus of our charity is about the health impacts of lighting, we do not intend to respond to questions exclusively aimed at lighting manufacturers and importers.

12. We are particularly keen to ensure that we can set up a system that allows light sensitive people to get the light bulbs they need while assuring the department that the system does not lead to ‘leakage’ of bulbs into general circulation. We do not want a lifeline for light sensitive individuals to be seen as a potential ‘loophole’. If requested, LightAware would be pleased to arrange further meetings with the Department to discuss how the exemption could work best.

LightAware response to the questions in the consultation

Question 1 - Are there any additional policy impacts (benefits or costs) which have not been captured by our impact assessment? Please provide evidence to support your answer

The impact assessment takes no account of the elasticity of the demand for lighting, which may frustrate efforts to reduce carbon emissions

13. The initial statement of the impact assessment is, 'The current minimum energy performance standards (MEPS) for lighting products are below what is reasonably achievable, resulting in untapped potential carbon, energy and energy-bill savings'. This statement may be reasonable when applied to appliances such as refrigerators, toasters and vacuum cleaners, but light is different in nature to these products. In particular:
    - **Demand for lighting is elastic and price sensitive.** people will not purchase more than one vacuum cleaner or kettle or use them more often if they are cheaper to run and there is a natural limit to the amount of hot water one family can consume or vacuuming needed to keep a home clean. But many households and businesses can and do buy and use additional lighting as its unit price falls.
    - **Health impacts** - other appliances subject to minimum energy performance standards do not have the significant health and environmental impacts that lighting has.

14. In particular, the impact assessment does not take into account the effects of the reduction in the cost of lighting on its level of use, or even discuss this issue. Evidence set out below shows that the increase in lighting efficiency is leading to an increase of lighting use. In economics, this well-known effect is known as the Jevons Paradox, in summary, this states that, in the long term, an increase in efficiency in resource use will generate an increase in resource consumption rather than a decrease.

15. For LED lighting, this means that reductions in electricity use due to the replacement of incandescent and halogen bulbs by LEDs may be outweighed by the increased use of LED products in new situations unless additional measures are taken. It is an example of the rebound effect, where efficiency gains from new technologies may lead to increased resource use in the long-term.

16. Regrettably, this is already proving to be the case for LED lighting, despite the current energy price crisis. Recent examples include the planned MSG arena planned near the Olympic site in Stratford, which is reported to have an outside screen powered of 36 million LEDs. There are also plans to install 1,000 London bus shelters with 84-inch digital LED screens. The Adfree cities network calculated that a double-sided shelter screen uses as much electricity as four average homes. In many cities giant LED screens are replacing old fashioned billboards. Even home refurbishments commonly install several LEDs in a room to create task and area lighting where previously one central incandescent bulb was seen as adequate. Without additional controls, an increase in energy consumption is inevitable, frustrating the aims of the MEPS process.

17. That this is the case is evidenced by a ground-breaking study of global light pollution and the rise of LED outdoor lighting technology published in Science Advances. The researchers found both light pollution and lighting energy consumption are increasing over much of the globe, challenging widely-held assumptions that improvements in the energy efficiency of outdoor lighting have led to a decrease in energy consumption. [2]

18. More recent publications in *Remote Sensing* reveal an acceleration of light pollution, suggesting that the true increase in radiance in the visible spectrum may be globally as high as 270% and 400% in specific regions. [3]

19. Without stricter planning laws to control unnecessary and intrusive lighting and light pollution, carbon emissions may well increase as a result of MEPS for lighting. Effective legislation to reduce unnecessary lighting use and light pollution has been introduced in France, which could also be effective in reducing carbon emissions if adopted in the UK (**Appendix 2**).

The impact assessment 'Health and Well-being Impacts' significantly understates the health impacts of LEDs

20. The Impact assessment 'Health and Well-being Impacts' mainly covers the impact of Temporal Light Modulation (TLM) from lighting products. Although these impacts are important it does not properly consider the impacts of:
    - CCT (or more accurately, spectral content distribution)
    - Luminance (excessive brightness and glare)
    - Non-uniform light distribution.

[2] Artificially lit surface of Earth at night increasing in radiance and extent; Science Advances, 22 Nov 2017, Vol 3, Issue 11 https://www.science.org/doi/10.1126/sciadv.1701528.

[3] First Estimation of Global Trends in Nocturnal Power Emissions Reveals Acceleration of Light Pollution, Remote Sens. 2021, 13(16), 3311; https://doi.org/10.3390/rs13163311.

Reviews of the impact of LED lighting on health

American medical association

21. One of the earliest publications that highlight the impact of LED lighting on human health was published in 2016 by the American Medical Association (AMA) Council on Science and Public Health. This considered the impacts to human health and the environment caused by LEDs that emit excessive amounts of blue light. Their report "Human and Environmental Effects of Light Emitting Diode Community Lighting provides rigorous scientific evidence on the threats associated with exposure to blue-rich white light sources.[4]

22. The report details findings from an increasing body of scientific evidence that implicates exposure to blue-rich white light at night in increased risks for cancer, diabetes and cardiovascular disease. It reported that blue-rich white LED street lighting is five times more disruptive to our sleep cycle than conventional street lighting and that large surveys showed that brighter residential night-time lighting is associated with reduced sleep, impaired daytime functioning and a greater incidence of obesity.

23. The AMA report encouraged attention to optimal design and engineering features when converting from existing lighting technologies to LED. These include requiring properly shielded outdoor lighting, considering adaptive controls that can dim or extinguish light at night, and limiting the CCT of outdoor lighting to 3000 Kelvin (K) or lower.

The SCHEER report

24. The EU Scientific Committee on Health, Environmental and Emerging Risks (SCHEER) published its opinion on Potential risks to human health of Light Emitting Diodes (LEDs) in June 2018. The report concluded that:

    - "There is no evidence of direct adverse health effects from LEDs in normal use by the general population" – but this conclusion specifically excluded children, older people and light sensitive individuals from the 'general population'.
    - Some people report that they are sensitive to flicker from LEDs.
    - Children have a higher sensitivity to blue light and although emissions may not be harmful, blue LEDs (between 400 nm and 500 nm) may be very dazzling and may induce photochemical retinopathy, which is a concern especially for children below three years of age.
    - Older people may experience discomfort with exposure to light that is rich in blue light.
    - Either discomfort glare or disability glare can be temporarily caused by vehicle LED lights, and particularly daylight running lights and headlights.

[4] American Medical Association. 2016. Human and environmental effects of light emitting diode (LED) community lighting. Report of the Council on Science and Public Health. Chicago (IL): American Medical Association.

- Light sources that emit more short-wavelength light, as do some types of LEDs, will have a larger effect on the circadian rhythms at equal optical radiance, duration, and timing of exposure. [5]

The ANSES report

25. A third major health study produced by the French Government's institute for health is the ANSES report (2019). It concluded that "The new data confirm the 2010 result regarding the toxicity of blue light to the eye, which can lead to failing eyesight. They show short-term phototoxic effects associated with acute exposure and long-term effects associated with chronic exposure, which increase the risk of developing age-related macular degeneration (ARMD)". In addition, the expert appraisal showed that even very low levels of exposure to blue light in the evening or at night disrupt biological rhythms and therefore sleep. [6]

26. Although the report warns about the risks of blue light from mobile phones and tablets as a key risk for children, they conclude that even very low levels of exposure to blue light in the evening or at night disrupt biological rhythms.

Why LED lighting is different from other types of lighting

27. LED lighting is very different from earlier lighting sources in that it is produced using semiconductors. Because it is such a new technology, there has been no long-term research into LED safety and its health and environmental impacts. In particular the light propagation and distribution characteristics of LED lighting means it cannot be regarded as a like for like replacement of other lighting technologies (Box 1). There are four known issues with current LED lighting, and there may be others as even high-quality LEDs cause problems for some people. These are:

    A) Luminance (excessive brightness and glare)

    B) Flicker

    C) CCT (or more accurately, spectral content distribution)

    D) Non-uniform light distribution.

    These issues are discussed individually after box 1.

[5] Scientific Committee on Health, Environmental and Emerging Risks (SCHEER), Opinion on potential risks to human health of Light Emitting Diodes (LEDs), European Union, 2018.

[6] Opinion of the French Agency for Food, Environmental and Occupational Health & Safety on the "effects on human health and the environment (fauna and flora) of systems using light-emitting diodes (LEDs) April 2019.

