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LIGHTING EDITORIAL 5.0



Dorin BEU

One of the most interesting conferences I have attended this year was ALAN 2013 (Artificial Light At Night) and for two reasons: the interdisciplinary approach on lighting and the location. Beside lighting technology and chronobiology it covered also ecology, socioeconomy and astronomy. I must confess that before this conference I was not aware about impact on insects, birds and fish and knew little about people involved in dark sky protection. Being raised during communist time, with poor lit streets and energy reduction, I was tempted to associate bright light cities and their flashing advertisings as a symbol of civilization. Now, that at 4 am in the morning, some of the buildings are still lit and I am surrounded by blue light Christmas decorations I realized that the truth is somewhere in between (as usual). I am an admirer of French light pollution regulations, with simple measures like switch-off the lights on building facades, shop windows and adverts by 1 am. It is common sense, but these days you have to

regulate such simple solutions. There is a simple solution for checking lighting pollution and is a smartphone app: Verlust Der Nacht. It was one of the major reasons why I had to change my phone as my old one could not have apps. It is a nice gadget and students like to use it.

Second interesting thing about this conference was Berlin. The luminance and illuminance level is beneath the EN 13201 specifications (and this is deliberately), park are lighted (foxes live in the middle of the city) and the criminality is low. For many years we have heard papers making a correlation between rise of criminality and low lighting level and I remember a presentation by former CIE president van Bommel about road lighting where he stressed that current norms are based on research done in 50s and 60s, car headlamps have changed a lot, micro-sleeps etc. so we have to make new researches in this area. This topic was much discussed in Berlin as there is a revision of EN 13201 and there is a pressure to reduce luminance and illuminance levels. But how low you can go, still preserving the sense of safety it is a long discussion.

I am happy to have a paper by *Haim et al* which presents the state-of-the-art in Light At Night – LAN knowledge. Dr. Haim is a person full of charisma and the first time that I heard one of his presentations was in Stockholm at Daylight Symposium and since then I wished to have a paper from him in our journal.

The second paper by *Cañavate-García et al* raises the problem of dark-sky protection in Andalusia from measurement till legislation and gives you an idea of a roadmap to use for your projects.

In Romania we continue our work for lighting specialists' certification. We had the courses in September in Cluj-Napoca and in November in Bucharest. Around 40 people attend this course starting from resellers and ending with architects and interior designers. The main problem was to find lecturers, from universities or third parties, which can deliver a practical course and who can answer all the difficult aspects of today LED lighting

Due to difficulties regarding Ingineria Iluminatului administration we almost cancel this issue, but thanks to Cătălin Gălațanu effort it was possible to be ready on the last minute with this version.



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PROTECTION OF THE NIGHT SKY IN ANDALUSIA: MEASUREMENT, COMMUNICATION, OUTREACH AND LAW

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Abstract: *The night sky of the Autonomous Region of Andalusia has historically enjoyed an exemplary quality, being a worldwide benchmark for astronomical observations. Proof of this, is the situation of two important astronomical observatories within our boundaries. However, the darkness of the sky could be threatened by the indiscriminate growth of outdoor lighting fixtures. Light pollution is a problem that not only affects astronomical observations, but also the natural development of ecosystems and even people's health. A change towards a sustainable model of outdoor lighting is totally necessary to avoid the aforementioned negative consequences. A sustainable model of outdoor lighting also prevents energy wastage, which is directly related to the emission of greenhouse gases and an unnecessary economic expenditure. The Regional Government of Andalusia is driving outstanding efforts in pursuing an integral approach to the protection of the night sky. The Andalusian approach covers all possible fields: advanced legal regulation, education, public outreach, information programs for technicians and for the general public, etc. The scope is not only astronomical (protecting the forefront astronomical facilities in the area), but much wider, taking into account the protection of the ecosystem, the natural landscape, the population and energy savings as well. Changing the habits of a society that associates lighting with economic prosperity is a difficult and slow process. Although, the perseverance, political will and social participation will undoubtedly help to reach the objectives. Regarding this challenge, Local Corporations have a key role and the Regional Administration is therefore providing them with all the possible support.*

Keywords: Light pollution, Environmental Quality

1. Introduction

Andalusia is a region situated in the southern most point of Europe with an area of 87,300 square kilometres and population

of about 8,500,000 inhabitants, it is almost 18 percent of the national total. It is made up of 771 municipalities whose per capita income is below the national average and has a coastline of 945 kilometres. The

tourism sector represents 70 percent of Andalusia's annual income.

A third of the territory of Andalusia is protected due to its great environmental value. Andalusian protected areas represent

30 percent of the total protected areas of Spain. These protected zones are inhabited by many animal and plant species vulnerable to anthropogenic disturbances.

