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Balancing narrative, culture & environment

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Abstract:

In an era where brightness is often considered a sign of progress in many metropolitan cities, this thesis attempts to question conventional notions of facade lighting by suggesting a contextual approach. Focusing on Mumbai, a city where illuminated buildings are becoming a growing trend as a reflection of cultural pride and economic ambition, this study reimagines facade lighting as a medium that can enhance urban identity while respecting the environment.

The research includes comparative insights from Copenhagen, combining quantitative analyses with qualitative perspectives from users and professionals. An adaptable two-tiered framework based on ecological zones and architectural typologies is evaluated through two site-specific lighting design proposals : a heritage monument and a residential building.

The project aims for facade lighting that users can observe as well as experience. It communicates narratives, honors darkness, and fosters a sustainable urban nightscape. Re-imagining excessive illumination as intentional, inclusive, and deeply rooted in context.

RE – IMAGINING FAÇADE LIGHTING

Balancing narrative, culture and environment

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I would also like to thank the developers in Mumbai who generously granted access to construction sites and supported the testing of the proposed design. Their cooperation was essential in translating theoretical insights into practical applications.

My sincere appreciation extends to the lighting designers from Mumbai, Copenhagen, and Paris, whose shared insights enriched the comparative dialogue. Their perspectives on façade lighting design contributed significantly to the multidisciplinary foundation of this study.

Thank you to everyone involved in this research for contributing to a shared vision of a more thoughtful and sustainable nocturnal environment.

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link to view video documentation on Google Drive:
https://drive.google.com/drive/folders/1EqEKR6zkxtagzIPE62ZVOLrg05YyVFHj?usp=sharing

1. INTRODUCTION

1.1 BACKGROUND

Architectural façades are intended to be the surfaces by which cities convey their modernity, historical narrative, and cultural identity. The natural light and shadows interacting with these façades help to accentuate the features of these buildings during the course of the day. They are lit during dark hours with artificial light to highlight different architectural elements and improve the urban surroundings. Emphasizing architectural form and distinct qualities can help to develop a building's identity and visually distinguish it from others, which in turn affects viewers emotionally. (Descottes, 2020). According to Lynch (1960), façade illumination is useful in improving urban navigation, safety, and the emotional state of the neighborhood. Illuminated façades, which have the ability to influence perceptions and interactions that take place within the environment, contribute to the enhancement of captivating and liveliness of urban places. Lighting can transform a building into a dynamic component of the urban environment by evoking emotions, encouraging cultural narratives, and promoting social interaction. Such goals can be accomplished by emphasizing textures, colors, and structural shapes.

Urban design in metropolitan and developing cities increasingly relies on façade lighting to create dynamic nightscapes supporting the visual character of a city. However, relying heavily on artificial light comes with a cost. Inappropriate regulation of façade lighting causes substantial energy consumption and light pollution. It also disturbs natural ecosystems, affect human health, and obscure the night sky. According to Kyba et al. (2017), the global artificially lit outdoor area expanded by 2.2% yearly between 2012 and 2016, increasing the total radiation annually by 1.8%. Therefore, urban development requires a balance between aesthetic considerations and environmental responsibilities.

Modern practice employs façade lighting for additional purposes including seasonal celebrations and special events, where lighting design greatly influences the intended mood. Thereby, enhancing the experience of inhabitants and visitors. Carefully calibrated lighting systems enable designers to create surroundings that feel more inviting, comfortable, and immersive, therefore ensuring that buildings stand out visually and serve to develop important relationships between people and their surroundings.

