There are Several ways of Lighting the Future

Comments on EC Green Paper

Lighting the Future
Accelerating the Deployment
of Innovative Lighting Technologies

There are several ways of Lighting the Future

Recognizing that the Green Paper “Lighting the Future” will constitute a basic reference in the development of an innovator European illumination policy, with particular impact on outdoor lighting, it seems appropriate and forward-looking to take into account the desirable requirements of Smart Lighting. This concept needs the use of a much wider perspective, focusing on general interests of European citizens.

The Solid State Lighting (SSL) is a substantial change in the illumination concept. It is in fact one of the most innovative technologies emerging in the market. However, beyond its recognised advantages, there has been little discussion either regarding documented or potential environmental impacts arising from the change in spectral energy distribution, or the criteria to be used in the design of outdoor lighting.

The Green Paper states that it could contribute substantially to the objectives of the Europe 2020 strategy for smart, sustainable and inclusive growth and in particular to its energy efficiency improvement target. But we cannot forget that the European Union Strategy remarks that sustainable growth also means protecting the envi-

ronment and capitalising on Europe's leadership in developing new "green technologies".

The great importance that this process would have in terms of energy sustainability should be emphasized. However, the concept of energy sustainability takes into account other aspects besides energy efficiency, such as health and human well-being, and the ecological dimension, which are all included within the "intelligent energy" concept.

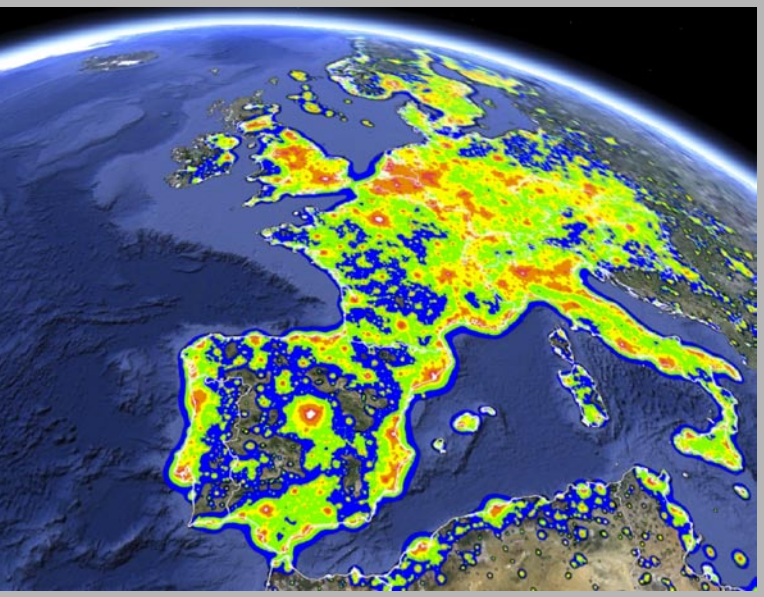
It should be reminded that the continuous increase of efficiency in producing light for outdoor use in the last century has reflected into an increase of light output with the connected light pollution and not in a decrease of energy consumption at equal light flux produced. This cannot happen again with the advent of SSL.

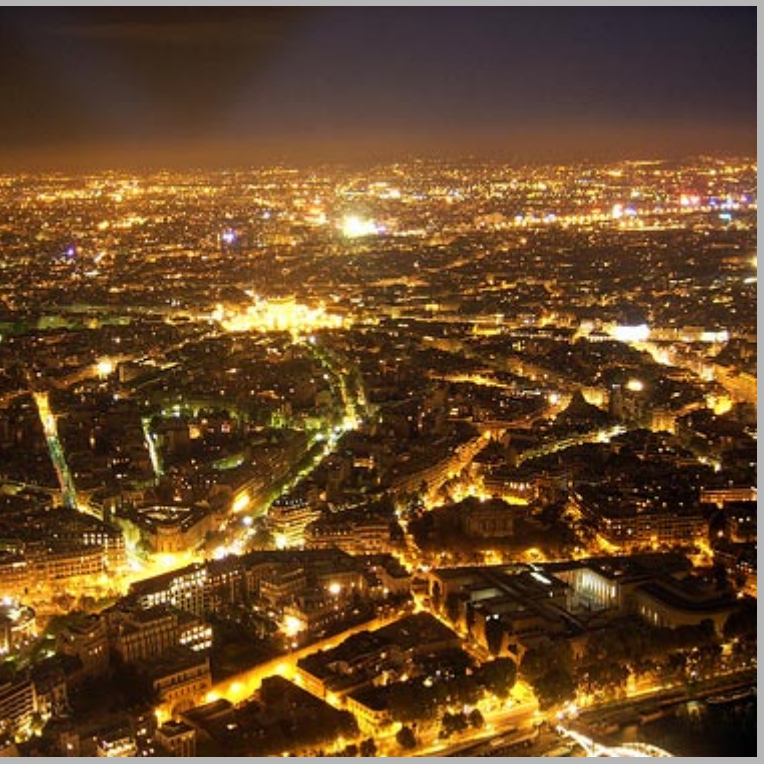
The search for SSL efficiency cannot be separated from the side, dangerous and pollutant effects of Light At Night (LAN). A parallel can be traced with the automobile industry. If the only aim would be to have more efficient cars, then we should cut away all the pollutant abatement systems of the engines. We'll surely obtain far a higher efficiency, at the expense of far higher pollutant production. With light it is the same, we cannot pursue efficiency unbounded to all the other aspects. For example, it is surely more advantageous for the community to have a little lower efficiency, but with a higher human health compatibility by decreasing the blue content of LEDs.