BOX 1

LED lighting is a semiconductor light source

LED lighting is very different from the lighting sources it replaces

A light-emitting diode (LED) is a semiconductor light source that emits light when current flows through it. Each LED emits light of only one particular colour, usually blue. To produce white light, a powerful blue LED is shone on to compounds called phosphors that absorb blue light and emit yellow light. This yellow light combines with the blue light and appears white to the eye. Most white-light sources emit a range of wavelengths, which, when combined, produce the colour of light perceived by the human eye. The resulting shade of white depends on the blend of phosphors and is measured on the colour-temperature scale. Colour temperature is conventionally expressed in Kelvins, using the symbol K, a unit of measure for absolute temperature. It is measured on a numbered scale, where the higher the number, the 'cooler,' or bluer the light, the lower the number, the 'warmer,' or yellower the light. Examples of the colour temperatures of different forms of lighting include:

- 1700K – Low pressure sodium lamps
- 2400K – Standard incandescent lamps
- 2550K – Soft white incandescent lamps
- 2700K – Tungsten, Halogen and quality domestic LED
- 3000K – Warm white LED street lights
- 4000K – Neutral white LED street lights (the most commonly used type)
- 5000K – Cool white LED street lights, Tubular fluorescent lamps

Early "white" LEDs were very blue and harsh on the eye. Adding more phosphors to a 'white' LED makes its light look warmer and less harsh, but at the expense of reduced efficiency, as energy is lost in converting high-energy blue photons to lower-energy photons. This means that 'warmer' LEDs are slightly more expensive to run and achieve marginally lower electricity savings.

Unlike other forms of lighting, LEDs are highly directional with light emitted in an arc of around 60 degrees, rather than 360 degrees common in other lighting. LED light is usually emitted from a small, flat, surface using focusing optics that concentrate light. Because of this the vast majority of LED luminaire designs suffer from acute drawbacks as they attempt to illuminate wide areas, some distance away from a small, flat light source.

Also, LED light is not distributed evenly across its beam but concentrated on its axis. This causes glare, for example, car headlights can be blinding to pedestrians and oncoming traffic when cars approach over the brow of a hill and shine directly in people's eyes. A recent RAC survey found that "the headlights of some newer cars are so bright they are causing a road safety hazard for drivers with as many as two-thirds (65 per cent) of motorists saying they regularly get dazzled by oncoming headlights even though they are dipped".[7] There are similar issues with LED lighting where areas directly under the light are brightly illuminated, but with poor illumination between lights (the zebra effect). White LEDs also affect circadian rhythms and cause sleep disturbance when they shine into people's homes.

[7] https://www.mynewsdesk.com/uk/rac/pressreleases/motorists-claim-to-being-regularly-left-dazzled-by-modern-vehicle-headlights-2458363.

A) High luminance can cause problems with glare

29. The human eye can adapt to a wide range of light levels from bright sunlight to almost total darkness. However, comfortable vision requires a limited range of light levels at any particular time and excessive light levels and luminance contrasts can lead to glare. Many light sources have their high-luminance LED chips visible, which can be a source of glare for dark adapted eyes. Glare can be experienced as disability glare or discomfort glare:
    - **Disability glare** affects the ability to see and leads to some degree of temporary loss of vision and is produced by high luminance in a lower luminance scene, for example at night when a car with LED headlights comes over the brow of a hill or goes over a speed bump. [8]
    - **Discomfort glare** causes irritation, anxiety, visual fatigue, and eyestrain and can adversely affect wellbeing [9] Depending on an individual's sensitivity it can also cause dry or watery eyes, itchiness, tense muscles, breakdown of vision, blurred or double vision, headaches and fatigue.

30. A French government report published in 2013 indicated that a luminance level higher than 10,000 cd/m2 causes visual discomfort whatever the position of the lighting unit in the field of vision. As the emission surfaces of LEDs are highly concentrated point sources, the luminance of each individual source can be 1000 times higher than the discomfort level. The level of direct radiation from this type of source can therefore easily exceed the level of visual discomfort. [10] [11]

B) LED flicker can cause migraines and also presents a safety hazard

31. Circuitry within the LEDs converts mains alternating current to the low voltage direct current required by the LED. Unfortunately, some circuitry is inadequate in reducing the variation in the power supply and this generates flicker. LEDs vary in their degree of flicker; some do not flicker at all while others flicker very badly. There is no reason LEDs can't be flicker free, except cost. The Swedish Government has calculated that the cost of eliminating flicker is equivalent to around 10 pence per LED unit. [12]

32. Flicker is mainly perceived towards the edges of the visual field, which is more sensitive to motion. Flicker can cause ill-health, even if it is so rapid that you are unaware of it. It can cause headaches, eyestrain, migraines, fatigue and disturbs the control of eye movements. Unlike other light sources, which may flicker slightly, the flicker from LEDs can change almost instantly between bright and dark. In some circumstances. people see a trail of the

[8] The Lighting Handbook. London, Society of Light and Lighting, 2009.

[9] Stone PT. A model for the explanation of discomfort and pain in the eye caused by light. Lighting Research and Technology, 41, 2009, 109-121.

[10] ANSES, the French Agency for Food, Environmental and Occupational Health & Safety, September 2013

[11] American Medical Association. 2016. Human and environmental effects of light emitting diode (LED) community lighting. Report of the Council on Science and Public Health. Chicago (IL): American Medical Association.

[12] https://www.eceee.org/static/media/uploads/site-2/news/swecovernotesvm_study_181212.pdf

same image of a lamp repeated one after the other, each time their eyes move across it, known as a phantom array, it is particularly noticeable with the LED tail lights of cars. [13]

33. Flicker can also disrupt the movement control of the eyes and force the brain to work harder, causing discomfort and migraine in some people. Flicker stresses the nervous system and rapid changes in light subconsciously activate the alarm system and have different effects on people depending on the frequency. This explains the anxiety and stress many people feel when exposed to flickering LEDs. For people suffering from migraine, LED flicker commonly induces feelings of dizziness and pain within 20 minutes, but for some it can be instantaneous. [14]

34. One of the biggest triggers for those people with epilepsy are decorative lights, notably those lights that are flickering or flashing. People with epilepsy are sensitive to 16-25 Hz frequency lights. Decorative lighting also has adverse health impacts for people on the Autistic Spectrum and people suffering from migraine. [15]

Some of the LED sources assessed by Public Health England and others vary in illuminance at a frequency of 100 hertz. At the extreme, the LEDs switch on and off 100 times per second. This is of concern for a number of reasons. Some people seem to be very sensitive to this light modulation, resulting in headaches, migraine and less specific feelings of malaise.
Annual Report of the Chief Medical Officer

C) Spectral content - LED lighting can cause sleep disturbance

35. A core health concern about LED lighting is the disruption of people's circadian rhythms leading to disturbed sleep patterns. Humans have a natural body clock that has an approximate 24-hour cycle. At dusk, and in the absence of electric lighting, humans begin the transition to night-time physiology to prepare for sleep. The blood concentration of the hormone melatonin rises, body temperature drops, sleepiness grows, and hunger subsides.

36. In the early 2000s a new type of sensor was discovered in the eye, in addition to the rods and cones, which was also sensitive to light. These intrinsically photosensitive retinal ganglion cells (iPRGCs) were identified as the main sensors for entraining our circadian rhythms. Light is the main trigger that ensures that our circadian rhythms are properly maintained and retinal light exposure is the dominant synchronizer of the human circadian system. Recent evidence has revealed that the human circadian system is more sensitive to evening light than previously thought and that there are also substantial differences between individuals in light-sensitivity.[16] [17]

[13] Flicker can be perceived during saccades at frequencies in excess of 1 kHz, Lighting Research and Technology 45(1):124-132 February 2013, J. E. Roberts, Arnold J Wilkins.

[14] "Light flicker: Determination and Assessment. Discussion Peter Erwin Discussion Paper Oct 2017.

[15] https://www.epilepsyalarms.co.uk/how-to-stay-safe-at-christmas-with-epilepsy/#:~:text=What%20Is%20Photosensitive%20Epilepsy%3F,have%20epilepsy%20have%20this%20condition.

[16] Phillips, A. J. K. et al. High sensitivity and interindividual variability in the response of the human circadian system to evening light. Proc. Natl. Acad. Sci. USA 116, 12019–12024. https://doi.org/10.1073/pnas.1901824116 (2019).

[17] Boivin, D. B, Duffy, J. F, Kronauer, R. E. & Czeisler, C. A. Dose–response relationships for resetting of human circadian clock by light. Nature 379, 540–542 (1996).

