

Emlyn Etienne Goronczy

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# Light Pollution in Metropolises

Analysis, Impacts and Solutions

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Emlyn Etienne Goronczy  
Hannover, Germany

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# Introductory Remarks

# 1

The history of light goes back a long way. Initially, light was only available in the form of fire, which was an uncontrollable and dangerous element at night. Burning light became safer over thousands of years through the development of candles, oil lamps and gas lamps, but the luminous efficacy was very low. As a result, the large-scale illumination of interior and exterior spaces was associated with a considerable cost factor, which is why for a long time only particularly important buildings and streets were illuminated (cf. Descottes and Ramos 2011).

With the introduction of the electric carbon arc lamp in the middle of the nineteenth century, this changed abruptly.

The light that flooded a large area was so strong that the ladies opened their umbrellas - not out of respect for the inventors, but to protect themselves against the rays of this mysterious new sun. (La Lumière électrique, 1883, quoted from: Schivelbusch 2004, P. 59, translated)

With this innovative light source, a new, radical way of thinking about light at night began.

The new technology was perceived as a liberation from darkness. Ideas were born such as the idea of illuminating entire cities with a single “artificial sun” (Schivelbusch, P. 11). The new enthusiasm for artificial light did not even stop at areas that are still considered unusual to this day. In fashion, for example, there was the idea of being able to produce glowing jewels (ibid. P. 75).

As a result of this enthusiasm, cities gradually started equipping their streets with electric lights.

At the end of the nineteenth century, after the US American inventor and entrepreneur Thomas Alva Edison had perfected the “light bulb”, electric light and the “passion” associated with it moved into private households throughout the country. The “nights” in the cities became brighter and the artificial light became a symbol of progress and prosperity in our culture.

Even if particularly radical ideas were not successful in asserting themselves in every case, there are still many places today which have become a trademark for specific cities precisely because of excessive lighting, and have thus attained cultural importance. Two impressive examples are Piccadilly Circus (London) and Times Square (New York City).

The passion for artificial lighting has meant that we are currently in a situation where cities are literally flooded with artificial light. The general global brightness level at night has increased considerably (Cinzano et al. 2001). The border between day and night is increasingly disappearing in the big metropolises. First scientific experiments show that the excessive luminance levels after dark has negative consequences. This is where terms such as “light pollution” and “light smog” come into play.

Some cities are already trying to counteract this problem with constructional or legal measures. The focus is often on functional street lights (see Marcellino 2014; City of Boston 2015a, b; The City of Toronto 2015).

Globally, however, the majority of people are unaware of the issue of light pollution, making it probably one of the most underestimated environmental pollutants.

This book aims to clarify this issue by dealing with the impact and development of solutions. The book is divided into four main sections.

The first section deals extensively with scientific texts on light pollution and its effects on humans, birds and insects. One key problem that has become apparent through light pollution is the unfavourable effect on the circadian rhythm of different living beings. Hormonal imbalance has been registered, which leads to a series of consequences. The extent of the negative consequences depends mainly on exposure times, and the light spectra and light distribution curves of the luminaires.

The second section includes a comparative analysis of the cities New York City, Boston, Toronto, Warsaw and Hanover. Different urban lighting constellations are explained that have a positive or negative effect on light pollution. Impressions on site and luminance measurements are included in the analysis. With regard to the perception of brightness in urban areas, discrepancies can often be found between the perception of brightness on site and the actual measured values. As a result of the analysis, the initial main problems of the respective cities can be identified. One problem across all the cities is the overexposure caused by clutter situations. Clutter is a term that refers to groups of luminaires which are installed or mounted too close to one another, for example, and as an overall consequence emit unnecessarily high luminance levels.

It is also interesting to see to what extent and in what way the individual metropolises generate light. They differ in many fundamental points, such as the horizontal and vertical dimensions of the cities, the number of inhabitants, the cultural background or the density of buildings.

Moreover, some cities are already implementing measures to reduce light pollution. This is likely to result in a wide range of examples of both good and bad lighting.

The third section deals with the testing of full cutoff luminaires. These are designed to produce little light spill. The tests are carried out using computer-aided lighting simulations. The third section also describes the method developed for evaluating light

emissions in urban space. This entails a model-like lighting simulation. The percentage of emissions towards the sky was calculated for the cities under analysis.

Conclusions are drawn from the results of the three main sections, which in turn give rise to the concept solutions defined in the fourth section. The findings contribute to the development of a flow chart, from which solutions for minimizing light pollution can be derived.

The flow chart comprises four blocks: Analysis, Initial measures, Secondary measures and Further measures.

In order to be able to develop particularly efficient solutions, the Analysis is the most important part of the flow chart.

Initial measures are minimal changes to the existing luminaires in the urban space. The measures are therefore low cost, but effective, to achieve a fundamental reduction in light pollution.

The Secondary and Further measures entail structural actions. A lighting master plan is developed to enhance the quality of living in the urban environment and the architectural aesthetic of night-time urban spaces. Light pollution is minimized even further than the effects achieved through the Initial measures.

The lighting master plan mainly concerns street luminaires in urban areas. The actions listed under Further measures also address improving conditions in semi-public buildings.

On the basis of a part of the City of Warsaw, the flow chart is simulated with all measures planned in. It shows that a reduction in light pollution does not necessarily result in a dark urban space. The reduction of light pollution can also be achieved by increasing the quality of stay and enhancing the aesthetic quality of the architecture.

Further summarized results from the work can also be found in issue 04–06/16 of the architecture magazine XIA, *intelligente Architektur—Zeitschrift für Architektur und Technik*.

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## What Is Light Pollution?

# 2

In general, the term “light pollution” or “light smog” refers to the excessive brightening of the night sky by artificial light (see Dark Sky). Street luminaires, billboards, shop windows and similar lighting installations that are switched on overnight produce light that reaches the atmosphere directly or indirectly (through surface reflections). On the way there, various molecular components of the air are made visible by reflections. The night sky is artificially brightened (Fig. 2.1, 2015).

The intensity of whitening depends on the aerosol composition and can vary on different days or even within a few hours. The resulting “veil of light” over the cities is referred to as a “light dome” or “urban sky glow” (cf. Mizon 2012, pp. 40–47).

The renowned international associations that work against light pollution, “Dark Skies Awareness” and “The International Dark-Sky Association”, have added three more key terms to the term urban sky glow: “Light Trespass”, “Glare” and “Clutter” (see Dark Skies Awareness; International Dark-Sky Association). Light Trespass refers to incorrectly controlled or incorrectly directed light—i.e. light that radiates into areas where no light is intended and therefore fulfils no purpose. In this context, the term glare means the disturbing glare caused by light sources. Clutter is the expression for groups of luminaires which are positioned too close together, for example, and emit an unnecessarily excessive amount of light as an overall consequence (Fig. 2.2, 2015).

Light in the context of light pollution includes not only the visible range of electromagnetic radiation between 380 and 780 nm, but also the adjacent ranges, infrared (IV) and ultraviolet (UV). IV and UV radiation are located in the visual range of different flora and fauna organisms and thus also have an influence on the environment (Fig. 2.3) (cf. Bartenbach and Witting 2009, pp. 5–11).

In summary, the term light pollution comprises: