anses
French agency for food, environmental and occupational health & safety
Investigate, evaluate, protect

# Press Kit

14 May 2019

# Effects of systems using LEDs on human health and the environment

## ANSES 2019 expert assessment

*Press liaison: +33 (0)1 49 77 13 77 / 22 26 - presse@anses.fr*
*Follow ANSES on www.anses.fr*

# Contents

# Press release

## LEDs: ANSES's recommendations for limiting exposure to blue light

**Now that the use of LEDs for lighting has become widespread and the number of LED objects has proliferated, ANSES is publishing an update of its 2010 expert appraisal on the health effects of LEDs in light of new scientific knowledge. The Agency confirms the toxicity of blue light on the retina and highlights the biological rhythm and sleep disruption associated with exposure to blue light in the evening or at night, particularly via screens and especially for children. The Agency therefore recommends limiting the use of LED devices with the highest blue-light content, especially for children, and reducing light pollution as much as possible to preserve the environment.**

Against a backdrop of energy-saving policies and the phasing-out of traditional lamps (incandescent and halogen lamps), LEDs have seen strong growth due to their energy-efficient performance. In a few decades, therefore, the population's exposure to blue light has increased sharply, especially in the evening with artificial lighting or screens rich in blue light. This is due to the unique technological characteristics of LEDs, which enable them to emit more short-wavelength light, known as "blue-rich". This lighting is more intense than other light sources, and can have effects on human health and the environment.

When this technology was initially deployed, ANSES's first expert appraisal underlined the retinal toxicity of the blue light contained in LED lighting systems and recommended adapting the regulatory and normative framework. As a result, for domestic lighting, only LED lamps in risk groups 0 or 1 (in accordance with the NF-EN-62471 standard on photobiological safety) are currently accessible to the general public. The most at-risk lighting systems (groups 2 and 3) are reserved for professional use under conditions that guarantee worker safety.

Today, ANSES is publishing a new expert appraisal covering all LED systems and taking into account all the scientific data acquired since 2010.

### Demonstration of new effects associated with the blue light of LEDs

The new scientific 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). "Warm white" domestic LED lighting is no different from traditional lighting and has a low risk of phototoxicity. On the other hand, other types of LED lighting systems, such as hand-held lamps, vehicle lights, decorations or toys, may emit particularly blue-rich light and belong to risk group 2, and yet they are not covered by the current regulations.

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. ANSES stresses that the screens of computers, smartphones and tablets are major sources of blue-rich light, and children and adolescents, whose eyes do not fully filter blue light, are a particularly susceptible population.

The expert appraisal also showed that a high proportion of LED lamps have significant variations in light intensity. Some groups of people, such as children, adolescents and workers, may be more susceptible to the potential effects of this light modulation: headaches, visual fatigue, risk of accidents, etc.

### Adapt the regulations and improve the information provided to the public about the risks associated with exposure to blue light

In view of the results of its expert appraisal, ANSES is making a series of recommendations to limit the population's exposure to blue light. The Agency reiterates the importance of favouring "warm white" domestic lighting (colour temperature below 3000 K). To prevent the disruptive effect on biological

rhythms, it recommends limiting the exposure of people – children in particular – to the blue-rich light of LED screens (mobile phones, tablets, computers, etc.) before bedtime and at night.

In addition, ANSES recommends adapting the regulatory framework for all LED systems, particularly in order to:

- restrict the sale of LED objects to the general public to those in photobiological risk group 0 or 1;
- limit the light intensity of vehicle lights, while guaranteeing road safety;
- minimise the temporal modulation of the light emitted by all light sources (lighting, screens, other LED objects).

Moreover, with regard to the protective devices available to the general public, such as treated lenses, protective glasses or specific screens, the Agency stresses that their effectiveness against the effects of blue light on the retina varies widely. Moreover, their effectiveness at preserving circadian rhythms has not yet been proven. ANSES encourages the establishment of standards defining performance criteria for protective equipment in relation to blue light.

**An impact on biodiversity and the environment**

Concerning the environment, the available studies mainly focus on artificial light at night in general and not specifically on LEDs. Regardless of the studied ecosystem, scientific knowledge consistently shows an increase in mortality and a decline in the diversity of the animal and plant species studied in environments lit at night, including by LED lighting systems. The Agency recommends strengthening regulations to limit light pollution, while ensuring public safety.