37. Unfortunately, many LED street lights and other LED lighting has a spectrum containing a spike at the wavelength that most effectively suppresses melatonin during the night (Figure 1). It is estimated that a “white” LED lamp is up to 5 times more powerful in disrupting circadian physiology than a high-pressure sodium light. [18]

38. Recent large surveys have found that brighter residential night-time lighting is associated with reduced sleep time, dissatisfaction with sleep quality, night-time awakenings, excessive sleepiness, impaired daytime functioning, and obesity. Disruption of the circadian system can have a major impact on sleep quality and daytime alertness, which in turn impacts wellbeing and safety. It is a bit like having permanent jet lag.[19]

39. The human eye is not equally sensitive to all wavelengths in normal daylight vision, known as photopic vision, the eye has a peak sensitivity at 555 nanometres (green). LED street lights producing a peak of blue light, which is the hardest colour to see (**Figure 1**). As the use of devices emitting blue-enriched light has increased, so have concerns about its negative effects on the retina.[20] [21] Excessive exposure to blue light can cause insomnia and Transient Smartphone Blindness,[22] damage the retina, and threaten vision. [23] [24] In general, the retina is most sensitive to shorter-wavelength light, which causes damage that is primarily photochemical in nature.[25] Excessive blue light can cause photoreceptor death and retinal gliosis, which leads to retinal degeneration. [26] [27]

40. Blue light exposure may also affect intrinsically photoreceptive retinal ganglion cells (ipRGCs), as these cells contain melanopsin, a photopigment with peak absorbance at around 480 nm.[28]

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[18] Human and Environmental Effects of Light Emitting Diode (LED) Community Lighting, American Medical Association, 2016.

[19] Outdoor artificial light at night, obesity, and sleep health: Cross-sectional analysis in the KoGES study Chronobiology International, The Journal of Biological and Medical Rhythm Research, Volume 33, 2016 - Issue 3

[20] Tosini G, Ferguson I, Tsubota K. Effects of Blue Light on the Circadian System and Eye Physiology. Review Mol Vis. 2016; 24: 61–72. [PMC free article] [PubMed] [Google Scholar] [Ref list]

[21]. International Commission on Non-Ionizing Radiation Protection (ICNIRP). Light-Emitting Diodes (LEDS): Implications for Safety. Health Phys. 2020; 118: 549–561.

[22] Ratnayake K, Payton JL, Meger ME, Godage NH, Gionfriddo E, Karunarathne A. Blue light-triggered photochemistry and cytotoxicity of retinal. Cell Signal. 2020; 69: 109547.

[23] Grimm C, Wenzel A, Williams T, Rol P, Hafezi F, Reme C. Rhodopsin-mediated blue-light damage to the rat retina: effect of photoreversal of bleaching. Invest Ophthalmol Vis Sci. 2001; 42: 497–505.

[24] Jaadane I, Villalpando Rodriguez G, et al. Retinal phototoxicity and the evaluation of the blue light hazard of a new solid-state lighting technology. Sci Rep. 2020; 10: 6733.

[25] Ham WT Jr, Mueller HA, Sliney DH. Retinal sensitivity to damage from short wavelength light. Nature. 1976; 260: 153–155.

[26] Shang Y, Wang GS, Sliney D, Yang C, Lee L. White Light-Emitting Diodes (LEDs) at Domestic Lighting Levels and Retinal Injury in a Rat Model. Environ Health Perspect. 2014; 122: 269–276

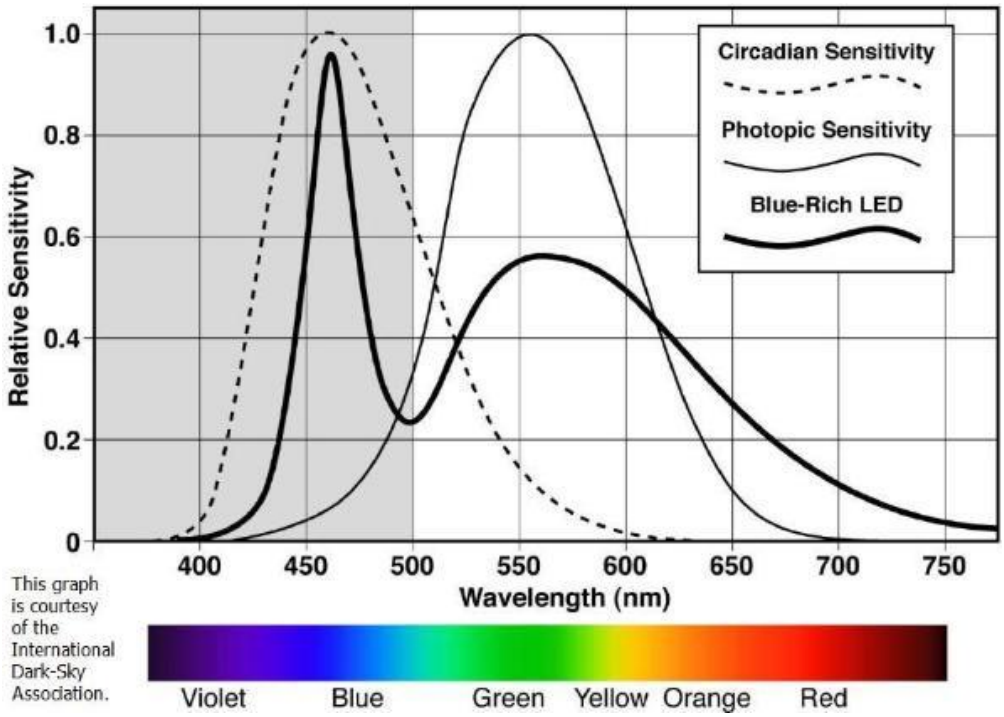
[27] Kuse Y, Ogawa K, Tsuruma K, Shimazawa M, Hara H. Damage of Photoreceptor-Derived Cells in Culture Induced by Light Emitting Diode-Derived Blue Light. Sci Rep. 2014; 4: 5223.

[28] Qi X, Kumbalasiri T, Carlson SM, et al. Induction of Photosensitivity by Heterologous Expression of Melanopsin. Nature. 2005; 433: 745–749.

Figure 1

Human photopic and circadian sensitivity curves displayed against a typical blue-rich LED light source spectrum

Blue rich LEDs have a peak at the wavelength that effects human sleep wake cycles but is less suitable for human vision.



Source: International Dark Sky Association.

D) Non-uniform luminance can create visual discomfort

41. Visual comfort is an important quality measure for indoor lighting and prevention of discomfort glare is essential. Some LED lighting fixtures have highly non-uniform luminance patterns. Unfortunately, the currently formulae used to predict discomfort glare are based on conventional light sources with much more homogeneous luminance patterns than LED.

42. Studies have shown that point array LED luminaires provoke more discomfort glare than uniform sources. This is because the small size and high brightness of LEDs compared to fluorescent tubes or incandescent lighting enable lighting fixtures with much higher peak luminance and luminance contrasts than other types of lighting. Research has shown that with equivalent average luminance, discomfort glare from a non-uniform stimulus is greater than that of a uniform stimulus A better understanding of the luminance characteristics of LEDs and their effects on glare perception is needed and a redefinition of the glare index is essential.[29]

[29] Cai, H., Chung, T. (2012). Evaluating discomfort glare from non-uniform electric light sources, Lighting Research Technology, 0, 1-28.

LED lighting exacerbates a number of light sensitive illnesses

43. Because LED is a new form of lighting with very different characteristics to the incandescent and fluorescent lighting it replaces, there is currently a limited research base on the impact of LED lighting on overall health. However, there is significant research on the impact of fluorescent lighting on specific illnesses which may give some indication of its long-term impacts, particularly when considering higher colour temperature LEDs

44. Many people with the following conditions are made ill or have their condition worsened by LED lighting:

- People who have a recognised disease or health condition that has photosensitivity as one of its known symptoms. This includes those with
  - **skin symptoms -** such as lupus, Xeroderma pigmentosum (XP), Chronic actinic dermatitis (CAD), solar urticaria and
  - **neurological symptoms**- such as epilepsy, autism, ME and migraine).
  - also some drug treatments are known to induce skin photosensitivity.
- People who previously had no illness recognised as including photosensitive, but who are nonetheless disabled by LED lighting. Standard neurological, dermatological and ophthalmological test results may sometimes be normal, but nonetheless they are unable to tolerate certain lighting technologies. Symptoms include insomnia, headache, eye pain, skin pain, nausea, confusion, joint pain, dizziness, fainting and anxiety and other severe and incapacitating reactions.

45. A detailed description of the illnesses where sensitivity to LEDs can be a factor, including links to articles and academic research in peer-reviewed journals, is included at **Appendix 3**.

46. As well as light-sensitive people, many others will be affected by high blue-content LED lighting. Although the EU's SCHEER report concluded that 'There is no evidence that the general public is at a risk of direct adverse health effects from LEDs when the lights are in normal use', their media release neglected to mention that the definition of 'general public' excluded children, the elderly and light sensitive people, who were classed separately as 'vulnerable populations'.

