Facade Lighting Proposal for Industrial Heritage Buildings: The Case Tirilye Olive Oil Factory

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ABSTRACT
The facades of buildings that have urban value and shape the silhouette of the city are often illuminated. Besides cultural and historical buildings, illuminating industrial heritage sites is a way of expressing a city's modernity, and development and memory in the context of today's urban design. This growing interest may foster social awareness and help to promote conservation and preserve these landmarks. Dating back to Byzantine times, Tirilye is a historical district of Bursa province on the south coast of the Marmara Sea. As an example of an industrial heritage site built by the Greeks in the 19th century. Tirilye olive oil factory embodies technical equipment used in the olive oil production process and represents the development of production technologies of the 1950s. The building is out of use and waiting to be renovated to become a part of daily life and tourism activities today.

This paper presents an outdoor lighting design proposal to highlight the architectural characteristics of the site by advancing observation and experience of the place's identity at night time. It is aimed to augment the attractiveness of the factory complex for citizens and visitors and contribute to tourism and indirectly local economy by illuminating the building's main facade and details. A three-dimensional model of the site was created and lighting simulations were performed in the DIALux Evo program. Quality and quantity of the facade lighting application together with the aspects of future user profile and recommended museum function of the existing building, and its surroundings are considered in the outdoor lighting design process.
Keywords: Urban lighting, facade lighting design, industrial heritage, olive oil factory, Bursa

1. INTRODUCTION
Light is necessary to illuminate task areas in conformity with relevant standards and to design a glare-free and convenient space for the health, well-being and performance of humans. Besides the visual and biological functions, light is important for non-visual and emotional perception since lighting enhances the architecture by creating scenes and effects. Outdoor lighting encompasses the illumination of urban and artistic values that take place in their surroundings, where residents live and passers-by discover for a certain period. Examples of urban, artistic and architectural values that are the subject of outdoor lighting are historical buildings and ruins, obelisks, squares, monuments, sculptures, theaters, concert halls, hotels, administrative offices, parks, gardens, fountains, waterlines, bridges, springs, benches, and pedestrian areas. Besides inspiring visitors and locals to visit places, outdoor lighting improves visual comfort, user navigation, and safety while enhancing the city's ambiance, identity, and quality at night (BS EN 12464-2, 2014; IES, 2014). Empty spaces can be converted into inviting living spaces supporting human activity. Urban lighting may turn familiar streets into something new and unexpected, capture the imagination of people, help orientation, encourage a sense of belonging to the place, and improve our experience of landmarks (Ünver, 2017).

Building facade lighting plays an important role within the outdoor lighting context. Facade lighting for historical buildings is a matter of projecting memory, legacy, conservation, and innovation all in meanings of light. In this regard, the facades of aesthetically and architecturally important buildings that have symbolic and public character, urban value and shape the silhouette of the city are often illuminated. General features of facade illumination with artificial lighting can be counted as; i) to strengthen the architectural expression of the building, i) to stimulate the aesthetic emotions of the observer iii) to be sustainable. From a technical perspective, the way that artificial lighting is used has a crucial impact on the ecological and economical performance of outdoor lighting. While providing visibility within the city with facade lighting applications and meeting the functional and aesthetic requirements, firstly the architectural features should be examined and necessary elements should be identified. Light should not be misguided to avoid unnecessary electric consumption and to protect against the negative effects of light pollution on wildlife and ecosystems.

Today, LED technology is widely used for new facade lighting applications as well as in the refurbishment of existing lighting projects. Instead of conventional lamps, dynamic LED lighting with adjustable light correlated colour temperatures (CCT) and luminous flux is preferred due to its reduced energy consumption, long service life, low maintenance effort, and integration with building automation. As a result, LEDs are lately used in different historical or modern building typologies. On the other hand, the following aspects should be taken into account for facade lighting with any kind of light sources (IESNA, 2011; BS EN 12464-2, 2014):

- Targeted illumination for both horizontal and vertical of areas should be visualized
- Three-dimensional perception of the space through different brightness levels and shades should be created
- Brightness distribution should be balanced
- Strong dark-light contrasts should be avoided
- Obtrusive light and glare for residents and passers-by should be limited
- Matching light colour and colour rendering should be chosen
- There should be no unused stray light
- When illuminating horizontal areas, there should be no light emission in the upper half of the space
- Darkness should be respected at night.