# An expert appraisal broadened to include all LED devices

ANSES's expert appraisal sought to update the state of knowledge since 2010 on the various health effects likely to be associated with exposure to blue-rich light as well as other characteristics of LED lighting, which are different from other lighting technologies. To do so, it used a methodology for assessing the levels of evidence associated with the health effects in question. In total, more than 600 scientific publications were analysed.

In addition, to obtain data on the population's exposure to LED technologies, the Agency funded specific measurement campaigns, in particular to describe the type and quantity of light emitted by LED systems used on a daily basis. Three studies were therefore conducted:

- A study in partnership with the French National Consumer Institute (INC) on the technical properties of various lighting systems available on the market.
- A study conducted by the French Scientific and Technical Centre for Building (CSTB), in order to characterise the population's exposure to various artificial lighting and LED systems, in real conditions of exposure. A software program developed to that end enabled light exposure to be assessed for several exposure scenarios (children, workers, elderly people, etc.).
- A study conducted by the CSTB to assess the blue-light filtration capacities of protective devices intended for the general public (screen filters, treated lenses, blocking glasses, software protection).

## 1. The toxic effects of blue light confirmed

Acute exposure to intense blue light can lead to a permanent, partial or total loss of vision over time. The ANSES expert appraisal conducted in 2010 demonstrated the toxicity of blue light to the retina. The new scientific data support this result and identify short-term phototoxic effects associated with acute exposure to blue-rich light, and long-term effects associated with chronic exposure over several years, which may increase the risk of developing age-related macular degeneration (ARMD). Some animal studies also show that the retina is more vulnerable to phototoxic effects at night.

Measurements carried out as part of the studies funded by ANSES showed that some LED lighting devices, such as hand-held lamps, head torches, toys, some vehicle lights and some telephone and tablet screens emit particularly blue-rich light (devices that can be classified in risk group 2). In addition, the experts mentioned the significant commercial development of small bare decorative LEDs emitting blue light, particularly for ornamental items such as string lights and ambient lighting.

**ANSES therefore points out that LED lighting and objects can significantly increase exposure to blue light and the risk of phototoxicity.**

The Agency also confirms the high risk of glare induced by high-intensity LED lighting and certain devices in particular: hand-held lamps, vehicle lights, LED spotlights or LED arrays. Several factors can modulate these effects, such as advanced age.

## 2. Exposure to blue light in the evening disrupts the body's biological clock and sleep

The body's internal clock, which regulates many essential biological functions, including our sleep rhythm, needs a high level of brightness during the day and total darkness at night to synchronise. Adequate regulation of production of the sleep hormone, melatonin, is therefore essential for properly synchronising all biological functions with the day/night rhythm.
However, current lifestyle habits are increasingly tending to disrupt this circadian rhythm, with intense light exposure in the evening and at night via lighting and screens.

Several experimental studies conducted in humans, in which people were exposed to blue-rich lights from artificial lighting or screens (computers, telephones, tablets, etc.), indicate that even very low exposure to blue-rich light in the evening has an impact on the circadian clock: nocturnal melatonin synthesis is delayed or inhibited. The measurement campaigns showed that the light emitted by screens of televisions, computers, mobile telephones or tablets was particularly rich in blue light (4100 K to 7000 K). Some LED lighting sources can also be very rich in blue light (colour temperature around 6500 K).

**The Agency concludes that exposure before bedtime to LED lighting and screens enriched with blue light can adversely affect sleep duration and quality. It draws attention to the fact that children and adolescents, exposed from a very early age to screens in particular (tablets, game consoles, mobile telephones, etc.), constitute a particularly susceptible population group.**

## 3. Effects related to variations in light

LED lamps are highly sensitive to electrical current fluctuations, and this can vary to different degrees the intensity of the light they emit. This is known as "temporal light modulation". This modulation varies according to the quality of the electronics associated with the marketed LED.

Three visual phenomena were described in the expert appraisal: flicker, the stroboscopic effect (apparent immobility or slowing of a moving object) and the phantom array effect (persistence of an image during a brief eye movement). Effects can be induced directly by these phenomena, or appear without conscious perception of any modulation. These include visual fatigue, headaches, migraines, traffic accidents and those related to the use of machines, or even epilepsy attacks.