47. The SCHEER report concluded under the heading 'vulnerable populations' that "*Children have a higher sensitivity to blue light and although emissions may not be harmful, blue LEDs may be very dazzling for young children. Older people may experience more problems with glare. Some people appear to be susceptible to flicker and many people experience the phantom array effects caused by flickering LEDs when they move their head or eyes*." In addition to the 'vulnerable populations' above, as discussed earlier, blue rich LED lights are a powerful disruptor of people's circadian rhythms which can cause disturbed sleep and a large number of other health impacts **(Figure 2).** [30]

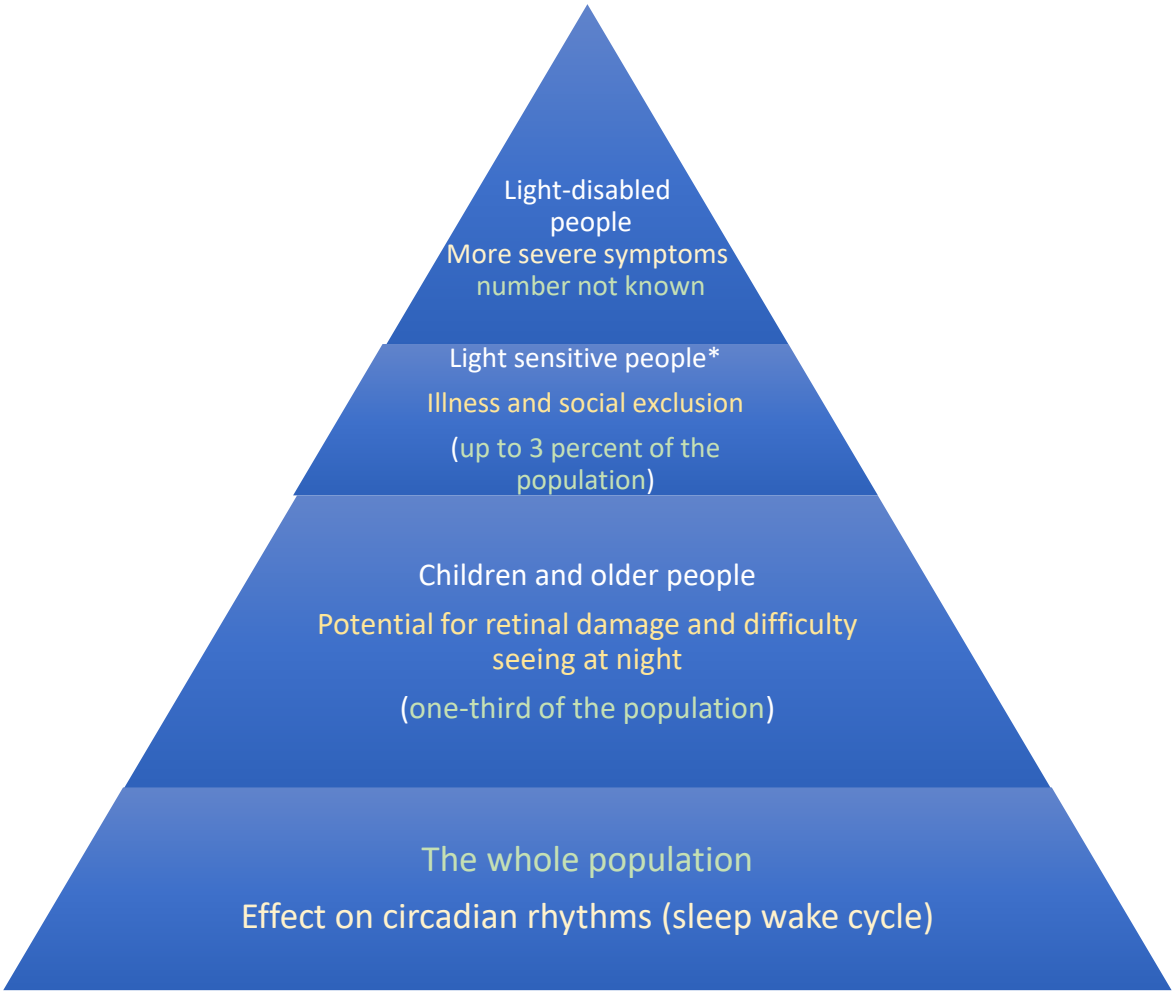
[30] Scientific Committee on Health, Environmental and Emerging Risks (SCHEER), Opinion on potential risks to human health of Light Emitting Diodes (LEDs), European Union, 2018.

48. There are also a smaller number of people who suffer more severe symptoms, such as disabling migraines, seizures and severe skin conditions who are effectively light-disabled. More research is required to establish the reasons for such hypersensitivity to LED lighting.

Figure 2

LED lighting can affect us all

The government should be wary of policies which may encourage manufacturers to increase the level of blue light to achieve efficiency standards.



Note*: The estimate of the number of light sensitive people relates to sensitivity to compact fluorescent lighting. Further research is required to establish the numbers sensitive to LED lighting.

Source: LightAware, Spectrum Alliance, SCHEER report.

How many people are affected by light-sensitivity

49. An estimate of the number of light sensitive people in the UK was made in 2012 by the Spectrum Alliance for light-sensitivity, a grouping of UK charities supporting medical conditions where sensitivity to some forms of light is a recognised symptom. They estimated that around 2 million people (3.25 per cent of the UK population) suffered adverse health effects due to compact fluorescent lighting. Their health impacts were due to flicker and because CFL bulbs emitted more UV light than linear fluorescent tubes.

50. The move from fluorescent lights to LEDs seems to have reduced the size of the problem and the adoption of new LEDs that flicker free, with lower quality temperatures and with reduced glare will further lower the number of people affected. However small numbers remain severely affected by all forms of LEDs. It is difficult to estimate how many people are affected in this way due to the lack of research. However a minimum number can be derived from the number of people that LightAware has directly helped over the years and similar reports by other relevant charities. This would suggest a number from the low thousands to the low tens of thousands, although academic research is essential to establish the scope of the problem.

51. **LightAware has not responded questions 2 to 22 because they are outside of our remit as a charity.**

Question 23 Do you agree with the proposed review date of December 2029?

52. Yes, however we suggest that during this time the UK government sponsors systematic research on the health impacts of LED lighting. A starting point might be evidence collected be the current House of Lords inquiry into the health effects of light pollution which is currently taking evidence.

53. LightAware, would be pleased to assist any research. We are in contact with a large number of people who suffer LED light sensitivity and who would be keen to participate in any research and take advantage of any therapies or technologies that might alleviate their symptoms.

Question 24 Do you agree with the proposed amendments to the exemption for light sources for people with a photosensitivity condition?

54. As part of their consultation process, the EU requested that LightAware should produce proposals as to how such an exemption should work (**Appendix 4**). The EU chose to incorporate what we felt was one of the more bureaucratic mechanisms for putting the exemption into effect, and unfortunately, in the UK context, has not worked at all, given no action was taken to get non-LED bulbs approved by the NHS as prescribeable items, or to obtain appropriate funding and buy in from Clinical Commissioning Groups and GPs. Each of these stages would be complex and difficult and would not necessarily result in consistent outcomes across different areas of the country.

55. We welcome the proposed amendments as they will help light-sensitive individuals who react severely to LEDs obtain lighting for their homes. It will benefit their partners and families who otherwise also face a future without artificial light in their homes, or not in areas where they are spending time with their light-sensitive member. It will help light-sensitive people who work at home continue to have task lights to work by. It may also help a number of people to re-enter the workforce, given the opportunities for working at home that have

become more apparent since Covid – many of the people light aware supports have had to abandon promising careers when new unsuitable lighting was introduced in the workplace.

56. The amendment also raises the prospect of light-sensitive individuals creating decent work at home conditions, through acceptable task lighting using incandescent lamps (typically an Anglepoise with a 60w lamp). This should benefit the UK Governments policy of getting more people back into the workforce.

57. Using self-certification would remove a lot of the bureaucracy (and cost) around prescriptions and the system would be simplified to basically:
    - identifying a supplier of appropriately priced good quality incandescent bulbs
    - identifying disability aid suppliers willing to take on the distribution and order processing role
    - setting up a system for self-certification by light-sensitive individuals.

58. There may be those who see a system of self-certification as opening up a potential 'loophole' in the ecodesign system, which would result in people purchasing incandescent bulbs who do not have a serious medical need to use them. However there are several reasons to believe that this is unlikely to be the case:
    - **economy** – in the current climate of very high energy costs, who, except for LED light-sensitive individuals, would be willing to pay the additional costs of using incandescent bulbs
    - **efficiency** – although the system might be less bureaucratic than getting prescriptions, it will still be more time consuming than simply going to the supermarket and buying a (more economic) alternative
    - **effectiveness** – LED bulbs now last over 10 years, who (other than light sensitive individuals) would be willing to regularly climb step ladders to change light bulbs.
    - in addition, the regulations require bulbs sold under this provision to be labelled "for the use of photosensitive people only.

59. As the regulations are currently drafted, it appears to be left open to the Government whether to collect any data on the number of people self-declaring as photosensitive. If the Government decided to collect data from suppliers, they could monitor the use of the exemption and gain important insights into the prevalence of severe LED sensitivity in the population.