1.2 MOTIVATION

The motivation for this subject of study arises from personal and professional experiences. Growing up in Mumbai, I have experienced the evolving , dynamic change in nocturnal transformation of the city. Further, my academic journey and travels took me to other cities such as Copenhagen and Paris, where I observed different approaches to lighting in an urban environment. These experiences helped me to better understand the differences and similarities about façade lighting practices across different regions.
In Copenhagen, I learned about lighting strategies that focus on energy efficiency and sustainability, prioritizing the city's commitment towards environment in urban planning. Conversely, Paris prioritizes the enhancement of architectural history through unique illumination, while recent developments indicate a substantial commitment to reducing light pollution. Witnessing these differences reinforced my determination to explore how Mumbai may implement sustainable lighting techniques, harmonizing environmental consciousness with its vibrant cultural identity and aesthetic appeal.

1.3 VISION

This research envisions façade lighting as a design tool that thoughtfully merges aesthetic narratives, cultural identities, and ecological sustainability.

" To re-imagine façade lighting that balances narrative, culture and environment."

Informed by literature review and international case studies, the study proposes a framework tailored to Mumbai's diverse architectural typologies. The aim is to contribute to nocturnal cityscapes that respect the natural environment, elevate urban identity and foster meaningful community connections.

1.4 SCOPE AND LIMITATION

The study examines how façade lighting affects identity of a city, with an emphasis on cultural and environmental aspects in lighting design. It begins with review on lighting practices and policies of different cities, supported with literature that looks at regulatory, aesthetic and perpetual aspects of façade lighting. It analyses building types in order to know the relation of façade illumination in different urban environments. These analyses guides a design framework that is eventually evaluated by using it at specific locations in Mumbai.

The study is based in Mumbai, however the methods and framework proposed might be used in other cities as well, especially those that are growing quickly and having comparable cultural and environmental issues.

However, there are several limitations. The geographic focus on Mumbai may limit the application of proposed outcome in other urban contexts with different climatic and cultural background. Additionally, the technical limitations of lighting simulations may not be able to record the accuracy of energy consumption and light pollution.

Due to the subjective method of analyzing user perceptions, the findings of this research may not be universally applicable. While the report references regulatory frameworks from other regions, it does not propose explicit legislative actions. Instead, it introduces and proposes designs that policymakers may use as reference. By exploring how visual appeal can coexist with eco-friendly approaches, the research seeks to support future initiatives in urban lighting design that effectively address both cultural significance and sustainability objectives.

1.5 INITIAL RESEARCH QUESTION

The initial research question considers façade illumination as a driving component influencing metropolitan urban character. It aspires a design framework that blends environmental responsibility with cultural value of urban nightscapes.

How can façade lighting in metropolitan cities enhance urban identity by creating inviting urban spaces that are energy-efficient and compliant with dark-sky principles?

2. METHODOLOGY

2.1 MIXED METHOD APPROACH

Combining qualitative and quantitative methods, a general overview of function of façade lighting in different cities is achieved. Incorporating human experiences, perspectives and cultural narratives with tangible considerations like energy efficiency and environmental impacts, this approach offers a holistic perspective.
The research examines key aspects of façade lighting techniques in Copenhagen and Mumbai city, with different geographical and cultural background. This comparative perspective will help to adapt global practices in city's urban environment.

2.2 QUANTITATIVE METHOD

The main objective of the quantitative phase of research is to assess the technical performance of façade lighting concerning energy consumption. This section will compile objective data to analyze the effectiveness of lighting systems and the probability of light pollution.

While Greece is not examined as a site specific case study, it is used as a methodological reference that informs the analytical and design phase of this research. The quantitative methodology is adapted from the doctoral thesis by Militsa Tomasovits (The impact of exterior lighting in buildings on sustainability and the environment, Hellenic Open University). It provides thresholds for light power Density - LPD and is used to access buildings in Copenhagen and Mumbai.

