

Lighting of protected historical city centers

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ABSTRACT

All cities are different, but when it comes to the lighting of their protected historical centers, with its cultural and historical sites, such as monuments, city walls, cathedrals and other valuable objects, their needs and wishes are similar. They all seek for lighting solutions which contribute to visual identity of the city and make their citizens proud, but at the same time preserve protected cultural heritage and environment. When implemented correctly, such lighting solutions provide distinctive night appearance of the city and help its touristic promotion. These solutions are quite different from usual lighting techniques used for streets. Criteria which designers should follow are: creation or improvement of city center's visual identity, emphasis of historical amenities, temperature of light, appearance of light source, reduced maintenance possibilities, energy efficiency and lighting pollution.

Authors of this paper presented theoretical aspects of all mentioned criteria. Afterwards, they analyzed them through practical examples of lighting in Croatia and abroad: main pedestrian area - Korzo in Rijeka, historical city of Dubrovnik, both in Croatia, and historical architecture in Liverpool, UK. Beside that, it has been shown a unique and attractive way of lighting of historical buildings during Festival of light in Lyon, France.

New technologies available on the market enable designers to produce lighting of historic city centers which meet all mentioned criteria. When that is achieved, it is the best reward for all parties involved.

Keywords: lighting technology, LED, protected cultural heritage, night appearance, old city center, Rijeka, Dubrovnik, Liverpool, Lyon

INTRODUCTION

Illumination of old historical centers is very different from classical illumination of streets. Although, both fall under the common denominator "Public lighting", requests and the way of design are completely different. While designing classical street illumination, lighting designers have to pay attention only to several aspects such as: intensity and uniformity of illumination, amount of light pollution and energy efficiency. In addition to those, requirements that are placed before lighting designers in case of illumination of protected historical city centers are numerous: creation or improvement of visual identity of city

center, emphasis of historical amenities, temperature of light, aesthetic appearance of light sources, reduced maintenance requirements, energy efficiency and lighting pollution.

Sometimes it is difficult to achieve all of mentioned above. Sometimes the best lighting designers find it hard meeting all the demands of the profession and clients, at the same time bearing in mind the protection of cultural heritage. Once this is achieved, the highest reward is beautiful and quality illumination of historical city centers, to the satisfaction of all.

REQUIREMENTS TO BE MET BY WELL DESIGNED LIGHTING

Creating a distinctive night appearance of a city center

Urban planners are partially responsible for creation of visual identity of each city. Also, creation of visual identity for each city depends on urban planning. Respectively, public lighting of city centers, and especially protected historical city cores must be conceptually planned and designed in collaboration with urban planners or municipality employees responsible for those issues.

For creation of the visual identity of city lighting, designers need to wisely choose the way of shedding light on streets and squares, as well as famous historical buildings. Regarding that, some other parameters need to be defined, like: lighting technologies, colour temperatures, light intensity, types of poles as well as possible demands of urban planners for particular light-fittings to be hidden from the view. The choice of these parameters is influenced by many factors and there is no universal best solution that would be applicable to all cities. Therefore, designing public lighting for protected city centers should be done in collaboration with urban planners. Also, lighting designers should consider all aspects of each city, such as its architecture and historical buildings, historical and cultural heritage and climate in which it is located. Only then can the optimal solution for each city be selected, which will meet all the criteria of the profession and contribute to creation of appealing and distinctive visual identity of a city. Of course, when we talk about lighting, we think of visual identity of a city during the night.

Highlighting famous historical buildings

Highlighting of famous historical buildings in open space is narrowly connected to creating good visual identity of a city, so again, urban planners must be consulted during design of these parts of public lighting. However, for emphasizing an individual building within a historical core of a city, commonly used light-fittings are conventional reflectors with a beam of light directed towards the object that is to be highlighted. Light sources used in these occasions are metal halide or highpressure sodium lamps. These methods of illumination are nowadays being abandoned and replaced by LED light sources. They can effectively highlight a particular building or an object in open space with much lower power consumption and much less light scattering.