60. However if there are still concerns within the department, we would suggest replacing presale self-declaration with a requirement to present written evidence from a health professional stating that they are a photosensitive patient. There is already a definition of photosensitive patient in schedule one. The intention of this would be not to require people to obtain a fresh letter from their doctor specifically for the purposes of buying bulbs (which would result in increased pressures on an already overburdened NHS) but to allow the use of existing medical evidence confirming that they have a photo sensitivity condition. It should also enable medical evidence submitted once to be used to enable subsequent purchases,

again to avoid nugatory additional requirements on doctors. Again, the Department would have the choice in implementation to require suppliers to monitor the number of people presenting such letters to suppliers and whether to conduct some spot checks.

61. However this approach will lead to some increased requests to the NHS from people who do not have relevant evidence to hand and will be more burdensome on the businesses undertaking the supply of these bulbs as they will need to arrange for the uploading and storage of sensitive health information, which is in a higher category for GDPR compliance.

Setting the Photosensitivity Exemption in the context of disability policies

62. Although it is in DENZ legislation, this provision is a health and disability policy. It sits alongside a range of provision made across Government supporting the health, well-being, family life, access to work and social inclusion of sick and disabled people, where the consequence is some increase in energy use. Examples include:

    - **The Motability scheme** run in conjunction with DWP - This enables 640,000 disabled people (source: mobility.org.uk website) in receipt of mobility allowances to exchange that payment for a brand-new car, Wheelchair Accessible Vehicle, scooter or powered wheelchair, so they can enjoy more freedom and independence. Many of them would otherwise be unable to afford or finance a vehicle. In 2019, the average car in the UK drove 7,400 miles (source: the Government's National Travel Survey report), producing the equivalent of approximately 272 grams of CO2 per mile. As more than 200,000 vehicles are purchased per year by Motability Operations, total carbon emissions could be up to 400,000 tonnes per year.
    - **Access to Work** - Access to Work is a program to help people get or stay in work if they have a physical or mental health condition or disability. The support people can apply for includes taxi fares to work and electric wheelchairs.
    - **Disabled Facilities Grant** - This is a grant available from local authorities for disabled people to make adaptations to their homes to make life for them and their carers and families better for their health, more manageable and dignified. Grants can be made for installing a stairlift, installing better washing facilities or adapted bathrooms, and installing a heating system.
    - **Disabled Taxi Cards** - Provided by some local authorities including Greater London, giving disabled people subsidised taxi journeys.

    There are many more examples and as far as we are aware, CO2e calculations are not made for any of these schemes to help disabled people.

Question 25 Are there any reasons why the proposed amendments to this exemption would not be effective?

63. LightAware do not see any reasons why the exemption would not be effective. There are supplies of incandescent bulbs available and light disabled people who need them.

Appendix 1. Light sensitive individuals' experience of LED lighting – UK case studies

LightAware receives accounts from people all over the world who are shut out of their lives by new forms of lighting – people who can't get to work without blinding headaches or visit a library without a severe skin rash. We hear from people having to leave their jobs, their studies and even their homes.

LightAware believes we need much more research and much more dialogue to join the dots between different fields of medicine and technology in order to understand how and why some people's health is so profoundly affected by LEDs.

The case studies below are all people who live in the UK, names have been changed to protect individuals 'anonymity.

Amanda

I have Systemic Lupus Erythematosus (SLE) with skin involvement and associated photosensitivity. I also suffer from photo-aggravated rosacea. Following the imposition of energy-saving bulbs and other newer forms of artificial lighting including LEDs, I became increasingly aware of their detrimental effects on my health and wellbeing.

In 2004, I began working in an environment that had barely any natural lighting but was instead illuminated by very powerful fluorescent lights. I suffered a major lupus flare requiring hospital admission and treatment. In 2010, shortly after leaving a shop where I had been obliged to stand beneath energy-saving bulbs at very close quarters, I developed a sunburn-type rash to my face, neck and chest with spontaneous bleeding to my lip.

Despite taking precautions, it is virtually impossible to escape the harmful effects of newer forms of modern lighting, which truly are ubiquitous. Access to good medical care for those with chronic and serious conditions is an ongoing challenge, with more recently built and modernised hospitals the worst offenders with regards to unsuitable lighting systems. In such places lighting is usually all on one circuit making it impossible to isolate small areas in order to render them safe for light-sensitive patients.

What greatly concerns me is the absence of a specific and coherent policy that serves to protect specific groups from the harmful effects of artificial lighting.

Jessica

I am a 45-year-old female with Lupus and photosensitivity. I have been retired on health grounds from the impact of working environments due to being photosensitive, particularly to artificial lighting.

I cannot tolerate any form of overhead lighting and have up-lighters in my home with low wattage bulbs. I am affected by computer screens, mobile phone screens, car lights, street and road lighting, shop lighting, in fact anything that is lit – even fairy lights on the Christmas tree.

Exposure to artificial lighting causes the immediate effects of dizziness, racing pulse, headache, disorientation, nausea and on occasions numbness to my face; I then go on to experience flares of my Lupus symptoms such as fatigue, joint pains and swelling and a general feeling of being unwell. These symptoms are a product of the cumulative effect of exposure to light so they are unpredictable and can occur up to a week after exposure. I therefore have to carefully plan events to make sure I have the space to recover from feeling unwell; it is not possible to avoid artificial lighting entirely without giving up any quality of life. My family are very understanding – my twin sister also has Lupus with photosensitivity – even my grandchildren are able to understand to a degree, but I try to balance my need for protecting myself with being able to enjoy time with them.

I have UV filter screen on my car and wear factor 50 sun screen every day but no matter how I cover up with clothing, the artificial light still affects me via any skin exposed.

I am frustrated by laws that are made from a general assumption that modern lighting is better. When my sister and I have the same conditions but different tolerances, how can one rule be made for the general population without consideration for the additional and varying needs of so many?

Elizabeth

Elizabeth is extremely sensitive to indoor and outdoor LED lighting. When LED Street lights were erected outside her home, she couldn't even step into her front garden without symptoms including severe eye pain, migraine, nausea, vomiting, and vertigo, these symptoms starting immediately upon exposure.

She recently moved house to live in the countryside to escape the LED street lighting in her town. However, there is no escape as neighbours and farms nearby have started to install LED security lighting outside, restricting her access to only parts of the garden. The neighbours next door has LED Christmas displays so she is trapped in her home for 1 month after dark at Christmas time. She feels this shows little compassion.

When the street lights changed to LED, her employer also switched to LED backlit computer screens. She was already working under LED lighting and very sick everyday living on painkillers and anti-sickness tablets. She eventually had no choice but to leave her job. The widespread adoption of LED lights in the workplace has left her long term unemployed on no income.

Cut off socially at home, Elizabeth is excluded from using essential communication technologies such as modern phones and computer screens as they are LED backlit. CFLs can cause symptoms for her too, though nowhere as severe or immediate as those from LED lamps. Although she is only in her thirties, Elizabeth feels most of the time she is living a very isolated life, that no-one should be subjected to.

"I don't know where else to go. It's distressing that nothing is being done, but at least now I know many others who feel the same. LED lights have become commonplace, so I'm glad I have school and college behind me because I wouldn't be able to go if I were a child today."

Tony

Tony was just a 'normal young guy' in his 30s: living in London, working in an office, with a computer and smartphone and enjoying travelling. Some years after having laser eye surgery, he started suffering extreme eye pain and headaches when exposed to LED lighting. He is unable to use modern televisions, computer monitors and phones as the LED backlights trigger severe pain. In the work world, Tony is increasingly cut off from normal activities that people take for granted.

"The LED streetlights I have encountered have been pure and utter hell for me. Being around them I just feel burning right on my eyes. Afterwards I feel like my eyes have been cut to bits – the pain is almost unbearable; it feels like somebody has either burnt into or sliced my eye. It actually feels like the white part of my eye was bleeding".

This turned his life upside down, making everyday life a constant negotiation to be able to travel and work without exposure to lighting. His employers in an office had helped to accommodate him, using old screen technology and sitting away from difficult lighting. He was just about coping when LED street lighting began to be installed across his borough. This situation is increasing difficult as his office is due to shortly replace fluorescent overheads with overhead LED lights, which are intolerable for him.

He fears being forced out of his job within a matter of months, leaving him in a financially precarious situation. Lastly, if the supply of sodium street lights runs out, he could even be forced out of his home. Currently he is lighting his home using a diminishing supply of old incandescent bulbs and having to wear a hat to try to shield his eyes when outside.

Kevin

Kevin is a father and the family breadwinner, but he was unable to continue with his career as an IT professional, as he is not able to tolerate LED lighting and many modern fluorescents, now ubiquitous in the workplace.

Commuting to work has become impossible for him, as LED and HID lights on cars blind and trigger migraines for him whilst driving. Public transport is now also out of his reach as buses, trains and stations have upgraded to LED lights. He finds road signs with white LEDs too uncomfortable to read and they give him bad headaches. Since LED street lights

have been introduced into his county, including his street, he's had to cease driving altogether at night – significantly disrupting family life.