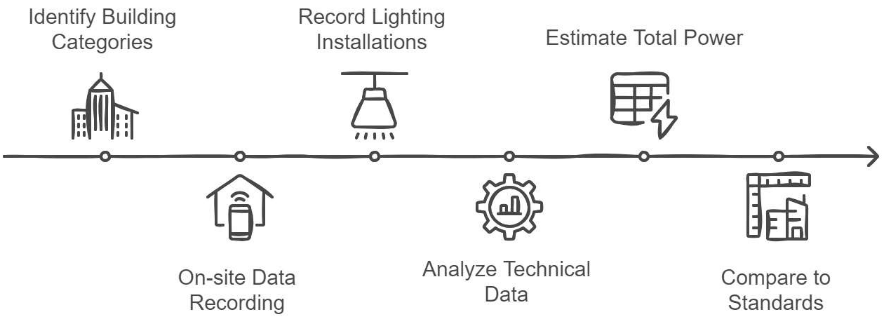

Fig 2.1: LPD assessment workflow for façade lighting , author 2025

This methodology begins by identifying building typologies, followed by on-site data gathering and documentation of light installed and analyzing the collected data. Overall power consumption is estimated and the findings are compared with established standards of the city.

ENERGY CONSUMPTION ASSESSMENT : Lighting Power Density (LPD) is measured in watts per square meter. (W/m2). This will calculate the use of energy with respect to the area lit on a surface. This data will help to understand the energy usage of different buildings in Copenhagen and Mumbai.

LIGHT POLLUTION : Existing research data provides insight about the spatial distribution of light pollution. Satellite data helps to identify the intensities of light pollution. It is used as background information to identify geographical zones with rich bio diversity.

2.3 QUALITATIVE METHODS : Interviews and User Perception Studies

Qualitative approach deepens understanding of human experience under façade illumination. This part of the research aims to document how various user groups in different cities experience and interact with lit façades. These techniques will be used:

EXPERT INTERVIEWS : Semi-structured interviews with lighting designers, architects provides insights about challenges , opportunities and optimal practices associated with façade lighting. The interview addresses their views and opinions about, balance between aesthetics, sustainability, cultural sensitivity and dark-sky compliance in façade lighting design. These insights will provide the research with valuable context to inform the development of design recommendations.

USER PERCEPTION SURVEYS : A structured questionnaire is administered to get diverse perspectives on façade lighting, focusing on its emotional impact and influence on the overall experience of city spaces at night. Respondents are asked to select from the choices of questions and share their experiences in open-ended section. It involves reflecting on cultural background and regional lighting preferences. The collected responses provide valuable qualitative insights into the social and cultural roles of façade lighting, highlighting differing regional expectations and the potential of light in creating an inviting space.

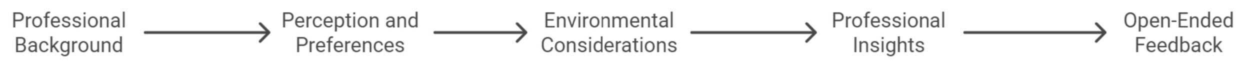

Fig 2.2 : Structure of User Survey and Interview Questions , author 2025

2.4 CASE STUDY SELECTION CRITERIA

Buildings from Copenhagen and Mumbai are selected based on architectural significance, cultural representation, and data availability. Most preferably building structures at city centers are taken into consideration. These buildings represent the architectural typologies from heritage landmarks to modern structures, showcasing its lighting intensity. The selection considers cultural influences on lighting practices in both cities, with a focus lighting design trends in both the cities. The case study is structured into two phases. Phase 2 presents Copenhagen as a reference case, while Phase 3 focuses on Mumbai as applied case , where the design is proposed, tested and evaluated.

2.5 DESIGN EXPERIMENTAL MODEL

The research adopts Lighting Design Experiment (LDE) Model as outlined by Hansen, E. K. (2014) as a guiding methodological framework. This method promotes a transdisciplinary approach, integrating principles from natural science, social science and humanities. This study comprehensively addresses the technical, cultural, and social aspects as follows :

Natural Science : Evaluates environmental aspects by assessing energy use and current satellite data to reduce light pollution.

Social Science : Examines how lighting shapes public perceptions and social interactions within of metropolitan settings.

Humanities : Investigates how lighting can accentuate architectural details and reflect cultural narratives.