According to the available data, it is estimated that a significant number of household LED lamps have degraded temporal modulation performance compared to halogen and compact fluorescent technologies. Some groups of people, such as children, adolescents and workers, may be more susceptible to the potential effects of this light modulation: headaches, visual fatigue, risk of accidents, etc.

## 4. Susceptible populations identified

The expert appraisal highlighted certain populations at higher risk from blue light, particularly children, as their crystalline lens – which protects the retina – is still developing until the age of 20.

**More specifically, the susceptible populations are:**

- infants, children and adolescents, due to a clearer crystalline lens (phototoxicity, circadian clock disruption and effects associated with temporal light modulation);
- aphakic (no crystalline lens) and pseudophakic (with an artificial crystalline lens) individuals (phototoxicity, circadian clock disruption);
- pregnant women, due to potential health effects on the unborn child (circadian clock disruption);
- elderly people (effects associated with glare);
- professionals with particularly high exposure to LED lighting (effects associated with temporal light modulation), night workers (circadian clock disruption and phototoxicity);
- people with eye diseases or abnormalities (phototoxicity), people with sleep disorders (circadian clock disturbance), people with migraines (effects associated with temporal light modulation).

## 5. Devices providing protection against blue light

The experts analysed the various protective solutions that claim to reduce or eliminate the effects of blue light, such as filters built into computer screens or into the lenses of corrective glasses, or tinted lenses.

On completion of these analyses, ANSES stressed that the effectiveness of these devices providing protection against the phototoxicity of blue light varies greatly. In addition, no effectiveness has been demonstrated against long-term exposure or against the effects of sleep onset delay.

- Specific blue-light-blocking glasses are more effective at filtering than treated ophthalmic lenses, but neither system is effective enough to be considered as personal protective equipment (PPE) regarding the risk of acute retinal phototoxicity resulting from prolonged exposure to a very high-intensity LED source.
- Depending on the protective devices tested, the capacity to filter blue radiation in the melanopic band (circadian rhythms) was highly variable: it cannot be said that this filtration is sufficient to prevent the decrease in melatonin secretion induced by exposure to light in the evening and the related effects of sleep onset delay.
- Concerning the screens claiming to limit blue-light emissions, no real effectiveness was observed. However, reducing the colour temperature (switching to warm white) and brightness of the screens was somewhat effective at reducing the quantity of blue light in the spectrum.

## 6. Impact on the environment and biodiversity

The available studies mainly focus on artificial light at night in general and not specifically on LEDs. Regardless of the ecosystem examined, current studies show a long-term increase in mortality and a decline in the diversity of the animal and plant species studied in environments lit at night, including by LED lighting systems.

These effects, in addition to other physical and chemical nuisances and combined with the effects of climate change, are all factors that certain animal and plant populations will probably be incapable of coping with, which will speed up the decline in biodiversity.

The categories of LED lighting systems that may be responsible for the greatest increases in light pollution are illuminated signs, billboards and advertising, lighting for commercial, agricultural, aquaculture and industrial zones, and lighting for outdoor car parks in these zones.

# ANSES's recommendations

In view of the results of its expert appraisal, ANSES is making a series of recommendations to limit exposure to blue light:

**Raise awareness and provide information to the public in order to limit exposure, especially that of children:**

- to blue-rich light before bedtime and during the night (LED screens: mobile telephones, tablets, computers, etc.);
- to blue-rich lighting, i.e. "cool white" lamps and lighting fixtures, by favouring indirect lighting or using diffusers; >> opt instead for "warm white" domestic lighting (low colour temperature);
- to direct light from LED objects in risk group 2 or higher (hand-held lamps, toys, vehicle lights, etc.).

**Strengthen the regulatory framework**

Adapt the regulatory framework for all LED systems, in particular to:

- restrict the sale of LED objects to the general public to those in photobiological risk group 0 or 1;
- limit the light intensity of vehicle lights, while guaranteeing road safety;
- minimise the temporal modulation of the light emitted by all light sources (lighting systems, screens, other LED objects).