Techniques used for highlighting certain historical sites with LED sources of light are: with classical directed beams of light and "wall washing" technique. This technique looks very attractive and offers tremendous possibilities for manipulation of illumination and for creation of different moods throughout the year.



Figure 1. An example of “wall washing” technique

Colour temperature of a light source

Colour temperature of each light source is expressed in Kelvin (K) and defines its "color", or whether the emitted light is yellowish, white or bluish, i.e. warm or cold. Psychophysiological studies have shown a relationship between daily biorhythm of a human organism and the color temperature changes caused by sunlight during the day. The study has also shown that a human body functions optimally if it is exposed to color temperature and spectrum changes that follow natural sunlight. That actually means that the colder light with bluish spectrum in morning hours awakens an organism and the warm reddish spectrum in evening hours contributes to the efficient rest of a human body.

Colour temperature of light does not define how natural or unnatural colors seem to be when illuminated. To define how the colors of an object will look like when being lit by different light sources, we use the coefficient of color rendering (CRI – colour rendering index), which is defined in range from 1 to 100. CRI 100 indicates the coefficient for rendering colors in daylight.

Today's lighting technologies can offer sources of light with any color temperature, from very cold, all up to very warm colour temperatures.

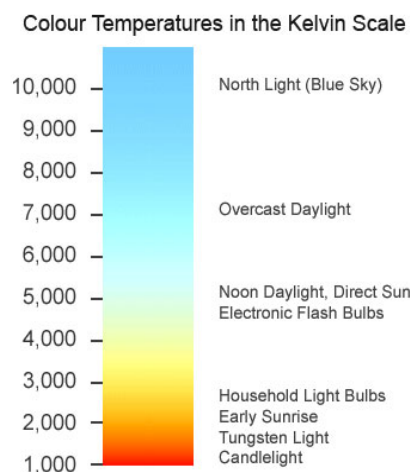


Figure 2. Colour temperature scale

For illumination of protected urban centers it is recommended to use those light sources that have greater CRI. Mostly, these are sources of light with color temperatures ranging from 2700 - 4200 K, i.e. light sources that emit light in the range of warm tones of white to pure white tones. It is not recommended to use light sources of cold tones, which is often the case with the LED light solutions of lower quality.

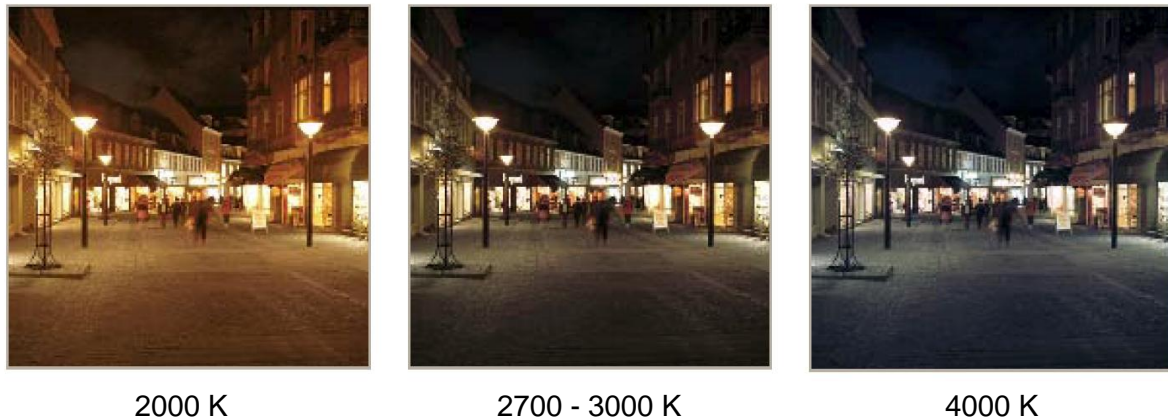


Figure 3. An example of the same object illuminated by light sources with different color temperatures

Aesthetics of light-fittings and requests for minimum maintenance

Between light-fittings of acceptable technical specifications, lighting designers have to choose those which are, by the opinion of urban planners and conservators, better suited for the environment in which they are installed. Well chosen light-fittings with appropriate aesthetic appearance and technical specifications can contribute significantly to the attractiveness of an old city center.