The Green Paper mentions the eco-design as the basis for the development of an innovator illumination policy, but as far as outdoor lighting is concerned, key issues such as health, environmental impact, and reduction of light pollution in general are not addressed. Nevertheless, we are convinced that it is possible to adopt Smart Lighting criteria that, combining technological and scientific innovation, contribute to energy saving and reduce light pollution and its effects at the same time.

The defence of the quality of the night sky as an environmental, cultural, and scientific right, as well as the reduction of the effects of light pollution, should be considered by any innovator outdoor lighting policy and, therefore, also integrated in the mission of the Green Paper.

Many international organizations and institutions are clearly positioned along this line. Particularly notable, among the others, the Starlight Declaration (2007) promoted by UNESCO, UNWTO, IAU, IAC and supported by several International Conventions (Ramsar, CBD, CMS, WHC). Point 7 of this Declaration states that: "The intelligent use of artificial lighting that minimises sky glow and avoids obtrusive visual impact on both humans and wildlife has to be promoted. Public administrations, the lighting industry, and decision makers should also ensure that all users of artificial light do so responsibly as part of an integral part of planning and energy sustainability policies, which should be supported by light pollution measuring, both from the ground and from space. This strategy would involve a more efficient use of energy so as to meet the wider commitments made on climate change and for the protection of the environment".





Summary of the suggestions to the Green Paper

a. Consider that the first step toward efficiency is to limit the unnecessary light.

b. Push for the adoption of standard rules that allow a substantial reduction of the levels currently used in outdoor lighting, guiding the market of SSL technologies.

c. Carry out research work to see if and how light lowers crime and/or traffic accidents.

d. Weight the benefits (eventually found in point c) against the benefits of different actions having the same cost (e.g.: more control by police).

e. Consider the health problems of using light at night, especially with blue content and so limit the blue content of light used at night indoor and outdoor.

f. Properly define the concept of eco-friendly technologies, which besides energy efficiency should take into account the control of light pollution by giving the following minimum prescriptions:
   - do not allow luminaires to send any light directly at and above the horizontal;
   - do not waste downward light flux outside the area to be lit;
   - avoid over lighting;
   - shut off lights when the area is not in use;
   - aim for zero growth of the total installed flux, then a decrease (like it is happening to all other pollutants);
   - strongly limit the short wavelength ‘blue’ light.

g. Warn that specific light frequencies with a high blue component affect many wildlife species and alter ecosystem function in urban environments and beyond them.

Comments to the Green Paper

The first step toward efficiency is to limit the unnecessary light. It is nonsense to install high efficiency lights that are unnecessary. They'll have an infinite cost/utility ratio. We keep our cities, villages, infrastructures lighted all night long with illuminances that are higher and higher. Why?

Because most people think that lighting our environment as much as possible will lower crime and traffic accidents. But first of all these claims must be proven, before using them to spend billions of Euros annually to power public and private lighting.

So the first step to do is to make independent (from lighting industry) studies with strong statistics (randomised trials and a register of trials before the publication, following the example of health research) (Marchant, 2004, 2005, 2006).

If and when there will be a proof of the efficacy of the light on crime and/or traffic accident reduction, then the cost of the implementation of light (all costs, not only the electric energy) should be compared to the cost of other possible crime/traffic accident prevention method (more control by police, for example).

If the proof will not be given, then most of the reasons to light up our environment at night fails.