Kevin is no longer able to cycle, walk or drive where ever LED street lights are installed as they instantaneously trigger bad headaches for him, which quickly develop into disabling migraines, including dizziness, not being able to think straight, some loss of coordination, and a general inability to function well – these disabling symptoms sometimes lasting more than a day. To try and cope with LED street lights, he wears a peak cap, specialised tinted glasses and has to keep his hand constantly raised to try and shield his eyes from their light – despite this, these lights still trigger symptoms. Besides all this, he doesn't feel safe driving on roads lit by these lights, as he finds they actually reduce visibility in areas not directly beneath them, including pavements, side-street parking bays, intersections and pedestrian crossings.

"I feel a constant sense of foreboding as LED lights take over public spaces, causing my life to be increasingly cut off. The resulting social exclusion also has an emotional impact and I feel my livelihood has been wrenched from me"

Charlie

Charlie was working in a job she loved with great prospects when the organisation she worked for moved to a purpose-built new premises with new fluorescent strip lighting. She soon became ill, suffering from severe headaches and shingles beside her eye. From this time she was unable to tolerate any fluorescent lighting and eventually had to leave her job.

"At first I thought I just had a problem with fluorescent lighting and was ok with LEDs," she explains, "but one day I was walking by the river when I was bathed in a very bright LED street light from a new housing estate. It felt like a floodlight. I felt a sudden urge to run away, followed by a severe headache, the pain lasted for a whole month and was accompanied by general light sensitivity to all bright light."

After a few of these episodes she increasingly found LED lighting too piercing and bright, and looking directly at LED lights resulted in migraine. Charlie managed to give medical evidence to the local council (from neurologists and optical specialists) and the council agreed to maintain her street as sodium and dimmed the very bright lights beside the river. This made a difference to the whole neighbourhood, as many people were having problems sleeping with the sky so bright at night. It was a huge relief to have sodium lighting on her street, but she still can't go out beyond this area after dark or take part in events in the town.

Bernadette

Bernadette was a university senior lecturer when her academic department altered the lighting in one of its buildings to fluorescent lighting, which for her triggered migraines. Bernadette took her case to an employment tribunal, which recognised she had a disability but ruled that the university's need to attract new students through refurbished facilities overrode her disability case. She had no choice but to leave a 30-year-old successful and

sociable career to work from home for a fraction of the income. An elected local councillor, Bernadette was also unable to attend council meetings in person as the council said it was unable to alter fluorescent lighting in the chamber. She was therefore unable to represent her electorate by voting on motions and was deselected by her local political party.

Bernadette has not left her home in the evening for several years since the street lights were replaced with LED ones that trigger migraines. Job loss and isolation have left Bernadette depressed and feeling desperate.

Jessie

Jessie is a good-natured young lady in her mid-teens, currently preparing for her GCSE exams. She finds that the fluorescent tube lights at school, especially the bright cool-white ones, often make her feel dizzy. This is accompanied with difficulty focusing, listening and remembering things. Furthermore, these symptoms can be followed by her experiencing troubling headaches. The impact is far worse from LED lights. She wears special tinted glasses to try and mitigate the effects from this lighting, but they only help to a limited degree.

She looks forward to following her dreams at college in coming years, but since many colleges are upgrading to LED lights, she wonders how this may impact her ability to earn the qualifications she needs to start a job one day.

Kelly

Kelly has light sensitive lupus, which means she has a severe sensitivity to UV light. She has to wear a medical mask to go outside in the daytime to protect her from the UV in sunlight. When there were sodium street lights around her home, she could safely go out of the house in the evening. However, now that the local council has replaced the orange sodium lights with blue-rich LED street lighting, she has to wear the medical mask even to go outside after dark. She also feels that the LED lights affect her adversely even wearing the mask, causing headaches and fatigue, and so there may be another factor affecting her other than the UV content of the light.

"When I first became ill, I thought I would become a night-time person going out and socialising at night. But I have a worse reaction to cool white and bright white LEDs, now in widespread use both outdoors and indoors, than to sunlight."

Alasdair

Alasdair suffers from a light-sensitive skin condition known as photosensitive seborrhoeic dermatitis and gets an extreme reaction from all forms of light even through clothing. For many years he couldn't go outside his blacked-out house in daylight as his skin reacted so badly to sunlight. He was only able to leave the house at night, for a limited period, which was his only opportunity for some fresh air and exercise. He had to leave a successful career where he'd had a senior professional role.

"When I heard that the council were planning to change the local area from sodium to white CFL street lighting I was horrified. Leading photo-dermatologists recognise blue light to be much more penetrating and therefore much more aggravating for people with light sensitive skin conditions. The high blue content of the proposed street lighting would mean that I would become housebound throughout the day and the night."

Backed by a lawyer, he argued the case with the local council that his human rights would be infringed by the installation of CFL street lights in the local area and that it also would be a breach of the council's duty to make reasonable adjustments for disabled people under the Equality Act, which covers public areas including the streets. He sent medical evidence to back up his case and the council agreed to replace a limited area with high-pressure sodium street lights rather than CFLs so he could continue to go outside for a walk.

Tania

64. The use of new lighting technologies has an impact on all aspects of a light sensitive person's life, including access to healthcare, education and employment. I myself have had to give up a career as a teacher. I lose consciousness with my basilar type of migraine and artificial lighting is a trigger for this. For the safety of myself and my students, I couldn't continue working under fluorescent lighting. Simple adaptations would make it safe for me to teach again, yet these are not possible because of the ban on incandescent lights. The teaching profession has lost a valued member and I have lost not only my career but also my ability to be self-sufficient and independent. Mine is only one story of many with light sensitive conditions.

Billie

Billie worked for a large employer in the north of England. When her employer moved to new premises, Billie found that she was completely unable to tolerate the lighting there. The building was equipped with automated fluorescent lighting throughout. There was no alternative lighting available, no private offices and the lighting could not be switched off.

From the first day Billie suffered excruciating eye pain which developed over three months to severe and lasting headache. Attempts to resolve the situation within the workplace were slow and ineffectual. After three months she was signed off sick with shingles. Since that time Billie has been unable to tolerate any exposure to fluorescent lighting without suffering lasting headache and nausea.

Billie now works from home. She finds she is well if she stays away from all fluorescent lighting but this means she is unable to work outside the home or take part in the life of her community. Medical services, transport, council services, education, places of worship, leisure and recreation are all out of bounds for her. However the lasting pain that she suffers on exposure to fluorescent lighting is of such severity that it feels there is no choice but to live with such social exclusion.

This situation has recently got a lot worse with the introduction of LED street lighting where she lives which causes the worst pain yet. The County Council are installing this lighting

across the county: a particularly bright version on main roads and a slightly less bright version on residential streets. Billie has found that this lighting causes migraine, extreme photobia and severe depression lasting many weeks. Billie no longer goes out after dark but feels this is an unacceptable constraint on her life too far.

Anna

I had no previous health conditions, optical sensitivity or problems with headaches, until exposed to a lot of CFL lighting at a conference centre in Birmingham. Every time they switched the lights on, I felt as if my head was swelling and splitting, with intense burning followed by long-lasting nausea and agitation, like the shaking inside after an electric shock. I've had similar reactions ever since when exposed to CFL lighting, especially naked bulbs. Bright, blue-ish LEDs also make me feel agitated and nauseous.

I'm perfectly well if I stay away from these lights, but that means staying away from my children's school, the health centre and hospital, most churches and Meeting Houses, libraries, swimming pools… much of life as I knew it. This makes for severe restraints, on my life and my family's. The time the symptoms last depend on the length of exposure to the lighting, but for ages afterwards I feel incredibly drained and down, and 'wrong' all over.

Appendix 2. Controls on lighting use in France

Controls on external lighting use in France could be effectively replicated in the UK. In France, the “Decree of 27 December 2018 on the prevention, reduction and limitation of light pollution' sets an important standard in western Europe for the protection of night-time darkness and the avoidance of unnecessary and harmful light use through controls on the emission of light in outdoor spaces. It sets technical requirements for the design and operation of outdoor lighting installations which apply to both public and private property owners. **The reduction in unnecessary light use will have a substantial impact on energy use**.