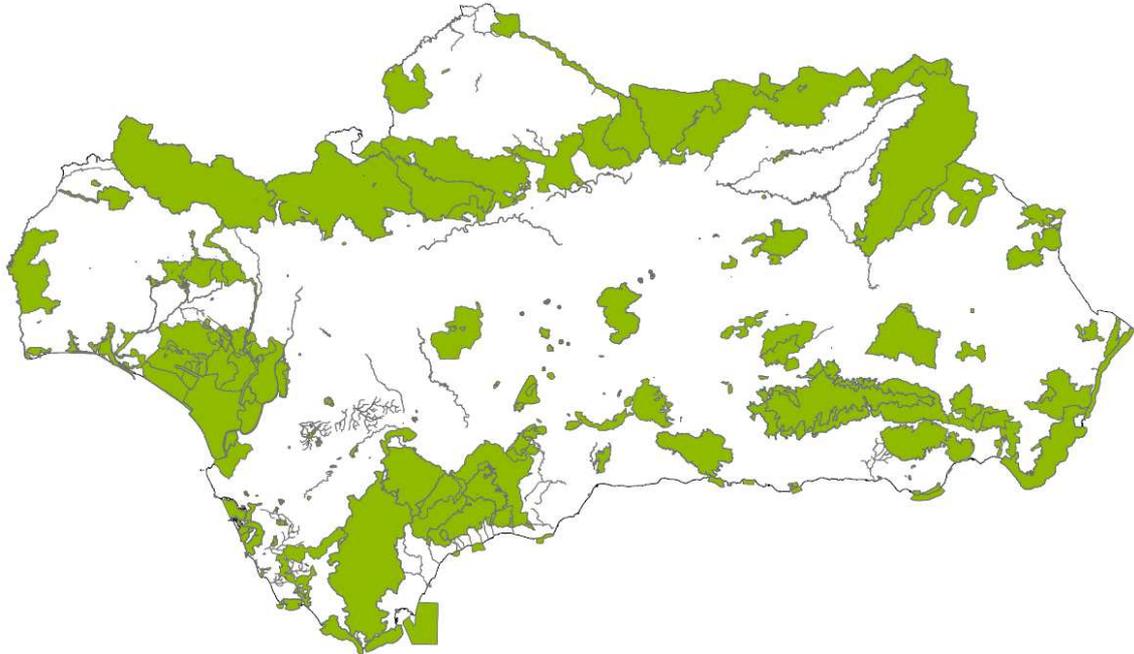


Figure 1 Network of protected natural areas of Andalusia

However, Andalusia's natural areas aren't the only thing that stands out, the night sky has been historically a worldwide benchmark for astronomical observations. Proof of this is the situation of two important astronomical observatories within our boundaries: the German-Spanish Astronomical Centre at Calar Alto and the Sierra Nevada Observatory¹.

Notwithstanding, the natural darkness of these areas and of our night sky is threatened by the growth of outdoor lighting fixtures, which have been, up to date, designed following technical or

economic criteria but, unfortunately, not environmental ones.

In order to protect this natural and astronomical heritage, as well as to guarantee a new economic development model for our territory, Andalusia has placed itself at the forefront of light pollution regulation. The regional government established the first guidelines with the July 9th Law 7/2007 of Integrated Management of Environmental Quality and with its posterior development in the August 3rd Decree 357/2010 which approves the Regulations for the protection of the night sky quality against light

pollution and the establishment of measures for energy saving and efficiency.

The regulation covers all the territory and considers all the aspects: astronomical, environmental, human, cultural, educational and energy savings.

The main principle which governs the regulation is coherence: to illuminate just what we need to see, with the appropriate intensity and direction. It is not a simple task because there are many economic sectors involved, sometimes with conflicting interests and it is necessary to unify lighting, economic and environmental criteria.

2. Andalusian regulation

Decree 357/2010, August 3rd, which approves the regulations for the protection of the night sky quality against light pollution and the establishment of measures for energy saving and efficiency defines light pollution as the emission of luminous flux due to artificial light sources which constitute the night lighting, when these sources have an intensity, direction or spectral ranges inadequate for the execution of the activities planned in the lit zone².

2.1 Objectives

- a) To prevent, minimize and correct the effects of the scattering of artificial light towards the night sky;
- b) To preserve the natural conditions of darkness for the benefit of night ecosystems in general;
- c) To promote the efficient use of lighting, without threatening the safety of users;

- d) To reduce obtrusive light on areas other than those aimed to be illuminated, especially in natural environments and inside residential buildings;
- e) To safeguard the quality of the night sky and to facilitate its vision in general, and especially in the surroundings of astronomical observatories.

2.2 Scope and competent bodies

Outdoor lighting fixtures, technical lighting devices, both public and private, as well as public lighting auxiliary equipment, in the territorial scope of the Autonomous Region of Andalusia.

The competent bodies in the implementation of the regulation are the Ministry for the Environment of the Regional Government of Andalusia and the City Councils.

2.3 Territory zoning

Andalusia's great weather conditions favour the development of night touristic activities at any time of the year. These activities are among the main touristic attractions of our region. In addition, a number of other economic activities take place during the night time and they require artificial lighting. Therefore, it is necessary to make these functions compatible with the following: people's quality of life, protection of vulnerable living beings, night sky observation and astronomical research.

With the aim of combining the demanded maximum protection in the most vulnerable zones with a comfortable night life among our towns and cities, the zoning of Andalusia is outlined in the regulations.

The zoning is understood as the delimitation of diverse lighting areas where different levels of protection will be implemented according to the actual needs of each of them.

The Decree distinguishes between four zones, called E1, E2, E3 and E4, which

have descending levels of protection from light pollution.

The regulation also includes a protection mechanism called reference points, the purpose of which is to protect astronomical observatories. Each reference point has an area of influence which guarantees its protection.

Table 1 Classification and competences for the zoning of Andalusia

ZONE	DESCRIPTION	COMPETENCE
Reference points and zones Z1 and Z2	Astronomical Observatories and corresponding zones of influence	Ministry for the Environment
E1	Zones in Protected Natural Areas	
E2	Zones in developable land and non-developable land, not E1	City Councils
E3	Urban land (population centres and industrial areas)	
E4	High building density zones in urban land with high night activity	

The Regional Government declared in 2012 Calar Alto and Sierra Nevada observatories as reference points and all environmental protected areas of Andalusia as zone E1.

Calar Alto's area of influence is the largest area in Europe protected against light pollution for astronomical reasons.

City councils have the obligation to declare the rest of the zones in their own territory before February of 2015.