In order to restrict the interfering effect, the luminous intensities and luminances quoted in Table 1 are specified in the standard for outdoor workplaces (BS EN 12464-2, 2014). It is also stated that *"in the event that there is no enforcement time, the higher values may not be exceeded and the lower values should preferably be taken as limit values".*

Table 1. Maximum permissible interference effects of outdoor lighting systems (EN 12464-2 2014).

Environmental Zone	**Light on properties**		**Luminaire intensity**		**Upward light ratio**	**Luminance**
	(E_v, lx)		(I, cd)		(R_{UL}, %)	(L_b, cd/m^2)
	Pre-curfew	Post-curfew	Pre-curfew	Post-curfew		Building Facade
E1	2	0	2500	0	0	0
E2	5	1	7500	500	5	5
E3	10	2	10000	1000	15	10
E4	25	5	25000	2500	25	25
E1: Dark areas such as national parks or protected places E2: Areas with little local brightness, such as industrial or residential areas in rural surroundings E3: Areas with moderate local brightness, such as industrial or residential areas in suburbs						

E4: Areas of high local brightness, such as city centers and commercial centers
E_v: The maximum vertical luminous intensity at the place of immission in lux
I: The luminous intensity of each light source in the potential direction of interference in candela
R_{UL}: The share of the light output of the luminaire(s) radiated above the horizontal plane with the luminaire(s) in its/their installed position and location in %
L_b: The highest mean luminance of a building's facade in cd/m^2

This paper represents an outdoor facade lighting design proposal to highlight the functional and architectural characteristics of an industrial heritage site by advancing observation and experience of the place's identity at night time. As an example of an industrial heritage site, Tirilye olive oil factory in Bursa - Turkey was selected. The case study building's architectural documentation and conservation project were previously completed by Acar Bilgin (2018). The study aims at augmenting the attractiveness of the industrial site for citizens and visitors and indirectly contribute to tourism and the local economy by illuminating the building's main facade and architectural details at night. In the results part, outdoor lighting results were evaluated considering the design principles of facade lighting and suggestions were given to promote the conservation of such industrial heritages and improve the quality of the nighttime environment for similar adaptive reuse projects.

2. MATERIAL AND METHOD

2.1. Case Study: Tirilye Olive Oil Factory

Tirilye is a coastal settlement in Mudanya Bursa, surrounded by a landscape of olive trees. The port city has been a peaceful multicultural and multi-religious hometown for Roman, Ottoman, and Turkish people through centuries. The Romans lived in Tirilye until the popululation exchange between Greece and Turkey in 1923 (Akkılıç, 2002). Today, as a suburban protected area, it has become a daily tourism center for visitors with its olive trees, inland sea, fish restaurants and architectural features. Tirilye hosts various monuments or traditional houses representing its multicultural history which some of which are registered and legally protected.

One of the early modern factories that can be considered as the reflection of industrialization on architecture in Bursa is the olive oil factory in Tirilye. The town's economy was based on agriculture, fisheries, olive cultivation, olive oil, and wine production in the past. After the industrial revolution, early modern factories were established in Anatolia as well as in olive-producer towns of Bursa between 19th century and the first quarter of the 20th century (Kaplanoğlu and Oğuzoğlu 2010). Today, the olive trade is still one of the main sources of villagers' income as well as tourism and fishery.