All renowned manufacturers of lighting equipment offer aesthetically designed light-fittings, especially designed for better integration in historical city centers. However, light-fittings intended for a city center are very often ordered and made especially for one specific city. Some parts of a renowned manufacturer lighting equipment is then installed in the casing specifically developed for the city. In addition to light-fittings, poles on which they are mounted should also aesthetically complement a city center area. An example of illuminating urban center comes from the City of Rijeka. The main promenade Korzo is illuminated by decorative lighting especially designed and ordered for that purpose. Lighting installed on Korzo includes decorative bronze poles and decorative light-fittings. Philips lighting equipment is installed inside those light-fittings.

There are situations when designers want to hide light-fittings from the view. Therefore, sometimes light-fittings can be installed in handrails on bridges or staircases, or inside roof structures of individual buildings. For this type of lighting, suitable light-fittings are the ones using LED technology or tiny built-in reflectors because of their small size. Light designers should also pay attention to power lines which should be hidden from the view, so that they do not distort the appearance of the building. This way of illumination is particularly suitable from the standpoint of conservators, because it does not interfere with the original look of the building.

However, when designing such lighting, conservators should be consulted and special attention should be given to the way light-fittings are installed. It should be realized without damaging any part of a building, which might happen with reckless drilling or installing light-fittings into the facade of a building.



Figure 4. An example of illumination with hidden light-fittings - Rijeka, Most hrvatskih branitelja

In historical urban centers we often have light-fittings located in places which are hard to reach, so the requests for minimal maintenance should be taken into account. Choosing light-fittings and light sources that require minimal maintenance and have a long life ensures a minimum number of interventions. Fewer interventions on public lighting system results in absence of negative public reaction caused by frequent repairs and also in reduction of maintenance costs. From the standpoint of conservators any intervention on the public lighting system, such as changing lamps or fuses in light-fittings located very close to monuments and facades of historical buildings increases the risk of damage. Reduced number of interventions ensures that protected historical buildings are minimally exposed to possible damage that may be incurred during interventions. According to these criteria, we recommend usage of light-fittings that have light sources with long lifetime. LED lighting is suitable for this purpose because it has the longest life expectancy, which amounts to about 60 000 hours.

Energy efficiency

Like classic road lighting, lighting of historical city centers should be energy efficient. Renowned manufacturers of lighting equipment are extremely careful on that field, and offer energy efficient light-fittings which are meeting the criteria of colour temperature and colour rendering index. It's recommended to use metal halide lamps, ceramic metal halide lamps or LED lighting.

Real savings generated by using energy efficient light sources can be displayed by two hypothetical examples. We can assume a promenade through a city center which is lit by 50 light-fittings with old highpressure mercury lamps. After reconstruction and instalation of LED light sources instead of mercury ones, annual power consumption of electrical energy would decrease almost 4 times.

Another example of energy efficiency can be presented on illumination of historical buildings. For shedding light on a famous city tower or a church tower, commonly used light-fittings are reflectors. They often exceed 2 kW of total installed power. The reflectors can be replaced with LED lighting, which combined with “wall washing” technique and hidden light-fittings results in a more attractive illumination. The total installed power of LED lighting would amount to only about 1 / 10 of installed power of the reflectors.

Considering the above, we can conclude that using energy efficient light sources is highly recommended because of financial savings and respectively greenhouse gas emissions savings.

Minimal light pollution

Lighting designers are very careful while designing street lighting because they want to achieve minimal light pollution. For that purpose they are using light-fittings that are completely shaded and with flat glass. Opposite to that, while illuminating historical city centers, primary goal is to provide convenience for citizens, highlight certain buildings and create distinctive visual identity of a city by night. Considering that, there will always be some amount of light pollution, but that does not mean that we should not worry about light pollution. For reducing light pollution generated from a city center lighting, it is advisable to use LED lighting technology, because of their precise direction of light beams.