2.4 Restrictions to new installations

The most important aspects of the regulation are:

- An upper hemispherical flux of less than 1% for all the territory is required;
- For the darkest areas, lamps must emit more than 85% of their emissions in wavelength over 440 nm or 500 nm in the case of LED technology;
- Lighting and obtrusive light levels to be applied according to the Royal Decree 1890/2008, November 14th;
- Lamps must provide the greatest energy efficiency;
- Lighting fixtures must not project light outside the object or area to be illuminated;
- Ornamental lighting, billboard lighting and advertising sign illumination must be directed downwards;

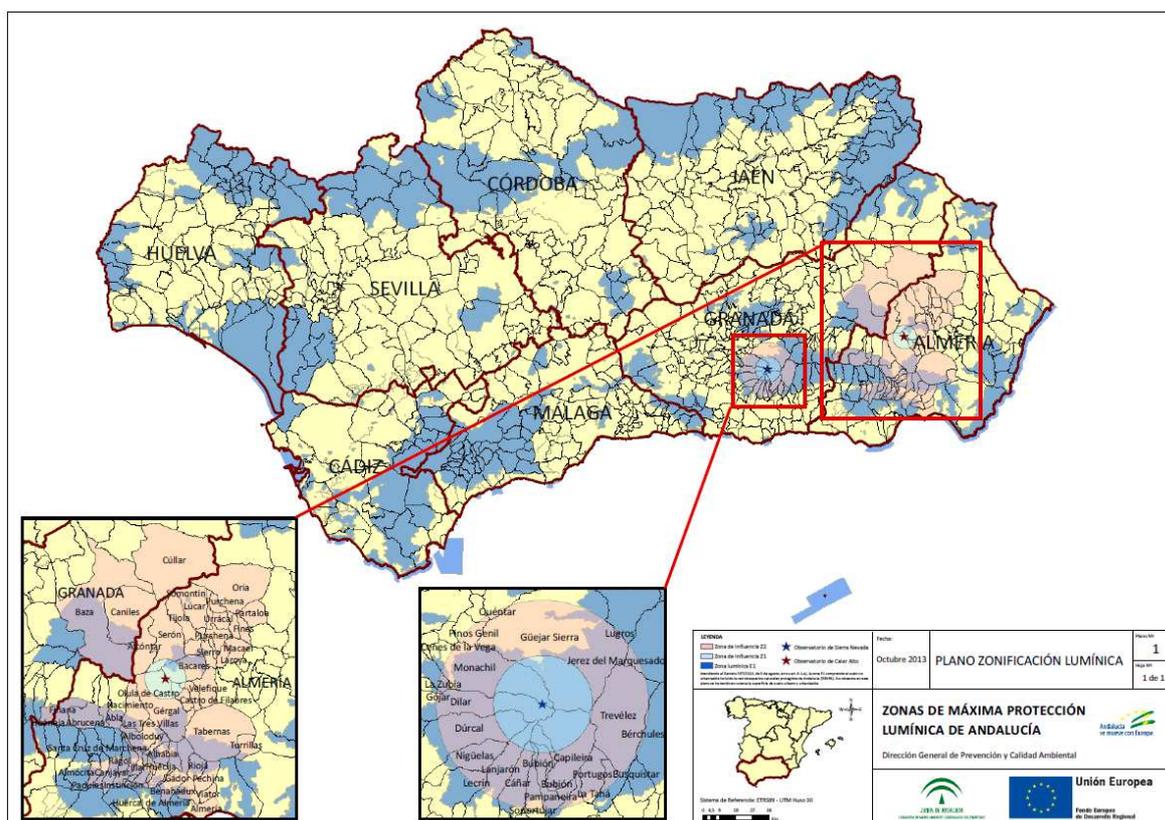


Figure 2 Andalusian E1 Zone

- Automatic regulation systems must be introduced in all new lighting installations for the reduction of light flow during night hours.

2.5 Restrictions to both new and existing installations

- Prohibitions:
 - LEDs, lasers and advertising projectors emitting all their flux above the horizontal level;
 - Lighting of beaches and coastlines outside population centres;
 - Illuminated aerostats for advertising purposes;

- Non-monochromatic lighting devices in Z1 zones;
- Illuminated electric signs in E1 zones;
- Switching off lighting fixtures during night hours, except those needed for safety reasons, in E1 and E2 zones. Switching off the ornamental lighting and luminous advertisements during night hours;

- It will be necessary to substitute lighting fixtures with an upwards light output ratio (ULORinst-upper light output ratio) over 25% before 2020.

It is estimated that the application of the regulations will lead to energy savings equivalent to the annual consumption of almost 40,000 homes, a saving of some 14

million Euros and a reduction in CO2 emissions equivalent to all of the cars in a town of 40,000 people³.

While it is necessary to establish a regulatory framework for the problems caused by pollution of all kinds, in the end, if there is no support from the sectors involved, it is impossible to achieve the objectives. Andalusian Regional Government, despite the critical economic situation, has therefore designed an ambitious communication and training strategy.

3. Support from the Regional Government for the application of the regulation

One of the main objectives of the Regional Ministry of Environment is to guarantee the application of the Decree 357/2010, August

3rd. To achieve this goal some difficulties have to be overcome: the general lack of knowledge about the causes and effects of light pollution, the historical association between a developed society and energy wastage, the sometimes conflicting interests of the sectors involved and the current constraint on resources.

With this purpose, the Ministry for the Environment has launched an extensive strategy which integrates various fundamental sectors:

3.1 Technical support to city councils

The Regional Government is providing Andalusian city councils with all the technical support needed for the implementation of measures derived from this regulation.