In addition, ANSES stresses the need to revise the exposure limits for blue light in view of the new experimental data available on phototoxicity mechanisms. These values should especially take into account the specific situation of children.

The Agency also encourages the establishment of standards defining performance criteria for personal protective equipment in relation to blue light.

Concerning the environment, ANSES recommends limiting light pollution, while ensuring public safety. Replacing street lamps and indoor lamps with LEDs could contribute to reducing light pollution, by better targeting of the areas to be illuminated (and thus limiting diffusion) and by modulating the quality and intensity of the light emitted, as enabled by LED technology.

**Advance knowledge in order to better quantify the levels of risk associated with the identified effects, and in particular:**

- improve knowledge of exposure for the general population, workers and the environment;
- better characterise the effects associated with the temporal modulation of the light from LEDs in addition to long-term phototoxicity;
- clarify the exposure-response relationship between exposure and the occurrence of health effects (especially those involving circadian disruption, phototoxicity, etc.).

# A few points about LEDs and lighting

Light-emitting diodes (LEDs) are electronic light source components used in different lighting systems, screen backlights and light objects. Until the 1990s, LEDs were only available in red, yellow or green and were used as indicator lights in electronic equipment such as remote controls or alarm clocks. With the creation of the first blue LED, it became possible, by combining it with a material that re-emits photons in longer wavelengths, to create a white light intense enough to be used in lighting. Since then, technological research has continuously improved their performance, focusing mainly on the materials or the combination of different types of LEDs. LED technology is now used in many lighting devices: traffic lights, portable lighting systems, vehicle lights, and domestic and public lighting.

**Key dates in the history of LEDs**

**1907:** discovery of the first electroluminescence phenomenon by Henry Round

**1962**: first red LED created by Nick Holonyak

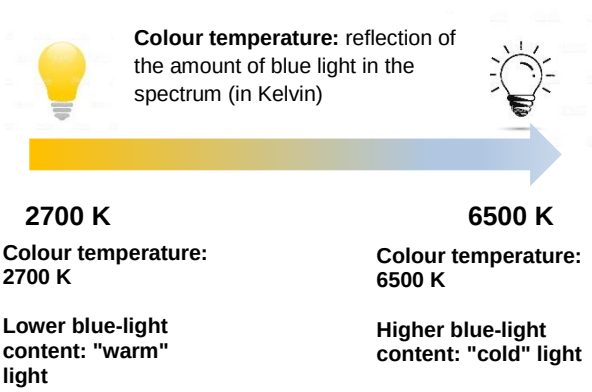
**1992**: first blue LED developed by Shuji Nakamura, enabling white light to be produced

**2000**: production of power LEDs began

**2014**: Nobel Prize in Physics awarded to the inventors of the blue LED

## From blue light to white light

By coupling a blue LED to a layer of phosphorus, which is usually yellow, a white light is obtained. The respective proportions of blue and yellow emissions yield a white that is either "cool" or "warm". The light spectrum of a lamp depends on the lighting technology. If there is a large proportion of blue in the lamp's spectrum, the light is similar to that of the midday sun and is known as a "cool" light. If red dominates, the light resembles that of the setting sun: it is then known as a "warm" light. It is important to note that the lower the colour temperature, the "warmer" the colour of the LED.