It should also be noted that in urban centers light-fittings often use sources of light that are stronger than the prescribed level for road lighting, which have been regulated for safety of traffic. But, in historical city centers we want to achieve well-being and comfort for all citizens and visitors of the a city. Therefore, it is necessary to provide illumination which has a little more LUX.

ILLUMINATION OF KORZO – THE MAIN PEDESTRIAN ZONE IN THE CITY OF RIJEKA

Korzo is the main pedestrian zone in the City of Rijeka and therefore it is important to ensure its quality illumination. Until 2007. the light-fittings installed in Korzo have used classic highpressure sodium lamps as light sources. They had color temperature of 2000 K and a colour rendering index of 20. So Korzo has been well lit by all the criteria of the profession, except by the criteria of color temperature and color rendering index. In 2007. Energo Ltd., in collaboration with the Dutch concern Philips performed a pilot installation of street lighting in white light on the Korzo. Doing so the City of Rijeka joined other European cities that have already applied this new concept. White light sources replaced the existing installation of yellow sodium lights. Sodium yellow light causes hypnotic and depressant effect in people due to poor quality of spectra and yellow tones. New white light appears fresh and appealing. People feel more comfortable and safer under white light and also remain for longer periods of time in the white lit areas.

New lamps which replaced the old ones are Philips MasterCity White lamps with a color temperature of 2800K and CRI of 83. Also, the dimensions and caps of the new lamps matches the old ones and allows easy and quick transition to white light. The technology used in the new lamp is ceramic metal halide technology, which has been

mainly used in shopping malls and high fashion shops until now. The investment is going to be quickly returned due to the increased attendance and attractiveness of the city and associated economic effects primarily in tourism, hospitality and trade. White illumination suites particularly good to Mediterranean colors of white stone, blue sea and green Mediterranean vegetation.

The difference in color temperature and in increased color rendering index can clearly be seen on the following photos of Korzo and its illumination before and after the reconstruction.



Figure 5. Illumination of Korzo, the City of Rijeka, before and after the reconstruction and transition to "white light"

The photos above show that the light-fittings installed on Korzo are not shaded and that they are placed along the left and right side of the pedestrian zone. Also, they are deliberately made in the spherical form. All mentioned ensures high quality illumination of the pedestrian zone and at the same time provides illumination of historical buildings and their facades.

ILLUMINATION OF THE CITY OF DUBROVNIK AND ITS CITY WALLS

The City of Dubrovnik is Croatian jewel in the architectural, cultural and touristic terms. Its historical center is under protection of UNESCO. Just mentioned is enough to understand the need for good illumination of its historical center.

Reconstruction of public lighting in the City of Dubrovnik began several years ago and was implemented through three phases. Given the value and importance of Dubrovnik's architectural heritage, it is necessary to acquire permission of the Conservation Department for each source of light. The goal of reconstruction was: to illuminate the City Walls from the outside, so that light and the entire City would be visible even from the sea, to illuminate the pedestrian part of the City centre and the Walls, to ensure extended stay of tourists in these parts of the City, and finally to illuminate the monuments and the approach zones of the City.

The first phase of reconstruction included illuminating an external line of the Walls of fortress Bokar all the way to the Revelin and the most frequent urban area Pile located in front of the western gate of the City. While designing the lighting of the Walls, light designers had in mind an example of Paris, the City of Light, in which

illumination creates an atmosphere of a day that lasts 24 hours. The second phase related to illuminating from Ploče to fort Sv. Ivan with all the important historical buildings. It also includes completely new appearance of Stradun, the main street. The appearance of the lights from the main street includes unification of light-fittings, with the possibility of power control and method of illumination that can create different moods depending on weather, time of day and season. Antique lanterns as a symbol of Dubrovnik have not disappeared, but there are no longer situations that one lantern gives yellow light and the other one gives white. The third and final phase of the project involved complex works to illuminate the southern Walls from the sea.