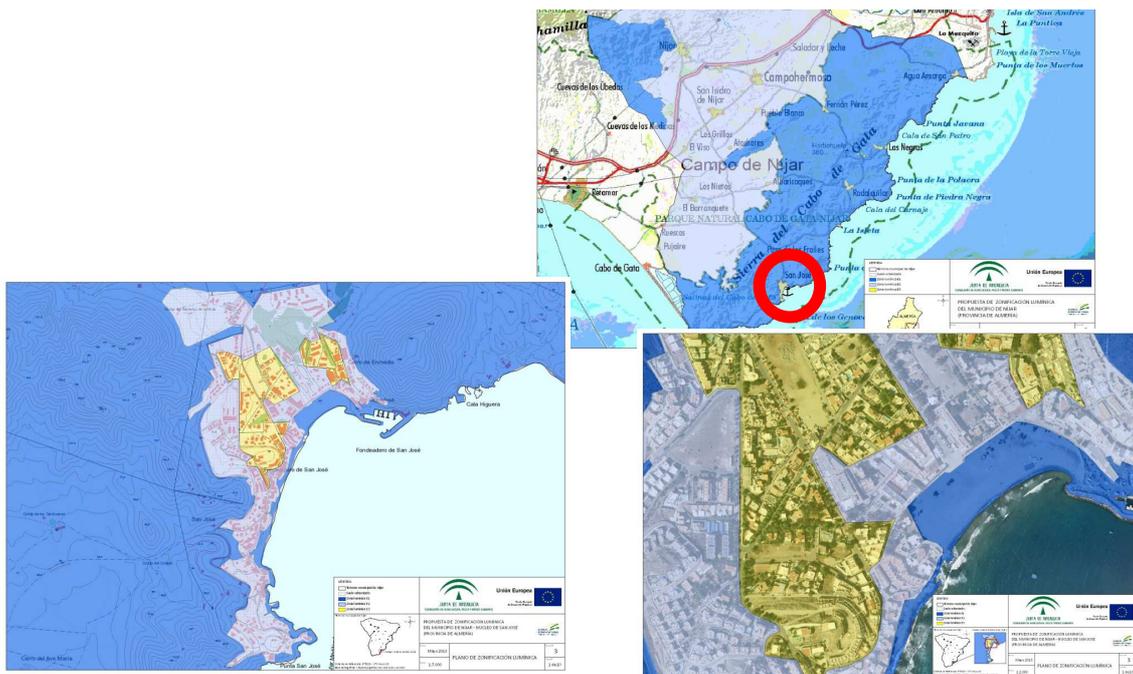


Figure 3 Example of municipal zoning

Regarding the zoning process that the municipalities need to do before 2015, the Regional Ministry is giving them support making a zoning proposal for all of the territory of Andalusia, so local councils just need to make the corrections they consider necessary. Thus, a cartographic output has been developed in PDF format, with layers visible on Google Earth and editable with geographic information systems. The city councils' task of zoning their territory is therefore simplified.

With the same aim of giving support to the Local Authorities, the Regional Ministry of Environment is taking other actions such as the following: the incorporation of light pollution queries through the citizens' advice service, the creation of an e-mail address for online

queries, the publication of a technical guide in order to facilitate the interpretation of the regulations by municipal technicians or **sub-regional training courses** aimed at technicians and municipal responsible for public lighting.

Additionally, since 2011, regional Government is promoting **ten projects adaptation of outdoor lighting** that will serve as example for other cities. The goals are to help municipalities implement the regulations and to promote the participation of environmentally-focused energy service companies as a solution for its financing. As a result, the government offers participating municipalities the inventories for lighting systems, adaptation plan to the regulation, financial analysis and economical support.

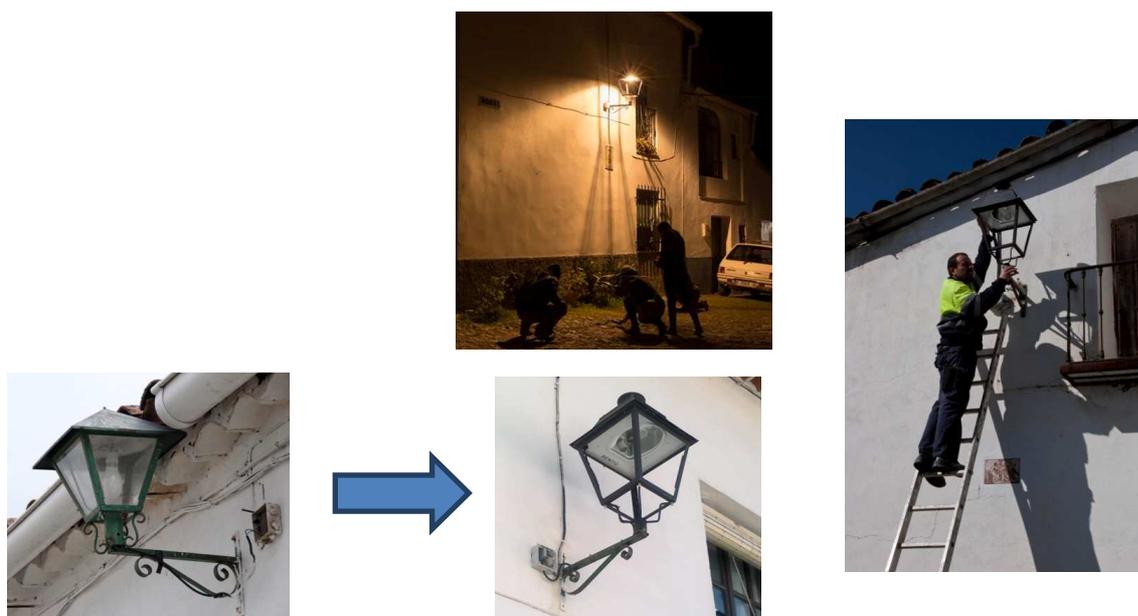


Figure 3 Adaptation of outdoor lighting

3.2 Diagnosis: campaign for measuring night sky quality

In this general frame, measurement and modelling play a central role, and considerable efforts are being devoted to this aspect. A general program to produce a region-wide map of light sky brightness is being developed. Also, several outstanding and innovative instruments have been built in our region, to produce all-sky multi-band scientific-grade photometric measurements,

that will be followed by instruments with all-sky spectroscopic capabilities very soon⁴.