**Colour temperature:** reflection of the amount of blue light in the spectrum (in Kelvin)

**2700 K**

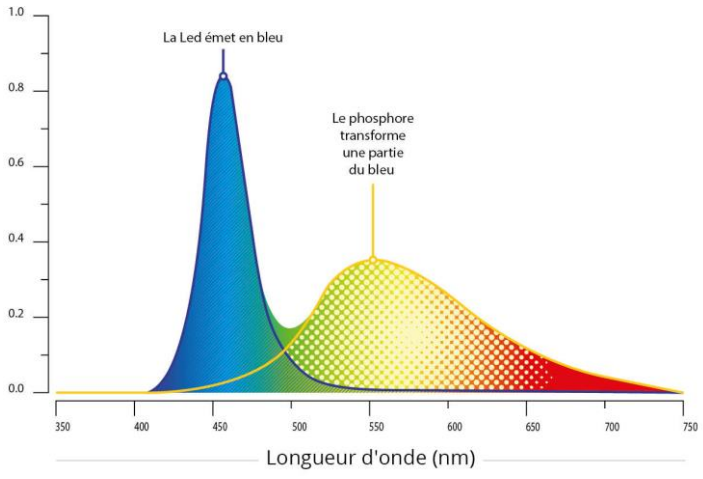
**Colour temperature: 2700 K**

**Lower blue-light content: "warm" light**

**6500 K**

**Colour temperature: 6500 K**

**Higher blue-light content: "cold" light**



## A widespread technology in everyday use

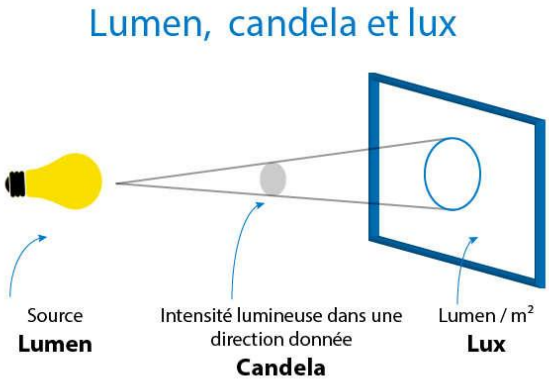
Due to their low power consumption and high efficiency, LEDs offer outstanding energy performance and environmental advantages compared to other types of lighting. As part of application of the European Directive on eco-design[1], the planned phasing-out of conventional incandescent and halogen lamps has led to a sharp increase in LED lighting on the consumer market, thereby increasing the population's exposure to this technology. The scope of LED systems has expanded: it now includes not only a large number of applications for professional use, but also applications for public use such as displays and signs, certain objects and devices (toys, decorative objects, etc.), backlighting in screens (mobile telephones, tablets, televisions, etc.) and indoor and outdoor lighting.

**Phototoxicity regulations and standards**

- The European "Low Voltage" Directive (2014/35/EU) on the harmonisation of the laws of the Member States relating to the marketing of electrical equipment designed for use within certain voltage limits, aims to ensure that electrical equipment on the European market meets requirements providing a high level of protection of individuals' health and safety.
- European Directive 2006/25/EC of 5 April 2006 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (artificial optical radiation - AOR) includes risk related to blue light.
- Exposure limits for blue light are defined by the International Commission on Non-ionizing Radiation Protection (ICNIRP).
- Risk groups: the standard on photobiological safety (NF EN 62471) refers to the ICNIRP's limit values and proposes that lamps be classified into risk groups: risk group 0 (no risk), 1 (low risk), 2 (moderate risk), or 3 (high risk).
- Since 2015, harmonised lighting standards have included photobiological safety requirements limiting the possible effects of radiation on eyes and skin. Regarding lamps, the requirements consist in limiting the photobiological risk group to level 0 or 1 in accordance with the NF EN 62471 standard.

**Not to be confused...**

**Lumens** indicate the amount of light emitted by a lamp (light output), while **lux** indicates the amount of light received on a surface (illuminance). The light intensity of a light source in a given direction is expressed in **candela**.
**Luminance** is a quantity corresponding to the perceived brightness of a surface. A very bright surface has high luminance, while a completely black surface has zero luminance. Luminance is expressed in candela per m².




**1** EuP (Energy-using Products) Directive No 2005/32/EC

## Who we are

ANSES is a public administrative institution (EPA)
founded in 2010 and accountable to five ministries:
the Ministries of Agriculture, Consumer Affairs, the Environment, Health and Labour.

ANSES's expertise covers health risk assessment in the areas of food, the environment and work,
with a view to informing the public authorities on health issues,
supported by a network of nine laboratories.
The Agency is responsible for human, animal and plant health issues, subscribing to the concept of one health for the benefit of all.
It assesses all the chemical, biological and physical risks to which humans may be exposed,
at all ages and times of their lives,
whether at work, while travelling, while engaging in leisure activities, or via their food.

It relies on a form of governance that is open to all the stakeholders,
and on dialogue committees whose mission is to inform the Agency about society's expectations in terms of risk assessment and research.


anses
French agency for food, environmental
and occupational health & safety
Investigate, evaluate, protect