The new public lighting system has been realized with the state of the art lighting technology in combination with highly efficient white ceramic metal halide reflectors which have 70W of power and LED lighting. Housings of the reflectors are prepared for the proximity of the sea and high salinity conditions. Color temperature of the reflectors was adjusted according to the color of stones. Access roads and parking lots are illuminated using Philips Metronomis light-fittings with light sources of 100W. Light-fittings with its aesthetics are very well blended in the Dubrovnik environment. To illuminate Stradun and historical heritage inside the Walls, generally used light-fittings are Philips LEDline with different lengths and powers, between 12-48W. All light-fittings and light sources are characterized by superior energy efficiency. Precision optics and abundance of different varieties adapted to specific applications ensures minimum parasitic light shining outside the illuminated zone and minimum glare. Speaking of efficiency, Stradun savings in power consumption are worth mentioning. Before reconstruction, Stradun was illuminated with tungsten bulbs, with power of 200 to 300W. After reconstruction, savings in power consumption of electrical energy are higher than 80%.

With the new lighting concepts and lighting technology the City of Dubrovnik stands alongside with world's most famous tourist destinations and ensures night impression worthy of this City.



Figure 7. Dubrovnik by night

ILLUMINATING HISTORICAL ARCHITECTURE OF THE CITY OF LIVERPOOL

Liverpool city center has a rich architectural heritage which includes the world famous Waterfront, Cultural quarter and two iconic cathedrals. The City owes its wealth of civic buildings and historical architecture to its development throughout the

18th and 19th Centuries as one of the worlds most prominent commercial ports. Today, Liverpool is enjoying a new period of revival, inscribed onto the UNESCO World Heritage List in 2004 and selected as European capital of culture for 2008. Following the above, Liverpool has delivered a 5 year programme of architectural and feature lighting for the City center.

Programme targeted landmark buildings and key beacons, defining the city identity & aiding orientation. Later phases focused on building up a critical mass of lighting within priority areas, giving consideration to key vistas and pedestrian routes. During the period 2002 to 2007 the City center feature lighting programme has seen more than 60 buildings and monuments lit in the heart of Liverpool. The impetus of this programme has also encouraged additional lighting schemes by building owners and developers outside of the programme.

Technical principles

There is a diverse range of schemes ranging from the lighting of landmark historical buildings; large scale new buildings and major public realm schemes, through to small schemes on existing commercial buildings. Design work has been undertaken by a number of different designers and consultancies. The following general principles of good practice have been applied:

Independent designers - Most schemes have been undertaken by independent lighting consultants ensuring that appropriate equipment has been selected for each task from a wide pool of manufacturers enabling the strengths of each supplier to be fully exploited and to ensure best value for their clients. **Control** - The equipment selected has been chosen with regard to its photometric performance and was fitted with accessories appropriate for the task for which it has been chosen to perform. The control of glare and light spill are essential criteria with any lighting scheme. **Lamp sources** - Many of the buildings that have been lit are historical or are located in a context where they are surrounded by historical buildings or within a conservation area or the UNESCO World Heritage site. In these circumstances the choice of light source has been informed by colour temperature and colour rendering. In many instances ceramic metal halide has been used, alongside high quality fluorescent with HF electronic gear with a colour temperature of 3000_K. On more recent projects LEDs have also been used as products with appropriate colour temperatures and consistency of colour have begun to become available. On new schemes other colour temperatures and coloured light has been used where appropriate - again ceramic metal halide and fluorescent have been popular. There is a commitment amongst all the designers involved to investigate the use of new technology to improve energy efficiency and maintenance frequencies. The Philips Cosmopolis white lamp is being used extensively on the Pier Head and other public realm schemes, along with the Extreme long life T8 Fluorescents. The Philips 20W CMD has been used extensively to bring down the overall intensity of schemes and allow very small /discreet light-fittings to be used. The new generation of LEDs has been used widely on more recent and pending schemes often in light-fittings developed specially for these projects. **Historical buildings** - As detailed above the choice of source is important. In addition the location and visual appearance of light-fittings is critical. Strict guidelines have been imposed to ensure schemes are discreet and where possible light-fittings are well concealed. Schemes have been designed to ensure that the electrical installation has minimal impact on the fabric of the building and is as well concealed as possible. **Light pollution & light trespass** -

Schemes are designed so that when properly focused light pollution and unwanted light spill is kept to a minimum.