The Government is measuring in order to diagnose the problem and to evaluate the impact of the new regulation. As a starting point it has performed a regional campaign of measurements using Sky Quality Meters, astronomical multiband BVR measurements and satellite images.

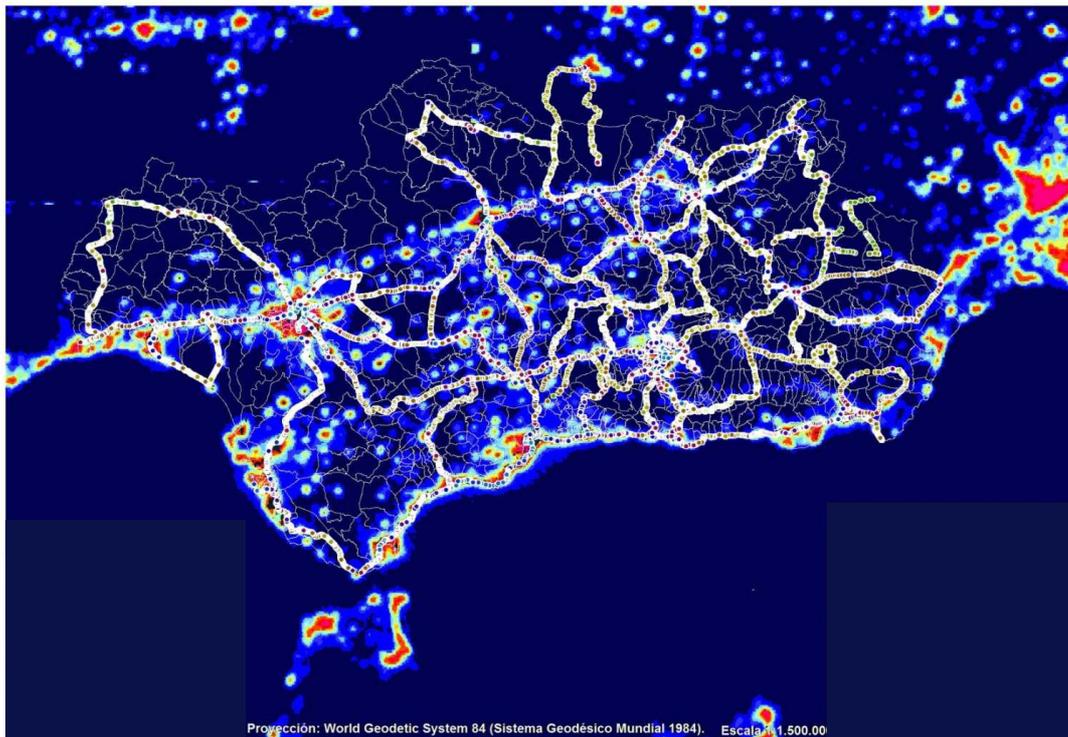


Figure 4 Campaign for measuring night sky quality

More than 20,000 data points of SQM measurements have been performed over the territory.

Then the dates will be compared with satellite images and the outcome will be the

first andalusian map of sky brightness based on real measurements from the ground.

3.3 Training, public outreach and social awareness

A wide training campaign is currently ongoing, targeted towards the university community, teachers and secondary school students, and to professionals of the public and private sectors: education sessions for university students, short-film contests and a teaching unit for primary and secondary school.

In addition, a complete set of materials for public outreach has been produced, covering the main social events of Andalusia's culture. These materials are being distributed in paper and on-line.

Just one example is the brochure on white and blue light⁵.



Figure 5 Brochure on white and blue light

Several outreach campaigns on the problems that light pollution generates, and the solutions to be adopted. Outstanding campaigns are “Natural spaces of Andalusia, quality skies” which aims to

emphasize the value of the Andalusian skies and to enhance astronomical tourism and sustainable development, other one is “How do you light your Christmas?”

aiming to achieve a sustainable lighting during Christmas, among others.

On the other hand, an effective way to reach the entire population is through the organization of competitions. Among them are sustainable short movies, posters, short stories, poetry and street art.

3.4 Creation of an international working group of experts and administrations

In the absence of legislation governing these environmental issues in the European Union, and given the lack of well-defined international guidelines on this matter, Spanish Autonomous Administrations and several countries around the world are approving different regulations, often following very diverse criteria. The aim of creating the international group is to constitute a common working forum to enable the exchange of experiences and to support the development of the regulations and their later implementation.

3.5 Other work in progress

One of the most promising and recent efforts of the Andalusian Government is to link the protection of night sky with economical progress through the promotion of astronomical tourism.

- A specific congress on this will be organized in Granada in 2014;
- The regional Government is preparing a process to promote the certification of the quality of the night skies in Andalusia, through the programs by IDA and Starlight.



Figure 6 Congress on Astronomical Tourism

4. Conclusion

In conclusion, there is a need to protect the night sky. Furthermore, it also needed to emphasize the value of our night skies as cultural heritage, and the value of our astronomical observatories as scientific heritage. Nevertheless, in order to achieve positive results, strategies for light pollution prevention should be supported by awareness and information campaigns. The solutions will be reached through coherence and consensus among manufacturers, Administrations, relevant economic sectors and citizens.