METHODOLOGY PROCESS DIAGRAM

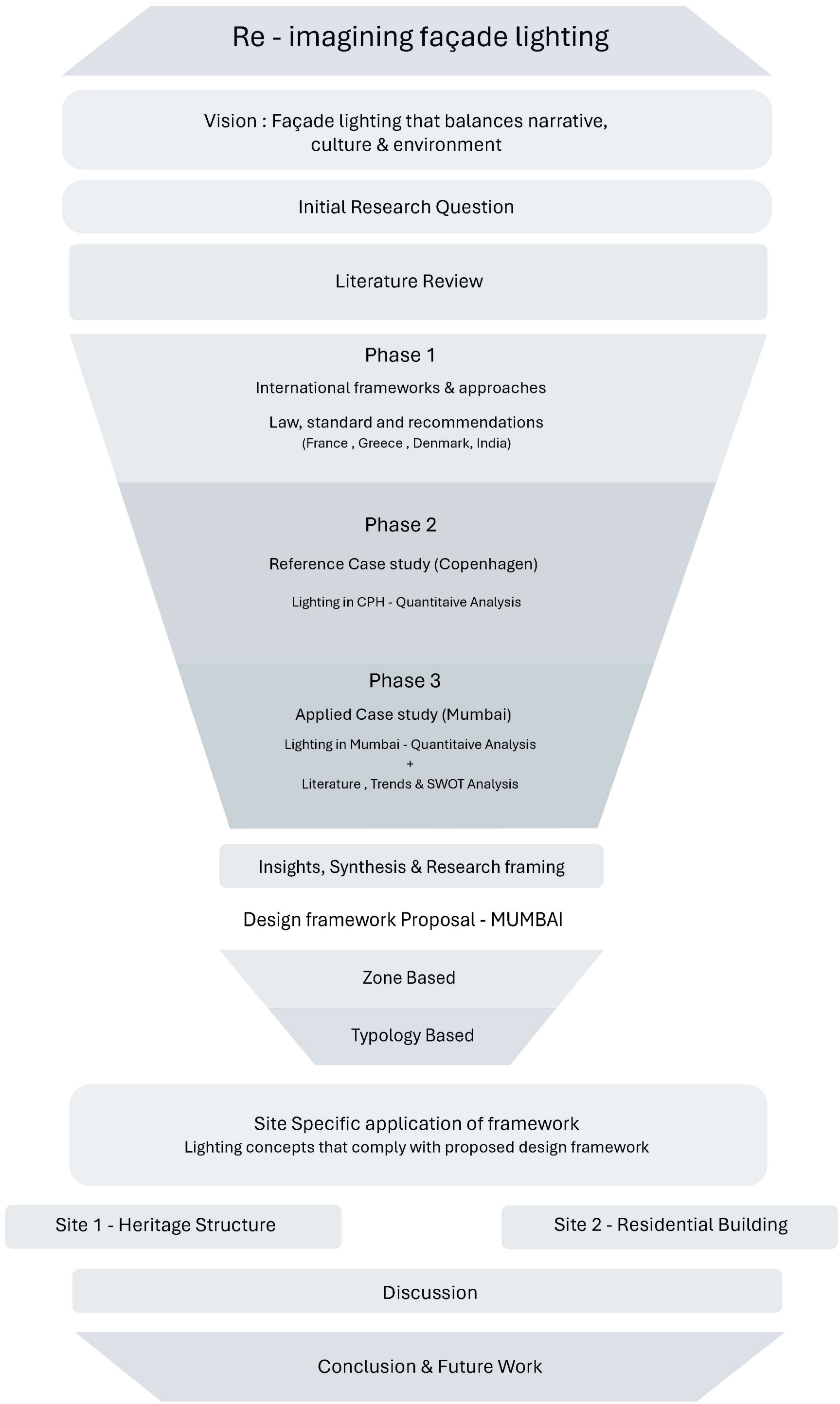

Fig 2.3 : Methodology process diagram , author 2025

3. LITERATURE REVIEW

This chapter explores the theoretical foundations of façade lighting by examining its evolution, technical principles, social and cultural implications. It begins with a review of key lighting concepts such as luminance, reflectance, contrast, and colour temperature. Then it looks how these ideas are applied in architectural façades. The chapter then discusses the broader roles of light in shaping urban experience, drawing from urban theory, visual perception, and cultural narratives. The focus is on regional lighting methods and the Indian aesthetic framework of Rasa, which offers a lens for interpreting emotional relation with lit environments. Together, these perspectives inform the research direction and establish the conceptual base for the framework proposed in following chapters.

3.1 EVOLUTION OF FAÇADE LIGHTING

The evolution of façade lighting has been significantly influenced by technological advancements and over time its cultural importance has grown substantially. Lighting was initially used for providing visibility and safety. But façade lighting became quite crucial in establishing the architectural and urban identity of cities as electric lighting evolved (Degen, 2019). As lighting technologies advanced, façade lighting moved beyond its utilitarian purpose to become an integral part of architectural aesthetics, influencing not just visibility but also the creation of atmosphere and identity (Benedikt et al., 2021).

Earlier, natural sources like candles and fire torches were used for ceremonial purposes, while the invention of the light bulb introduced new possibilities for highlighting building contours. In 1920s, advertising used lighting extensively, which spurred discussions about how it would compromise architectural integrity and beauty. Over time, designers began adding façade lighting into their creations, considering not only nighttime visibility but also how the building interacted with its surroundings. Today, façade lighting is crucial in defining urban landscapes, enhancing both navigation and aesthetics. A planned lighting design accentuates architectural character while ensuring harmony with its environment. It strikes balance between contrast and uniformity preventing monotony and ensuring a visually cohesive nightscape.