The phasing in of these policies started in 2019 and will finish by 2025. The provisions include:

- **Outdoor lighting curfews**. Curfews specify times of the night at which lighting must be dimmed or extinguished completely.
- **Limits on the allowed emission of light directly into the night sky.** The Upward Light Ratio (ULR) is limited in most cases to less than 1% of the total emission of a given fixture.
- **Reduced glare**. Outdoor lighting must conform to a requirement that at least 95% of the light emission is confined to angles at or below approximately 14.5 degrees from the horizontal. This substantially cuts down on light in the so-called ‘glare zone’ of lighting and discourages lighting design that directs light to areas far from the installation point.
- **Restrictions on the emission of blue light.** The Decree requires that, in all instances, the colour temperature (CCT) of light does not exceed 3000K. Additional requirements for protected areas such as nature reserves and parks set the CCT threshold at 2700K for the “built environment” of towns and villages, and 2400K otherwise.
- **Allowable illumination levels.** In order to prevent use of excessive lighting that can compromise public safety, the Decree limits the amount of light used in any installation to no more than 35 lumens per square meter of illuminated target surface. For suburban and rural settings, the allowed limit scales downward proportionately to as low as 10 lumens per square meter.
- **Light trespass** into dwellings is prohibited, regardless of its source.
- The use of skybeams, lasers, and similar high-intensity light is generally prohibited.
- Night-time lighting of waterways is generally prohibited, including light shining out to sea.

Appendix 3. The main clinical conditions which can involve sensitivity to LED lighting

People with skin diseases or skin manifestations of underlying conditions

Systemic Lupus erythematosus (lupus)

Lupus is an autoimmune disease in which the body's immune system mistakenly attacks healthy tissue in many parts of the body. Lupus is thought to develop due to an interaction between genetic susceptibility and environmental triggers. About one person in 3,500 has lupus and it is about nine times more common in women than in men.

As many as 70% of people with lupus have some skin symptoms, and around 60% will be sensitive to the sun. Lupus UK states that some of these people will also be sensitive to certain types of lighting inside buildings such as fluorescent tubes, halogen and ‘energy saving’ bulbs, and any high intensity lighting. Low colour temperature LED lighting is often considered better than fluorescent for lupus sufferers as it doesn’t emit UV, but many people with lupus cannot tolerate LED at all. Cool white and bright white LEDs emit short-wavelength blue light that is particularly risky for sufferers. [31] [32] [33] [34] [35]

Xeroderma pigmentosum (XP)

XP is a rare, hereditary skin disorder affecting 1 in 250,000 people. People with XP are not able to repair the damage caused to their skin by the ultraviolet (UV) part of daylight. Symptoms may include a severe sunburn after only a few minutes in the sun, freckling in sun exposed areas, dry skin, and changes in skin pigmentation. Complications include a considerable risk of skin cancer, with about half of sufferers having skin cancer by age 10 without preventive efforts. Treatment involves completely avoiding the sun and using protective clothing, sunscreen, and dark sunglasses. The life expectancy of those with the

[31] https://www.lupusuk.org.uk/eclipse/

[32] Fluorescent light photosensitivity in patients with systemic lupus erythematosus: Arthritis Rheum. 1992 Aug;35(8):949-52. doi: 10.1002/art.1780350816.

[33] A Guide to Artificial Lighting, Lupus UK, available at https://www.lupusuk.org.uk/eclipse/a-guide-to-artificial-lighting/

[34] Fluorescent light photosensitivity in patients with systemic lupus erythematosus August 1992, Arthritis & Rheumatology 35(8):949-52

[35] Characterization of clinical photosensitivity in cutaneous lupus erythematosus, Kristen Foering, et al. Journal of the American Academy of Dermatology. 2013 August 1.

condition is about 30 years less than normal. People with XP can tolerate very low power incandescent lighting but cannot tolerate fluorescent or LED lighting.[36]

Chronic actinic dermatitis (CAD)

In CAD, the skin is sensitive to UV light and in about half of sufferers to visible light too. There can be a delay of several days between exposure and skin reaction, so people with CAD are not always aware that the two are linked. It is thought that CAD is caused by an allergic reaction to sunlight and some artificial lighting, but it is unclear why this happens. Skin reactions are caused by exposure to CFL lighting but there has been little research on the effects of LEDs up to now.[37] [38] [39]

Solar urticaria

Urticaria is also known as hives, weals or nettle rash and solar urticaria is triggered by exposing the skin of susceptible individuals to sunlight or some types of artificial light. While it can start at any age, people aged between 20 and 40 are most affected. The radiation spectrum causing solar urticaria ranges from ultraviolet B to visible light (wavelength of 300 nanometres to 500 nanometres) and is variable from one patient to another.

Solar urticaria occurs when light causes the release of histamine from cells in the skin called mast cells. Its appearance can be quite dramatic as it usually develops within just a few minutes of light exposure. The main symptoms are itching, stinging and burning. The rash may last a few minutes, or hours, and usually disappears within a day. Treating solar urticaria can be difficult, especially if it is visible light causing the problem and may require major adjustments to a person's lifestyle.

[36] British Association of dermatologists https://www.bad.org.uk/pils/xeroderma-pigmentosum-xp/

[37] British Association of dermatologists https://www.skinhealthinfo.org.uk/condition/chronic-actinic-dermatitis/

[38] Photochem Photobiol. 2012 Jun 23. doi: 10.1111/j.1751-1097.2012.01192.x. [Epub ahead of print] The Effects of UV Emission from Compact Fluorescent Light Exposure on Human Dermal Fibroblasts and Keratinocytes In Vitro. Mironava T, Hadjiargyrou M, Simon M, Rafailovich MH.

[39] Photosensitive Atopic Dermatitis Exacerbated by UVB Exposure, Cutis. 2017, September;100(3):180-184, By Veronica L. Rutt, DO Kelly X. Reed, DO Xuehui Liu, MD Elisabeth G. Richard, MD Stephen M. Purcell, DO.

People with neurological illnesses

Migraine

10 million people suffer from migraine in the UK. Prevalence has been reported to be 5–25% in women and 2–10% in men. While everyone is sensitive to light to some degree, people with migraine can be hypersensitive. [40] For many migraineurs (32 – 40%) light sensitivity is closely linked to their condition. Flickering lights, including fluorescent and LED lighting can trigger a migraine attack for some migraineurs. Experts believe numerous factors contribute including:

- **Brightness levels -** people with migraine are known to have a lower threshold for light overall, making any exposure to an intense light source a cause for concern.
- **Blue light -** photosensitive retinal ganglion cells are more sensitive to wavelengths of blue-green light and transmit pain and other sensory signals to the brain. This may be exacerbated by central nervous system issues linked to migraine.
- **Flickering light -** rapid, flashing lights (such as emergency vehicles) is feared by those with migraine, and researchers have suggested that the sharp contrast between dark and light triggers activity in the brain.
- **During the migraine** -, photophobia is the second most frequent symptom after actual head pain and is included in clinical definitions of migraine. Exposure to light during the attack can make other symptoms worse too, leading to more pain and can extend the recovery time.[41] [42] [43] [44]

Light sensitivity is so common in people with migraine that it is itself a diagnostic criterion for migraine. Many people cite bright light, particularly fluorescent lighting and LED, as a migraine trigger and retreat to a dark or dimly lit room during an attack. Migraine Action produced a guide to Migraine and light sensitivity which sets out the issues. Symptoms include a throbbing one-sided headache, nausea and vomiting and visual disturbances.

Professor Arnold Wilkins, professor of psychology at the University of Essex, has done a huge amount of research on LED flicker and migraines. He found LED bulbs are capable of inducing feelings of dizziness and pain within 20 minutes of switching them on. LED bulbs can have greater flicker than traditional light bulbs, while fluorescent lights like those found in offices dim by about 35 percent with every flicker, LEDs may dim by up to 100 percent,

[40] https://americanmigrainefoundation.org/resource-library/photophobia-migraine/

[41] https://migrainebuddy.com/when-lighting-strikes-the-effect-of-light-sensitivity-on-migraine/

[42] Main, A., Vlachonikolis, I. and Dowson, A. (2000), The Wavelength of Light Causing Photophobia in Migraine and Tension-type Headache Between Attacks. Headache: The Journal of Head and Face Pain, 40: 194-199.

[43] Migraine photophobia originating in cone-driven retinal pathways Rodrigo Noseda, Carolyn A. Bernstein, Rony-Reuven Nir, Alice J. Lee, Anne B. Fulton, Suzanne M. Bertisch, Alexandra Hovaguimian, Dean M. Cestari, Rodrigo Saavedra-Walker, David Borsook Brain, Volume 139, Issue 7, July 2016, Pages 1971–1986, https://doi.org/10.1093/brain/aww119

[44] Bernstein, et. (2018). The Migraine Eye: Distinct Rod-Driven Retinal Pathways' Response to Dim Light Challenges the Visual Cortex Hyperexcitability Theory. Pain. 10.1097/j.pain.0000000000001434. <https://www.researchgate.net/publication/328028822

i.e. LED light bulbs effectively switch on and off hundreds of times every second. The flickering may disrupt the movement control of the eyes and force the brain to work harder. The risk of suffering a headache is more pronounced while reading, when the eyes are positioned carefully to scan the pages.[45] [46] [47] [48] [49]

Autistic spectrum

Many people on the autistic spectrum have sensory issues. This can affect one or more of the senses and these can be either over-developed (hypersensitive) or under-developed (hyposensitive). Both can have an impact on how people experience particular environments. Certain types of lighting, specifically fluorescent lighting, have been shown to have a negative effect on individuals on the autistic spectrum; around half of autistic individuals experience what is classified as a severe sensitivity to fluorescent lighting. [50] [51] [52]

One study found that the use of fluorescent lighting increased the repetitive behaviours of children with autism, which may be attributed to a hypersensitivity to fluorescent light flicker. LED lighting has a similar effect, but because it is such a new technology, there is less published research available. According to the National Development Team for Inclusion Autism Team's 2022 publication on sensory friendly lighting, "LED lighting can also be extremely problematic for autistic individuals or other light sensitive users." In the section on lighting control, they state "it is important for users to have the ability to control and adjust the lighting."