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She works in Environmental Quality Data Center of Environmental and Water Agency of Andalusia (public organization belonging to the Regional Government of Andalusia).

She has been working on light pollution since 2006. Among her main projects, she has worked on the creation of regulation regarding the protection of the quality of the night sky against light pollution.

Currently, she brings technical support for the implementation of regulation's measures.



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Ángela Ranea Palma is specialized in electricity, she has been working for the regional government of Andalusia as the head of the Sustainable Urban Development department since 2008.

Her areas of expertise are sustainable mobility, noise and light pollution. She has launched the endorsement of one of the most advanced legislations in Europe about night sky protection, followed by an ambitious strategy of communication that includes innovative ways of increasing awareness as well as an ongoing training aimed at professionals in both the public and the private sector.

Currently, she is promoting a pilot project about the certification of the night

sky quality as a green-jobs engine for protected areas.



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ARTIFICIAL LIGHT AT NIGHT – IS IT ONLY AN ENGINEERING ISSUE OR IS THERE MUCH MORE TO IT?

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Abstract: *Artificial light at night is becoming a worldwide problem in both developed as well as the developing countries. Massive new building programs in urban areas and increased illumination in public spaces create light pollution. There is no doubt that artificial lighting increases the time we have for work and leisure. However, there are environmental and health issues associated with exposure to light at night. The use of incandescent bulbs is in the process of being phased out in favor of so-called "environmentally friendly" illumination. This is light produced by devices such as light emitting diodes (LEDs) which emit a shorter wavelength of light than regular incandescent bulbs. Indeed, LED illumination is considered the illumination of the future for domestic and public spaces. However, chronobiologists and other scientists are becoming increasingly aware of the health issues associated with the use of such illumination. In this paper, the authors want to share their findings with decision-makers, light engineers and designers in order to stimulate the production of new illumination technologies which are sustainable i.e. energy efficient but not harmful to human health.*

Keywords: light pollution, light emitting diode, health concerns, circadian rhythm, prostate cancer, breast cancer, epigenetic modification.

1. Illumination and energy resources

One of the most dramatic societal changes that took place during the 20th century began with Tomas Edison's revolutionary invention, the incandescent bulb, Furthermore, by the establishment of an electrical network many lights can be operated over long distances. There is no doubt that this one invention has changed our lifestyle because human activity could be extended for many hours after sunset. In

the developed world, artificial light is currently being produced throughout the night. The so-called light at night (LAN), is made possible by continuous electrical energy produced by power stations.

Issues dealing with the production of artificial LAN concern, amongst others, light and electrical-engineers, light-designers, illumination-producers, artists tradesmen, illumination-importers, and advertisers. These and decision-makers may not be aware of all the pros and cons of the

types of artificial LAN. Some of the drawbacks of using artificial LAN are various negative impacts on the biological environment.

An accepted challenge for light engineers is to maximize the efficiency of light production by producing more light with less heat. Similarly, for classical environmentalists, where reduction of carbon dioxide production is the main target, the aim is to produce more light for less energy. In both these cases, short wavelength illumination is preferable because this can be produced by low electrical energy consuming bulbs. Indeed, a by-product of cheap short wavelength illumination is that larger areas or more places can be lit for the same cost. This “rebound effect” will only serve to increase the negative impacts of LAN on the environment.

One of the problems in Western culture is that publically elected officials, at both local and national government levels are highly motivated to demonstrate short-term successes, ostensibly for the purposes of re-election. Therefore, they are keen to show rapid development and also reduced costs in their constituencies. Promotion of artificial LAN and illumination of dark areas is an obvious way to illustrate how infrastructure has improved. This is usually an easy procedure, which has immediate results. Recently, at the level of local government or municipality, mayors are often persuaded to change illumination sources in public places to so-called “environmentally friendly” illumination, which should reduce electricity consumption and carbon dioxide emission while increasing short wave length light emission.

Other important players with respect to artificial LAN are electricity generating companies. In an attempt to keep electricity production levels constant, and, knowing that demands decrease at night, electricity can be offered to municipalities at a lower price during the night. This “spare” power can then be used for illuminating public spaces such as streets, free ways or motor ways as well as sports grounds, train and bus stations. An outcome of the fact that all main parties so far involved in illumination, are in favor of increasing production and use at night results in a new environmental source of pollution, known as “light pollution”. This is a well-known phenomenon amongst astronomers, and more recently among biologists and medical doctors. Therefore, two pertinent questions are: What makes artificial LAN a source of pollution? Are illumination and electrical engineers aware of the negative impact of LAN in terms of its effect on human health and natural ecosystems?

2. Short wavelength illumination and its negative health impacts

Over a year ago, the American Medical Association (AMA) adopted a resolution stating that LAN was a source of pollution. This is because it disrupts human daily rhythms, it interferes with sleep, and it suppresses melatonin (MLT) production. MLT is a neuro-hormone which signals to cells and tissues the dark period of the 24 hour cycle (AMA, 2012). The AMA suggested that new technologies should be developed for illumination which do not have deleterious effects. Such a call should result in the development of sustainable

illumination, i.e. energy efficient and not harmful.

In order to save energy and reduce carbon dioxide emission, European Union countries have moved away from the use of incandescent bulbs to shorter (460-500 nm) wavelength illumination such as fluorescent bulbs, and, more recently, to light emitting diode (LED) illumination. This has resulted in an increased intensity of artificial LAN, mainly of short wavelength illumination. This has had the effect of increased visibility at night and increased efficiency of electricity usage, however the question is what are the indirect costs of these changes?