By making façade lighting more energy-efficient, modern controllers and LEDs have helped to improve the sustainability of urban lighting (McKinney et al.,2020). These advancements enable more dynamic, context-sensitive designs. Overuse of floodlights may distort the appearance of a structure and isolate it from its surroundings. Conversely, strategic lighting techniques help to enhance textures and preserve depth, therefore helping to keep the natural visual coherence as perceived in daylight. Factors including light intensity, direction, color rendering, and material reflectivity affect final perception of illuminated building.

In Architectural Lighting : Designing with Light and Space, Hervé Descottes, explores how six visual principles of light shape architectural experiences. He emphasizes the importance of incorporating lighting in initial design process in order to enhance both functional and emotional effect. This approach highlights how façade lighting can redefine a building’s identity and engage pedestrians. Effective façade lighting demands a complex strategy to make sure that shadow and light collaborate to enhance rather than overpower the form and context of the structure. This intended approach to lighting design offers a consistent and strong visual experience by making conscious use of new technology.

3.2 FAÇADE LIGHTING PRINCIPLES AND TECHNIQUES

3.2.1 REFLECTANCE , LUMINANCE AND ILLUMINANCE

The interaction of light with the surfaces of façade materials is determined by characteristics such as absorption, transmission, and reflection. Reflectance - refers to the light that is bounced back from a surface. It often varies according to material. For example, glass and polished metals reflect more. While concrete and stone absorb or scatter light. A reflectance of at least 0.2 is typically recommended to ensure sufficient light return without causing excessive brightness (Descottes, 2020).
Luminance (cd/m^2) is basically the visible brightness of a surface that is perceived by human eye. It is influenced by both the reflectance of the material and Illumiance (lux), which measures the amount of light that falls on the surface. Higher illuminance is required on low-reflectance materials to obtain the same perceived brightness, therefore both of these are inter related.
As Santen (2006) and Elliott & Hoelscher (2020) explain, façades in darker environments require lower illuminance to be visually effective, while those in brighter surroundings demand more light to maintain visibility. For instance, a standalone building in a low-light setting may require less lighting, whereas one in an urban setting with abundant lighting may require more to be seen (Schulte-Römer & Röser, 2019). For sensitive structures like heritage buildings, Schulte-Römer et al. (2019) suggests brightness below 0.5 cd/m^2 to reduce glare and preserve the structure.