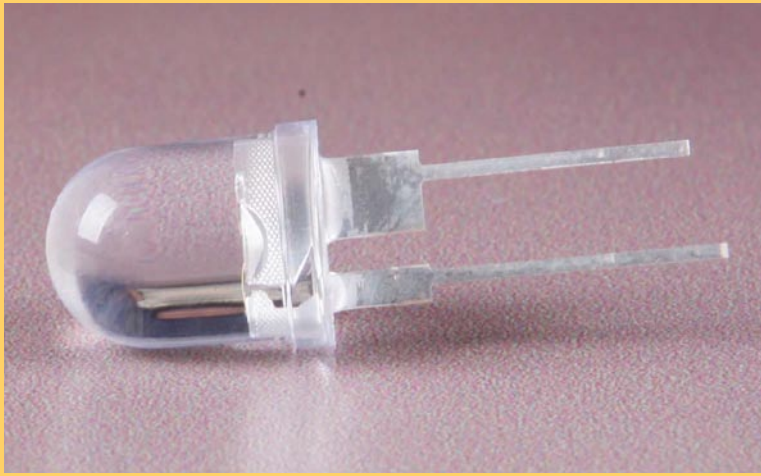
At page 4 of the Green Paper, the SSL instantaneous switching and dimming capability is cited. But the standard rules for road lighting don't allow for a substantial dimming of street lighting. The great potential of SSL is that we can keep them off (or dimmed to 1 tenth or less the normal flux) and, once there will be necessity, a motion or presence detector will light up all the street. In this way we could save most of the energy now wasted to light up roads, parking lots and other outdoor places when none is there. This will be a real advantage of SSL over High Intensity Discharge lamps.

In the same page, in the paragraph on 'lighting quality and visual control' the Green Paper talks about the advantage of some LED lighting in well-being, alertness, concentration and so on. The Green Paper should say that these are advantages when artificial light is used during the day, but disadvantages for our health at night. So, high colour temperature LEDs may be good in lighting building interiors during the day, but may be very dangerous at night (both indoor and outdoor).

Not a word in the Green Paper is given on light pollution, i.e. the alteration of natural light levels in the night environment produced by introduction of artificial light.

There is reliable scientific evidence that this artificial extension of the day produces serious adverse consequences to human health and environment, even if SCENIHR seems not aware of it and limits its comments on the consequences of blue light on the retina only.

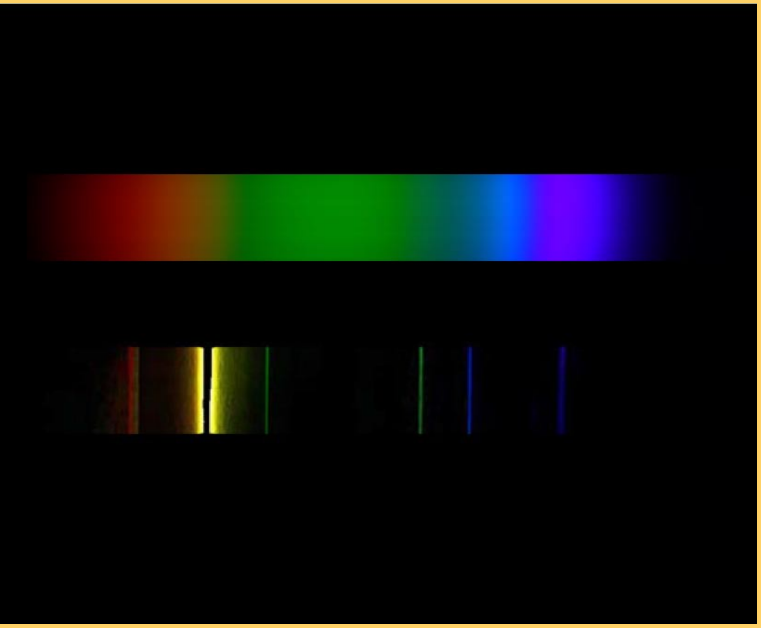
There are no doubts that exposure to LAN decreases the pineal secretion of melatonin (MLT). The two variables responsible for the suppression of MLT production are light intensity and wavelength, along with timing and exposure duration. As research progresses, light intensity levels found to suppress MLT production are decreasing. In 1980 Lewy et al. showed that bright light at an order of thousands of lux suppressed the secretion. While more recent studies found that illuminance in the order of 1 lux or even less affects circadian rhythms (Wright et al., 2001, Glickman et al., 2002). The discovery, about ten years ago, of a novel photoreceptor, the *Non Image Forming Photorecep-*



tor, and of the photopygment *melanopsin* allowed a better understanding of light perception by humans. These discoveries showed the effects of light spectrum in the human response to LAN exposure (Thapan et al. 2001; Brainard et al. 2001; Hankins & Lucas 2002; He et al. 2003; Berman & Clear 2008; Leonid et al. 2005). The results of a study (Cajochen et al. 2005), in which the impact of wavelength on humans was assessed by measuring melatonin, alertness, thermoregulation and heart rate, were that exposure of 2 h to monochromatic light at 460 nm in the late evening significantly suppressed melatonin secretion. Such effects were not observed under the same intensity, exposure timing and duration but at wavelength of 550 nm.