Results of a study carried out by the Swiss scientist Christian Cajochen and collaborators revealed that people were particularly sensitive to exposure to short wavelength (460 nm) illumination during the evening (Cajochen et al., 2005). This is a time families often spend together in places such as shopping malls, sport centers and stadiums where such illumination exists. The effects of exposure to this illumination are: suppression of MLT, maintenance of high core body temperature, high heart rate and alertness. Interestingly, exposure to illumination of a wavelength similar to that of the incandescent bulb (550 nm), under the same intensity, and for the same duration, does not manifest such a response. On the contrary, subjects exposed to these longer wavelengths responded as if they were not exposed to LAN at all. These results actually suggest that wavelength plays a major role on our circadian system.

An early indication that LAN had an effect on the biology of various mammals was startlingly illustrated by studies on the

“blind” mole-rat *Spalax hehrenbergi*. Haim et al., (1983), at the University of Haifa revealed that these animals were not actually blind. Laboratory experiments showed that the thermoregulatory mechanism of blind mole rats responded to changes in photoperiod, in which short-day acclimated mole rats were cold resistant whereas long-day acclimated mole rats were cold sensitive. If these mole-rats were truly blind, then changes in photoperiod would make no difference. Further, studies on the degenerate eye of the mole rat revealed that their retina contains a high number of bipolar cells. These cells were first described just over a decade ago and contain the newly discovered vision pigment, the protein melanopsin (Berson, 2007); they are known today as Non-Image Retinal Forming Photoreceptors (NIRFP). The main function of melanopsin appears to be the production of a signal to the pineal gland (PG), when exposed to short wavelength (less than 550 nm) illumination, which is naturally dominant during the middle of the day. Activation of melanopsin suppresses the production of MLT from the PG.

Our “Biological Clock” which resides in the Supra-Chiasmatic Nuclei (SCN) within the hypothalamus of the brain, also known also as the “major oscillator” is set or entrained to daily variation in the environment by neural signals which originate in these same bipolar cells. The SCN then transfers these signals to the pineal gland which produces MLT. As the SCN contains MLT-receptors, it will respond to MLT produced in the PG; MLT secreted to the blood signals the dark period of 24h light/dark cycles to body cells and tissues (Figure 1).

Of course, we would not wish to return to pre-Edison days with no artificial LAN. In order for us to continue benefiting from artificial LAN, we would need to assess the environmental impact of different forms of illumination, so that we may utilize on-harmful “sustainable” illumination. The

work of Cajochen and Colloquies (2005) highlights the fact that it is short wavelength illumination rather than the exposure to LAN *per se* which is the main issue. Short wavelength light suppresses MLT production and secretion (Berson, 2007).

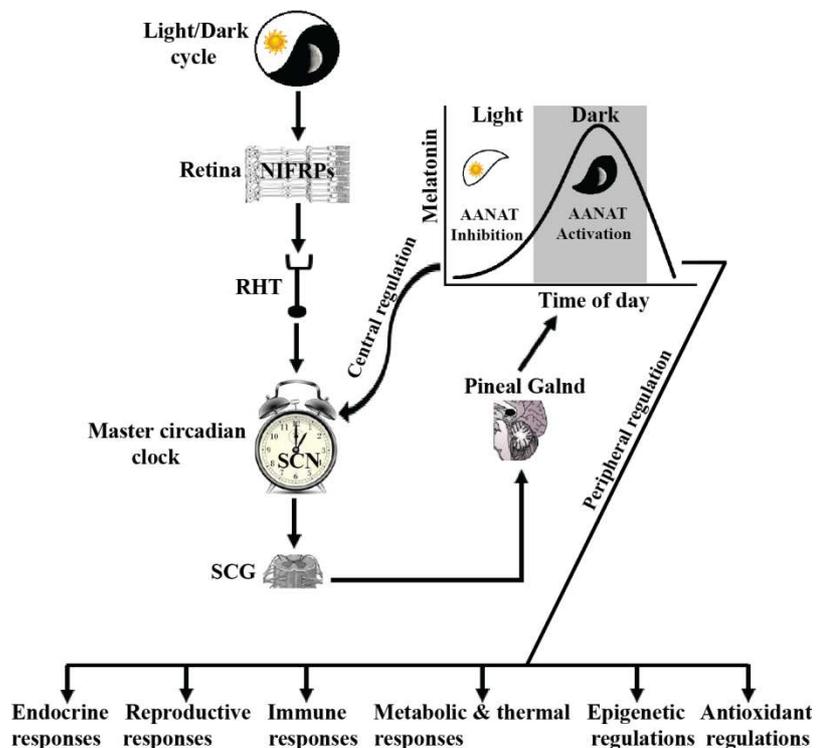


Figure 1 Regulation of the mammalian circadian system by light

The master circadian clock in the SCN is entrained by light via Non-image Forming Retinal Photoreceptors (NIFRPs) that project directly to the SCN throughout the Retino-hypothalamic Tract (RHT). The SCN conveys the circadian signal to the Pineal Gland via noradrenergic projections from the Superior Cervical Ganglion (SCG). Arylalkylamine N-acetyl Transferase (AANAT) plays a rate-limiting step in the sequential synthesis of melatonin

(MLT) from serotonin; AANAT is activated during the dark phase and inhibited during exposure to light. MLT is involved in regulating a variety of central and peripheral circadian related-processes.