$$L = \frac{E \times \rho}{\pi} \quad \text{or} \quad E = \frac{\pi \times L}{\rho}$$

L = Luminance (cd/m^2)

E = Illuminance (lux)

ρ = Reflectance (as a decimal)

π = Pi (approximately 3.14159)

Fig 3.1 : Relationship between illuminance, reflectance, and luminance , Santen (2006)

3.2.2 CONTEXT AND LUMINAIRE ARRANGEMENT

Building structures are key components of an urban environment. Therefore, they are often influenced by their surroundings. The illuminance required to adequately lit a façade is derived from the light levels in the surrounding area. While darker locations require less illumination to preserve visual harmony and follow dark sky criteria, brighter metropolitan streets demand more intense façade lighting to ensure that building shines out (Sickafus & Landis, 2021). For instance, façade lighting needs to be more radiant in areas like Paris where street lighting is abundant to maintain eyesight. Conversely, in locations with lower light levels and fewer street lights, a more subdued approach becomes more beneficial (Santen, 2006).
Kyba et al. (2017) caution towards façade brightness exceeding 2.0 cd/m^2 due to the potential of urban glare. Additionally, Falchi et al. (2016) emphasizes brightness levels in residential zones should remain below 0.5 cd/m^2, in order to avoid disrupting circadian rhythms. (Santen, 2006) recommends luminance values (cd/m^2) in a framework for calibrating lighting intensity according to context.

Situation	Luminance (cd/m^2)
Freestanding building or statue	3.2- 6.5
Building in a street with Dark surroundings	6.5 - 10
Building in a street with Well-lit surroundings	10 - 13

Fig 3.2 : Recommended luminance levels in urban context , Santen (2006)

Achieving the desired lighting depends not only on the light level but also on its distribution throughout the façade. This mostly relies on the position of luminaires as it ensures a consistent light distribution and contribute in preventing heavy shadows that might harm the architectural integrity. This can be challenging, especially when installation options are limited or in case of preservation restrictions. Such buildings demand careful design to balance lighting with the need to preserve the current construction. (Degen, 2019).
Combination of lighting techniques are used to address these challenges. While uplighting, downlighting, and grazing increase textures and depth, other techniques including floodlighting, silhouetting, and spot lighting can display important architectural characteristics. Additionally, Dynamic effects including colored lighting and media façades, add layers of visual interest and can be tailored to the particular requirements of the building. By integrating multiple lighting approaches, it is possible to overcome practical limitations while achieving aesthetic objectives. These techniques ensure that façade lighting accentuates the building and its urban setting in harmony.

Fig 3.3 : Typologies of façade lighting techniques (Tomasovits et al.,2025)

3.2.3 CONTRAST AND COLOUR

Façade lighting requires a balance between uniformity and contrast. Santen (2006) advises a 1:10 contrast ratio to avoid strong contrasts that could affect the appearance of the structure. It ensures that lighting accentuates the architectural qualities without overwhelming them, contributing to a more balanced urban environment. Appropriate luminaire selection and placement are critical to maintain this balance. Placing lights at a greater distance may enhance uniformity but could also make the façade appear flatter and increase the potential for light spill, which may disrupt the surrounding environment (Reilly & McHugh, 2021). Therefore, position of the lights and their brightness levels are important factors that must be taken into consideration.

Another important factor determining the initial appearance of the façade is the light source's colour temperature. Using lights with poor color rendering index can result in unsatisfactory lighting effects, such as making red bricks appear darker and distorting their natural shade (Cincinelli et al., 2019). High Color Rendering Index (CRI) values and appropriate colour temperatures are necessary to ensure that the light complements the façade's material, enhancing the colours' vibrancy and lifelikeness (Elliott & Hoelscher, 2020). Color temperature also influences the narrative that lighting conveys. Warmer tones create a softer, more inviting atmosphere, while cooler tones convey modern, energetic atmosphere (Gaston et al., 2012). Cultural differences in colour temperature perception are also worth considering, as different regions with different climates and social customs may have different preferences.