Sensitivity to light can manifest in diverse ways for people with autism. For instance, physical symptoms may include lower tolerance for light, discomfort from artificial light, light avoidance behaviours (e.g. shielding eyes), afterimages, visual snow, headaches or migraine. Some autistic people have reported finding cool white / blue light difficult to

[45] 1789-2015 - IEEE Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers.

[46] 1Lehman, B. and Wilkins A.J. (2014). Designing to mitigate the effects of flicker in LED lighting. IEEE Power Electronics Magazine, Vol. 1, No. 3, September.

[47] Roberts J.E. and Wilkins, A.J. (2013). Flicker can be perceived during saccades at frequencies in excess of 1kHz. Lighting Research and Technology, 45, 124-132.

[48] Lehman, B, Wilkins, A, Berman, S, Poplwski, M. and Miller N.J. (2011). Proposing measures of flicker in the low frequencies for lighting applications. In Energy Conversion Congress and Exposition (ECCE), 2011 IEEE 2865-2872

[49] Wilkins, A.J, Veitch, J. and Lehman, B. (2010), LED lighting flicker and potential health concerns: IEEE standard PAR1789 update. IEEE ECCE, 171-178.

[50] See Sensory differences, National Autistic Society, available at https://www.autism.org.uk/about/behaviour/sensory-world.aspx.

[51] Coulter RA. Understanding the visual symptoms of individuals with autism spectrum disorder (ASD). Optom Vis Dev 2009;40(3):164- 175.

[52] Howe FEJ, Stagg SD. How Sensory Experiences Affect Adolescents with an Autistic Spectrum Condition within the Classroom. Journal of Autism and Developmental Disorders. 2016;46:1656-1668. doi:10.1007/s10803-015-2693-1.

process. In some instances, this causes significant sensory processing delays and can lead to sensory overload.[53] [54] [55] [56]

Other symptoms may include increased anxiety, repetitive behaviours, as well as poor eye contact or eye movement. These types of sensory disruptions can lead to social problems and worsening educational outcomes, for school-aged people with autism.

Epilepsy

About 5 in 100 of people with epilepsy have photosensitive epilepsy. Photosensitive epilepsy is a form of epilepsy in which seizures are triggered by visual stimuli that form patterns in time or space, such as flashing lights, bold, regular patterns, or regular moving patterns. Flashing or flickering lights or rapidly changing or alternating images are an example of patterns in time that can trigger seizures. Fluorescent lights may not normally cause a problem, but faulty lights, which flicker at a lower frequency can cause problems. Much higher risks are associated with television and video games.

Often persons with photosensitive epilepsy have no history of seizures outside of those triggered by visual stimuli. Some people with photosensitive epilepsy have reported that LED lighting causes seizures extremely rapidly. Decorative flickering LED lighting is particularly difficult for some people to cope and guidance on staying safe at Christmas is available. [57]

Myalgic Encephalitis

Chronic fatigue syndrome (CFS) or myalgic encephalomyelitis (ME) is a debilitating disorder, affecting at least 250 000 people in the UK. It is characterized by long-term fatigue and other persistent symptoms that limit a person's ability to conduct ordinary daily activities. These symptoms include a profound, generalised post-exertional loss of muscle power, muscle pain and neurological signs. Patients are also prone to relapses which may take the form of recurrences of the original systemic illness, or fresh episodes of muscle weakness, neurologic changes or well-defined cognitive problems. People diagnosed with CFS/ME consistently report that they experience vision-related symptoms, indeed several diagnostic symptoms of the visual-processing deficit Meares-Irlen/Visual Stress Syndrome

[53] https://www.ndti.org.uk/assets/files/Sensory-friendly-LED-lighting-for-healthcare-environments_Final.pdf

[54] Victorio M. EHMTI-0290. Headaches in patients with autism spectrum disorder. The Journal of Headache and Pain. 2014;15(Suppl 1):B37. doi:10.1186/1129-2377-15-S1-B37.

[55] Light Sensitivity and Autism, ADHD, SPD and Developmental Delays. https://epidemicanswers.org/light-sensitivity-and-autism-adhd-spd-developmental-delays/

[56] Sullivan JC, Miller LJ, Nielsen DM, Schoen SA. The presence of migraines and its association with sensory hyperreactivity and anxiety symptomatology in children with autism spectrum disorder. Autism. 2014 Aug;18(6):743-7. doi: 10.1177/1362361313489377. Epub 2013 Sep 26

[57] https://www.epilepsyalarms.co.uk/how-to-stay-safe-at-christmas-with-epilepsy/

are very similar to symptom manifestations reported by individuals with chronic fatigue syndrome (CFS). [58] [59] [60] [61]

In October 2021, NICE issued new clinical guidelines for CFS/ME, advising health and social care organisations to take into account hypersensitivity to light as a recognised symptom. [62]

[58] Potaznick W, Kozol N. Ocular manifestations of Chronic Fatigue and Immune Dysfunction Syndrome. Optom Vis Sci 1992;69:811–14.2

[59] Vedelago LJ. Visual dysfunction in Chronic Fatigue Syndrome: Behavioural optometric assessment and management. J Behav Optom 1997;8:149–54.3

[60] National Institute for Health and Care Excellence: Myalgic encephalomyelitis (or encephalopathy)/chronic fatigue syndrome: diagnosis and management, October 2021

[61] Leslie S. Chronic Fatigue Syndrome: Optometric clinical presentation and management.J Behav Optom 1997;8:155–61

[62] https://www.nice.org.uk/guidance/ng206/chapter/Recommendations#suspecting-mecfs

Appendix 4. Original LightAware proposals for an exemption for light-sensitive individuals to the EU (January 2018)

Administering the exemption

This exemption could potentially be administered through the following measures, alone or in combination according to the preferences of individual member states' healthcare systems and market surveillance authorities. Validation of the purchaser could be undertaken through:

- a database of registered users (involving registration number, electronically read card etc)
- user self-certification with occasional spot-checks (as currently required in the UK for VAT exemption when purchasing. For example, dust mite proof bedding for sufferers of asthma or walking aids)
- certification of purchaser by a doctor or other suitably qualified professional (as in a passport photo)
- production of a doctor's note, prescription or medical letter from a neurologist, ophthalmologist, optometrist, dermatologist or other suitably qualified professional.

However, the following points must be taken into account:

- For a functional disability, such as intolerance to substances established as potentially toxic including certain types of lights like LEDs and CFLs, there should legally be no requirement on the part of the person functionally disabled to have any form of 'proof' as regards their disabling condition.
- Since intolerance is not an illness, with the person concerned perfectly healthy so long as absent from the toxic substance, there is no diagnosis possible of any disease since the condition is not a disease or illness. Instead it is essential that the potentially toxic environment is remedied and made healthy for all.
- To require 'proof' runs contrary to the intention of the UK Equality Act of 2010, disability legislation under the UK Health & Safety at Work Act of 1974 and the UN Convention of the Rights of Persons with Disabilities. 'Proof' is not required in, say, a theatre for a customer to be asked for 'proof' of a disability. Rather, the disabled person is accepted as disabled and provided with the necessary help to cope with

their disability in that situation. To require 'proof' is discrimination and is banned, since it is always an individual reaction in particular circumstances.

Restriction of the channels through which bulbs can be sold or advertised

This could be accomplished through relevant light sources being made available through the following channels:

- they could be sold as medical supplies rather than lighting supplies, for example from some pharmacies or disability products suppliers. This would allow the Eco-Design Regulations to allow an exemption for the production of 'medical lighting products' for people with photosensitivity. People accessing the lighting products through pharmacists etc would enable producers to measure the demand for the products.
- being reclassified as medical devices available on prescription across member states under Directive 2011/24/EU. This uses existing procedures, and access to the lighting would be treated as accessing any other prescription product.
- they could be accessed through Government schemes to help disabled people (e.g. Access to Work in the UK). A Government scheme would be another way of measuring demand for these products.
- they could be prohibited under the regulation from being advertised or sold alongside other lighting products
- In addition, all lighting should be labelled with full information regarding flicker rates, spectral content, colour temperature, intensity dispersion capability etc to help photosensitive people and others determine which, if any, of the types of lighting on sale they can tolerate and to select it for future purchases.