3. LAN as a new risk factor for breast and prostate cancers

A book published a few months ago entitled “Light Pollution as a New Risk Factor for

Human Breast and Prostate Cancers” by Springer (Haim and Portnov, 2013) deals with the issues of artificial LAN and calls for the development of sustainable illumination. In a recent study, the deleterious effects of LAN were demonstrated. Schwimmer *et al.*, (2013) exposed mice that had been inoculated with breast cancer (BC) cells to two conditions, exposure to 30min of short wavelength illumination during the night and no exposure. The results were clear where mice exposed to LAN had a higher daily rate of tumor growth than the control group. The study showed that MLT levels were suppressed in LAN-exposed mice, but not in control mice. Mortality rates were also higher in the LAN-exposed group. However, when LAN-exposed mice were treated with exogenous MLT in their drinking water during the dark period, mortality rates and tumor daily growth rates decreased. These results support the idea that suppression of MLT production by short wavelength illumination may have deleterious effects. Furthermore, upon *post-mortem* many metastases were noted in the LAN-exposed mice, which could explain their higher mortality rates compared with controls and those that were LAN-exposed but MLT-treated.

4. Epigenetic modification a possible mechanism responding to environmental changes

A possible mechanism of how LAN can affect cellular processes could be so-called “epigenetic modifications”. Epigenetic modifications arise from changes in gene expression which are not encoded in the

DNA sequence, but to changes in methylation (an addition or removal of methyl groups from nucleic acids) of the DNA molecule (Lyko& Brown, 2005). This can be measured as Global DNA methylation (GDM) levels.

The next logical step was to extract DNA from the tumors of LAN-interfered mice and those of LAN-interfered and MLT treated mice and compare GDM levels with control mice (Schwimmer *et al.*, 2013). Results revealed that LAN-interference reduced GDM-levels while MLT treatment elevated GDM-levels. It is possible that specific genes, for instance BC-inhibiting genes, may be modified epigenetically. For example, reducing GDM may promote the expression on oncogenic (cancer causing) genes such as BRACA 1 and 2, resulting in breast cancer.

Other mechanisms can also account for such modifications such as changes in affinity of receptors for estrogen. As we are in the early stages of understanding the consequences of such modifications, much research is needed. Epigenetic modifications as GDM are reversible (Bird, 2007; Korkmaz&Reiter, 2008) so if artificial LAN of short wavelength modifies GDM levels, removing the illumination source for several nights may result in a recovery of the modified DNA. As yet we have no idea what duration of exposure to LAN will cause a significant modification, and, subsequently, what the duration of recovery may be. Therefore, understanding the biological consequences of different types and wavelengths of illumination can result in important information for the illumination engineers, light designers, illumination producers and consumers. As

short wavelength illumination has become the main source of light in public spaces as well as private domestic spaces in many western countries, this is an issue which needs to be urgently resolved. Indeed, in many countries, it is now forbidden to sell incandescent bulbs above 60 W in preference for higher wavelength illumination. We should expect higher levels of light pollution with its negative impact consequences on human health such as increased breast and prostate cancers.

5. What is the problem?

For many citizens of the European Union, starting in 2015, municipalities will be required to phase out their old mercury and sodium vapor lamps from public spaces and replace them with more economical and significantly brighter LED lamps. If the current trend continues, there is no doubt that we are going to increase short wavelength light pollution in many European cities. Apart from increasing the risk of breast and prostate cancers incidence, exposure to artificial LAN will also increase obesity and diabetes rates through various epigenetic effects (Monk and Boyse, 2013) and it will also decrease the function of the immune system (Navara and Nelson, 2007). As epigenetic modifications are relatively slow to manifest the duration for response maybe in the magnitude of years. For instance in the case of breast cancer, it can be ten years or more before the tumor is identified and by this times metastases may already exist.

The results of our studies have revealed that artificial short wavelength LAN has an impact on GDM of breast cancer cells which

we think occurs through the suppression of MLT production. This can be used as a model for further research in understanding the relationship between environmental changes and epigenetic modifications. In a recent review by Zhang and Shuk-Mei (2011) it was suggested that epigenetic modification is a response to environmental changes, which are manifest through the endocrine system. Therefore researchers need to determine whether epigenetic modifications, induced by present life styles or environment exposure, can be heritable. This may lead to new ways of prevention. In the case of exposure to artificial LAN, we do not have sufficient experimental information on what the critical threshold values are which may be harmful. Although short wavelength illumination is installed worldwide, some of the profits should be allocated to research. This would allow us to (i) understand the environmental as well as social aspects of exposure to artificial short wavelength LAN and (ii) help to create sustainable illumination which will be economic as well non-harmful.

The use of illumination, to the best of our knowledge, does not demand approval from health authorities. To-date, chronobiological issues are largely ignored, as opposed to the use of novel drugs or food items which are carefully monitored. It is essential that the quality of illumination and the subsequent impact on human health be considered paramount when introducing new technologies and types of illumination. In conclusion, all the evidence suggests that artificial LAN has many negative impacts on human health through its interference with daily rhythms, sleep and MLT secretion. The quality and quantity of LAN

cannot be based purely on engineering and technological criteria but rather should be based on a more holistic approach. This short review will hopefully increase awareness for users of illumination and also policy-makers. Clearly, adopting a sustainable approach to illumination which considers the environmental, economical and sociological issues should be the basis for the development of next-generation illumination.

6. Conclusions

As we can see artificial LAN is not only an engineering issue but it also has a negative impact on our health. Engineers, thinking of energy efficiency, are considering only one aspect of illumination and may be unaware that other aspects exist. The approach should be more holistic. Results of recent experiments from our center and other laboratories revealed that short wavelength illumination interferes with circadian systems, sleep quality and suppresses melatonin production. However, we do not want to live in darkness as in pre-Edison days. Therefore, we call upon engineers and light producers to join forces and work hand in hand with chronobiologists to develop sustainable illumination, which will enable us to go on with activities at night but with a minimal risk to our health.

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