3.3 LIGHT POLLUTION

Light pollution is defined as the excessive and inappropriate use of artificial lighting that disrupts natural darkness of the night sky. It is predominantly seen in urban areas when nocturnal sky are clouded by illumination from building structures and commercial establishments. Each factor uniquely influences the nocturnal environment and has distinct effects on public health and urban development.
The International Dark Sky Association (IDA, 2011) categorizes light pollution into different types, including glare, skyglow, light clutter, and over-lighting, which are relevant in relation with façade illumination.

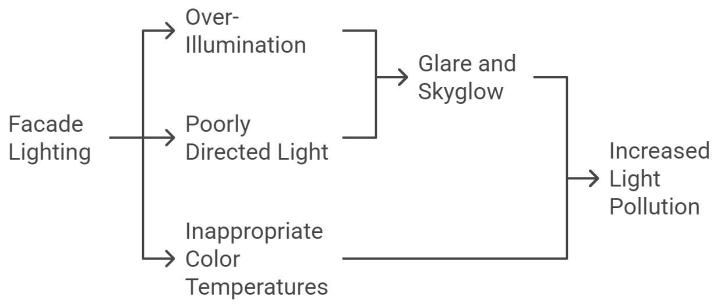

Fig 3.4 : Impacts of improper façade lighting , author 2025

GLARE

It arises due to poorly shielded or excessively bright luminaires. When façade lighting fixtures are incorrectly aimed or designed without appropriate optics, the brightness can be visually uncomfortable, reducing clarity and visibility during dark hours. This disrupts visual perception and comfort, decreasing the experiential quality by façade lighting.

SKYGLOW

The diffused brightening of the night sky. It is notably intensified by façade lighting, particularly when fixtures direct substantial amounts of light upwards. Illuminated building façades significantly contribute to urban skyglow, obscuring celestial visibility and affecting nocturnal ecosystems (Falchi et al., 2016). This disturbance exceeds beyond limits, affecting ecosystems in adjacent semi-urban, rural and environmentally sensitive areas.

LIGHT CLUTTER

In crowded urban areas, many illuminated façades compete for attention creating Light clutter. It leads to unorganized and overlit surroundings. It diminishes architectural appreciation and encourages confusion rather than clear architectural storytelling.

OVER ILLUMINATION

It is the caused due to unnecessary use of artificial light for aesthetic or visual purposes. This problem not only increases energy consumption but also intensifies various forms of light pollution, hence raising general urban brightness (Kyba et al., 2017). In densely populated cities, energy waste can further cause environmental challenges, financial pressures, and other issues.

LIGHT POLLUTION IN INDIA

India, as one of the fastest-growing economies, is experiencing rapid urbanization and infrastructure development. Although artificial lighting has contributed to more light pollution, it has significantly improved safety, business, and social interactions. According to Singh et al. (2020) in Artificial Light at Night in India, 58.5% of India's population is exposed to light pollution, covering 24.7% of the country's area. Major metropolitan cities are seen experiencing high levels of light pollution. Amongst the increasing light polluting cities, the brightness level show Bangalore with high intensity (28.7 nW/cm^2/sr) and Mumbai with the lowest (20.8nW/cm^2/sr).

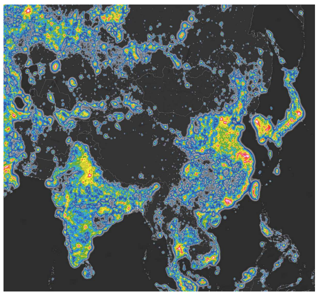

Fig 3.5 : Global map of nighttime light pollution across Asia , Falchi et al. (2016)

Bedi, T. K.,et al.(2021), highlights that Indian cities, being in a diversed architectural and climatic conditions, have been facing an increase in the luminous intensity which is parallel to conditions in North America and Europe. Likewise, Falchi et al. (2016) revealed in The New World Atlas of Artificial Night Sky Brightness that over 83 percent of the world population lives in light-polluted sky.