The International Committee for the Conservation of the Industrial Heritage (TICCIH) defined that "Industrial heritage consists of the remains of industrial culture which are of historical, technological, social, architectural or scientific value" (Douet, 2012). From this point of view, Tirilye olive oil factory, built by the Greeks in the 19th century, can be defined as an industrial heritage. The complex is located southwest of Tirilye, on the border of the residential district (Figure 1). The location of the factory and the prevailing wind direction from the Marmara sea to the land keeps the air of the residential area fresh and away from the factory fumes. (Acar Bilgin, 2018). The selected case study area was also legally registered as an urban conservation area by Bursa Regional Council for the Conservation of Cultural Property in 1981 (Ertürk, 2009).

Figure 1. Location of the case study Olive Oil Factory in Tirilye (GoogleEarth, 2022)

The factory complex consists of four parts; i) an olive oil workshop where human and animal power was used for production (second half of 19th century), ii) an atelier that has been used as a workshop for different purposes now (early 20th century), iii) service area including kitchen and toilets (second half of 20th century), iv) worker dormitory (second half of 20th century). The brick chimney was added to the factory late in the 19th century in connection with the steam engine. After the population exchange between Greece and Turkey in 1923, the factory was owned by a private family and a two-leveled building was added to the complex in the 1940s. The property has been owned by Tirilye Agricultural Cooperative since 1972. However, the factory and additional buildings have not been used for olive oil production since the 2000s except the olive oil workshop building which is used as an atelier. The images taken from the main (NW) facade of the olive oil factory and the site plan of the complex are given in Figure 2.

The olive oil factory has a rectangular plan scheme with a 5,1 m high single-storey. There exist six wooden window openings and three iron doors on the main facade of the masonry building. The cornices, jambs, and window sills were built of brick. As an attachment to the main building, the two-storey 7,5 m high atelier was also built with masonry construction tecnique using rubble stone and brick bonds. In this part of the facade, there exist four rectangular and four arched windows on both sides of the iron main entrance door. At ground level, front facade openings are rounded with brick architraves and have cast iron railings. The facades of the two buildings are plastered with lime mortar and painted in the 20th century. The timber frame roofs are covered with Marseille tiles.

Figure 2. Photographs and site plan of Tirilye Olive Oil Factory showing the present functions of the buildings and the development of the complex in the historical process (Reproduced from Acar Bilgin, 2018)

In the context of facade lighting, Tirilye Olive Oil Factory is selected as a representative of the development of olive oil production techniques and a component of the collective memory of olive culture in the Mediterranean region. In case the factory complex is renovated and reused in the future, the lighting project can contribute to the existing conservation project. Facade lighting can serve the social, psychological and physiological requirements of users by providing visual comfort as well as highlighting the factory's identity. Since the factory is located isolated from the town, outdoor lighting applications can also help ensure the safe and comfortable continuity of suburban life.

2.2. Facade Lighting Techniques

Various facade lighting techniques can be applied to buildings depending on the architectural features and the desired appearance to be revealed at night. Facade form, building envelope material properties and the desired effect to be created are effective in the selection of the techniques. Facade lighting design approaches can be classified into seven groups as i) floodlighting, ii) grazing, iii) accent lighting/selective highlighting, iv) silhouette lighting/backlighting, v) building openings, vi) contour lighting, and vii) media facade. More than one of the facade illumination techniques listed here can be applied based on the architectural context of the building, the texture of the materials used and the desired effect to be created. The specified lighting techniques have either static or dynamic lighting characters. In static lighting, CCT and light distribution on the surface and glare contrasts are applied according to lighting design decisions. Thus, facade luminous characteristic is maintained during the light application (CIE 94, 1993; IES, 2014). In dynamic illumination, the emphasis in different parts of the facade can be constantly changed by using fixed light colours and intensity and/or tuneable white technology. The difference in the night-time appearance of building elements is created by adjusting the luminous flux via dimming and/or tuning the light colors without changing the location of the light sources (IES, 2014). Facade lighting techniques are briefly explained as follows:

i. In CIE International Lighting Vocabulary (CIE, 2011) *floodlighting* is defined as the "illumination of an object or a view, often with projectors, to strongly amplify luminance relative to its surroundings". In the Society of Light and Lighting manual, the use of floodlights has been described as filling a surface with light (wash lighting) or highlighting a particular feature of a structure (SLL, 2009).
ii. *Grazing* technique can be considered a different approach from floodlighting due to the location of the lighting fixture. The lighting device located at a certain distance