Gooley et al. (2011) showed that typical evening bedroom illumination is sufficient to reduce and delay MLT production. All these studies found that MLT suppression by LAN is wavelength depended and intensities can be much lower than those believed to suppress MLT production several decades ago.

Since melatonin is an oncostatic or anti-carcinogenic agent, its deprivation in blood due to exposure to LAN may encourage the growth of some type of cancers (Glickman et al. 2002; Stevens et al. 2007; Kloog et al. 2008, 2009; Bullough et al. 2006; Haim et al. 2010). MLT seems also to have an influence on coronary heart disease (Brugger et al. 1995). As seen, LAN acts directly on physiology, but also indirectly by causing sleep disorders and deprivation that may have negative effects on several disorders such as diabetes, obesity and others (Haus & Smolensky 2006; Bass & Turek 2005; Reiter et al. 2011a; Reiter et al. 2011b; Bray & Young 2012). Physiological, epidemiological and ecological consequences of LAN are discussed in Navara & Nelson (2007) and Fonken & Nelson (2011).



The International Agency for Research on Cancer has added to the list of group 2A (probably carcinogenic to humans) shiftwork that involves circadian disruption (Straif et al. 2007). As seen, circadian disruption can be induced by LAN exposure. Light at night is becoming a public health issue (Pauley 2004; Stevens 2009; Fonken & Nelson 2011). This view is supported by the American Medical Association resolution (2009) saying that light pollution is a public health hazard.

The continuous increase of outdoor lighting combined with the wider and wider use of SSL with a short wavelength emission, will probably have severe negative impact on health.

In the natural night environment, animals and plants are exposed to LAN levels that vary from about 0.05 millilux of the overcast sky, to 0.10 millilux by the starry sky on a moonless night, to 0.02 lux at the quarter moon, to a maximum of 0.1-0.3 lux in the week centred on full moon. The artificial light of a typical road, 10-20 lux, is up to 200 times brighter than the illuminance experienced in the natural environment around new moon. So it is not surprising that artificial LAN has strong environmental effects in behavioural, population and community ecology by affecting the habits in foraging, mating, orientation, migration, communication, competition, and predation. For reviews of ecological consequences of light pollution see (Navara & Nelson 2007; Longcore & Rich 2004; Rich & Longcore 2006; Longcore 2010; Kempenaers et al. 2010; Hölker et al. 2010; Kyba et al. 2011).

These strong evidences of the adverse effects of artificial

light at night on animals and on human health should be balanced against the supposed (yet to be proved) positive effects on safety and security.

Light pollution is not, as commonly believed, just a problem for astronomers. It is a hazard to our environment and our health.

In order to reduce the adverse health effects of decreased melatonin production and circadian rhythm disruption in humans and animals, due to the dependence on wavelength of MLT suppression, we recommend a total ban of night time artificial light at wavelengths shorter than 540 nm. The relatively low emissions of High Pressure Sodium lamps in this spectral range could be set as the upper limit on what can be initially acceptable in terms of short wavelength light emissions. So, the following rule should be observed (Falchi et al. 2011):

The wavelength range of the visible light spectrum under 540 nm, corresponding to high sensitivity of the melatonin suppression action spectrum, should be established as a protected range. Lamps that emit an energy flux in the protected range larger than that emitted by the standard High Pressure Sodium lamp on a basis of equal photopic output should not be installed for nighttimes use.

At page 9 of the Green Paper are mentioned the efforts of EU toward the ecodesign. It should be absolutely clear that no light used outdoor can be eco-friendly if it pollutes the environment. Only for the fact that light is used outdoor at night, it pollutes the environment more or less. Fortunately there are ways to lower the effects of light pollution:

- do not allow luminaires sending any light directly at and above the horizontal;
- do not waste downward light flux outside the area to be lit;
- avoid over lighting;
- shut off lights when the area is not in use;
- aim for zero growth and then a decrease of the total installed flux;
- strongly limit the short wavelength ‘blue’ light.

Application of all these simple and wise rules would permit to light properly cities and, at the same time, to substantially limit the adverse effects of light pollution on ourselves and on the environment.

Therefore, an effective law to control light pollution should implement this set of rules. Most of the Italian regions have already enforced laws with most of these points since 2000. Slovenia has an effective law to limit light pollution too. Other European regions are implementing rules against light pollution. A Green Paper on light cannot avoid having, as the first target, the health of European citizens and their environment.

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Images: William L. Stefanov, Jacobs Technology/ESCG at NASA-JSC,
Cinzano-Falchi-Elvidge/MNRAS, Giubbilini/Buiometria Partecipativa, Paris @ night, Luis Mir/Composition

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