FESTIVAL OF LIGHTS IN LYON

Many cities have developed a special culture of decorative lighting, for example, the City of Lyon in France annually hires the World's best lighting designers to light the gorgeous creations in the city. "Festival of Lights" ("Fête des Lumières") starts each year in early December and lasts for four days. While it lasts, famous monuments of Lyon such as: Saint Nizier church, Town Hall Theatre (Theatre des Celestins), Cathedral (Cathedrale St Jean), hotels (L'Ville Hotelde, Jacobin square) are being illuminated. Those buildings must always be illuminated differently than the previous year. All artists from Around the World participate in the illumination of Lyon. They usually apply the latest technological innovations in lighting installations. From year to year, there are more new ideas in the approach to illuminating the buildings. From the very beginning of the festival "Fete des Luminres" was and still is a major tourist attraction.



Figure 8. Fête des Lumières example 1



Figure 9. Fête des Luminères exemple 2

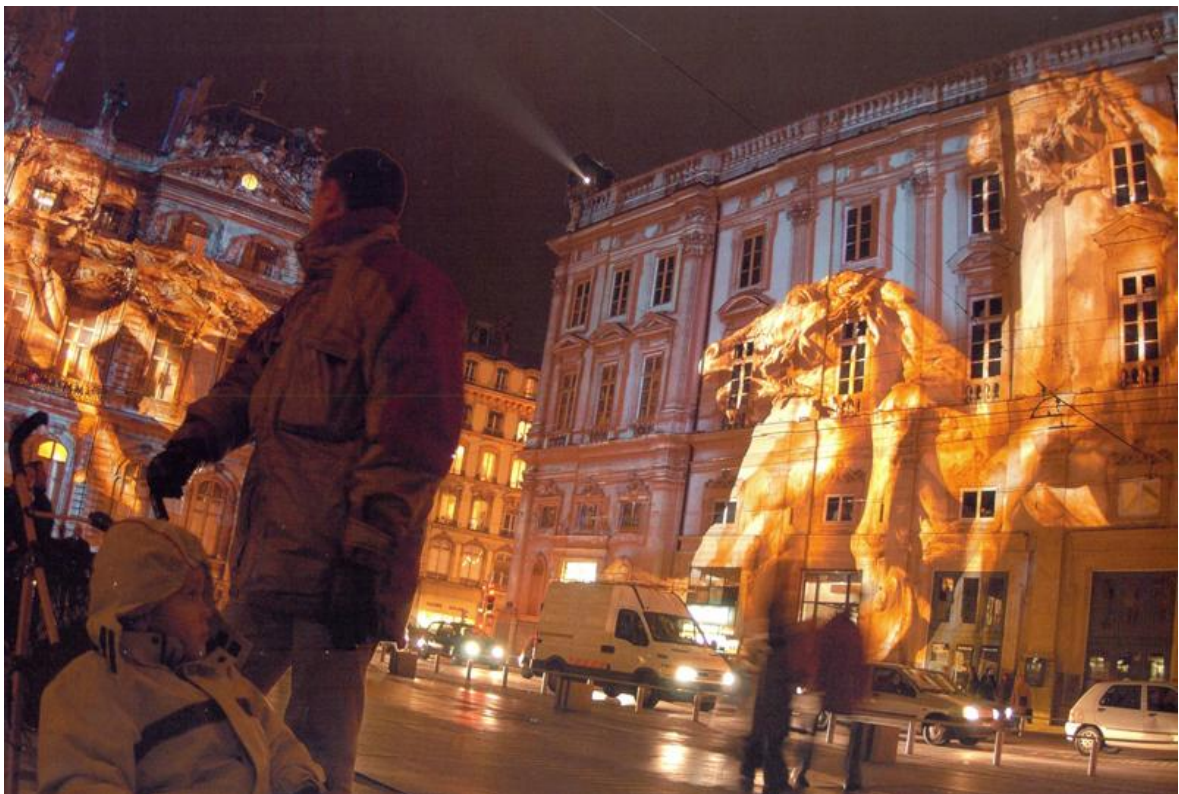


Figure 10. Fête des Luminères exemple 3

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