from the building ensures that the architectural elements such as the balcony, bay window, or horizontal and vertical architectural lines fall onto the facade. However, wall grazing does not reveal the textural character of the building material. Conversely, the natural material texture such as brick and stone may appear even flatter. The farther the lighting device is placed from the building, the shorter the length of the shadows on the facade, thus the shadow effect diminishes. On the other hand, the lighting fixture placed too close to the facade results in the shadows of small protrusions on the surface to fall on the surface. This was, three-dimensional features and textural properties of the materials become more evident.

iii. *Accent lighting* (selective highlighting) is used to highlight special objects; for artistic elements to be exhibited, conspicuous architectural features to be brighter than the surrounding surfaces. This lighting technique is similar to floodlighting and is used to emphasize the details.

iv. *Silhouette lighting* (backlighting) is the illumination of the background to reveal a silhouette of the main facade, leaving the surfaces in the dark in front of the illuminated background. In some circumstances, it is necessary to use a low level of lighting to reveal the shape of the main facade (CIE 94, 1993). A typical silhouette illumination is generally applied in buildings with coarse columns, allowing columns to be perceived as silhouettes. Another example of this technique is applied by leaving the main building in the dark and illuminating the facade of a simple building that is behind the main facade, thus revealing the architectural features as silhouettes.

v. In the *building openings technique* the structure is used as a lantern. The windows determine the architecture and the building is externally perceived through the openings.

vi. The *contour lighting* technique is described by simplifying the outline of the building (Philips, 2014). The purpose of this technique is not to illuminate the surfaces, but to illuminate the light source itself so that the luminaires appear. Thus, the geometry of the structure is clarified and the architectural lines are revealed. This technique is more appropriate to highlight the geometrical form of the building rather than the details of the architecture. For instance, large entrances, bridges, arches, and contemporary structures can be enlightened by this technique (CIE 94, 1993). Lighting fixtures used in contour lighting are generally in the form of linear or point modules. These modules can be inserted end-to-end, revealing the outline of the structure through light lines.

vii. As a result of the integration of the media with architecture, building facades become a dynamic communication medium transforming cityscape. Pixel-driven *media (communicative) facade* uses light to convey specific information. Facade lighting consists of a large number of small lighting points or luminous fields. Images, graphics, texts and videos can be played back on a usually grid-shaped matrix. The lighting fixtures used in the media facade technique are directly located in the field of view and can be created on a large scale covering the entire facade (Philips, 2014; Zumtobel, n.d.).

3. RESULTS

In the first step, the case study building was modeled using Autocad and Google Sketchup applications including the immediate surroundings and topography of the site. Secondly, the 3D model was transferred to DIALux Evo software. Facade lighting techniques that can be applied to illuminate different architectural elements were investigated and lighting design was developed in this program. In the last step, outdoor lighting simulation results were assessed according to the visual requirements recommended in CIE (1993), EN 12464–2 (2014), and IES (2014) standard and guidelines. Aspects related to architectural design such as facade material properties, recommended museum function, surrounding buildings together with outdoor lighting design aspects including permissible illuminance (lx), luminance (cd/m^2) and luminous intensity (cd), correlated colour temperature (CCT) and colour rendering index (CRI) of the light sources are considered. The compatibility and harmony of the lighting equipment with architectural features (surface textures, archways, windows, etc.) are

also taken into account. In terms of energy conservation, sky glow, and light pollution, lamps and luminaires were selected from the DIALux Evo library according to beam angles, delivered flux output, initial input power and luminous efficacy. Specifications of the light sources are summarized in Table 2. Google Sketchup day scene and DIALux Evo night scene images are given in Figure 3 and Figure 4 respectively.

Table 2. Facade lighting methods and luminaire specifications (Philips 2019, Artemide 2019)

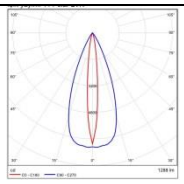
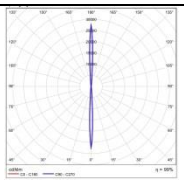
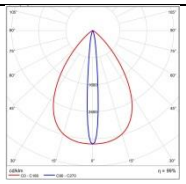
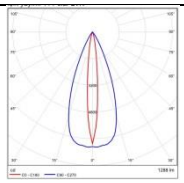
Facade Lighting Technique and Mounting Mode	Light Distribution	Product Image	Luminaire Specifications
Floodlighting Windowsill mounted 19 lighting fixtures			Φ: 3560 lm P: 40 W CCT: 2200 K η: 99,25% K: 89 lm/W CRI:80
Up/downlighting Doorjamb mounted 8 lighting fixtures			Φ: 467 lm P: 16 W CCT: 3000 K η: 98,7% K: 29,2 lm/W CRI:80
Grazing Ground recessed 37 wall washers			Φ: 1620 lm P: 60 W CCT: 3500 K η: 99,25% K: 27 lm/W CRI:100
Accent lighting Rooftop mounted (chimney) 2 spotlights			Φ: 7408 lm P: 273,8 W CCT: 3000 K η 99,86% K: 27,1 lm/W CRI:100

Figure 3. Google Sketchup 3D images of Tirilye Olive Oil Factory

(a)

(b)

Figure 4. DIALux Evo 3D night scene images of Tirilye Olive Oil Factory (a, b)

In the proposed outdoor lighting scenario, we aimed to integrate LED lighting solutions into the main facade, highlighting masonry stone and brick surfaces with light and shadow, accentuating the architectural details and revealing the building's remarkable elements. In line with these aims, we investigated the characteristics of the factory and its surroundings and the visibility of the building from the environment. As a result of the field study, day and night images of the factory were documented, which is located in environmental zone E3 (suburban, medium brightness) according to EN 12464-2 (2014). Narrow beam floodlights are preferred in the windowsills to evenly illuminate the windows and highlight the difference in colour temperature between the masonry walls (3500 K, natural white) and the wall openings (2200 K, warm white). Narrow beam up and down lights are proposed on the door jambs to emphasize the building entrances. Grazing luminaires were positioned close to the external walls to create a wall-washing effect. The close offset of the light source made it suitable for revealing the texture of rubblestone and the details of bricks by dropping shadows. Two wide-beam accent projectors were also mounted on the roof to emphasize the vertical geometry of the chimney, which will be perceived as a statue at night while contrasting with the background topography.

Simulated light levels on the building facade provide reference values recommended by IES (2014) and EN 12464-2 (2014) standards. Illuminance on the vertical plane (E_v) is below the threshold values of 10 lux and 2 lux on the surrounding properties.

4. CONCLUSION

Urban memory is a collective memory that is comprised of the experiences of citizens in historic and social environments of urban spaces. Industrial buildings are the spatial traces of this collective memory through experiences, traditions, habits, and knowledge of citizens. Preservation and improvement of industrial heritage can provide continuance of this collective memory for future generations.

Bursa is a well-known olive producer city for centuries. Olive oil production technology has been developing from antiquity to the present day around the Mediterranean basin. The olive oil factory in Tirilye is a social and cultural component of urban life in the Marmara region. The building itself is a document of local history and can play a significant role on creating and sustaining urban memory. Even though the building is waiting to be restored, the architectural features still represent the social, cultural, and economic relationships in Bursa by being a part of daily life. Therefore, the selected case study building can be counted as a reflection of industrialization in architecture in Bursa.

Within the scope of the research, a facade lighting proposal is presented for an exemplary industrial heritage building. Outdoor lighting is used as a key factor to improve user visual perception and the quality of nightlife, to create a cityscape and unique experiences through the local identity. The olive oil factory is expected to attract both passers-by and residents, as well as draw attention to the industrial heritage site of the city. It is aimed to transform the historically valuable area into a vibrant, social space for locals and tourists with facade lighting.

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