Emerging studies ,Singh, R. et al(2022) caution that growing brightness is not the only outcome of population density and economic growth, but also a result of unregulated façade lighting, commercial signage, and media façades. These light sources often lack context-sensitive design and shielding measures, thereby intensifying urban skyglow and causing ecological disruptions. Furthermore, health-oriented research now links prolonged exposure to artificial light at night (ALAN) in Indian cities with circadian rhythm disruption, indicating an urgent need to integrate light pollution mitigation strategies into urban master planning.

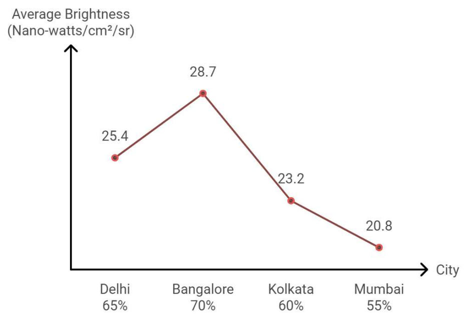

Fig 3.6 : Average night-sky brightness in Indian metropolitan cities , Singh, R. et al. (2022)

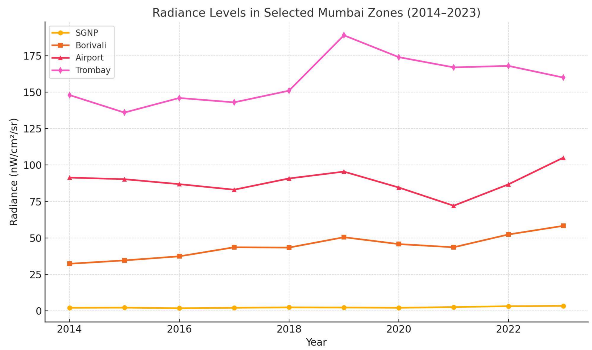

Fig 3.7 : Radiance trends in SGNP and adjacent urban zones, Khandeparkar. A (2024)

Being located in the northern part of Mumbai, Sanjay Gandhi National Park is one of the few protected forests in the world that is entirely within a city. It covers more than 20% of Mumbai's geographical area, however it is experiencing increased skyglow as a result of urban migration from nearby suburbs. As seen in Fig 3.7, the brightness levels of SGNP have been increased from 2.10 to 3.40 nW/cm^2/sr between 2014 and 2023, with an increase in 62% rise. (Khandeparkar, A. 2024)

This has been influenced by many factors , including light spill from the adjacent neighborhoods. For example, Borivali, which borders the park, recorded a significant higher radiance reaching 58.3 nW/cm^2/sr, nearly 17 times greater than SGNP. These substantial differences suggest the need for a zone based lighting regulation , especially in environmentally sensitive areas.

3.4 SOCIAL ROLE OF LIGHT

façade lighting serves as bridge between architecture and urban planning since it displays building's unique features and blends it with its surroundings. Beyond just emphasizing architectural aspects, effective façade lighting substantially helps to define urban character, thereby creating pleasant and motivating spaces for social interactions.

Kevin Lynch (1960) in The Image of the City highlights important components of urban design that influences people's perceptions and the way they navigate in urban environments. Façade lighting plays a supporting role for landmarks as it reinforces their location by enhancing wayfinding to orient an individual at night. Socially responsive façade lighting enhances the functionality of urban environments. It defines thresholds, edges and volumes, helping people interpret space during night hours. It becomes a visual guide, connecting zones of activity and fostering continuity between built form and human flow. Pedestrians confidently find their way and connect with their known surroundings mentally, which would otherwise become disorienting in darkness. (Schulte-Römer & Röser, 2019)

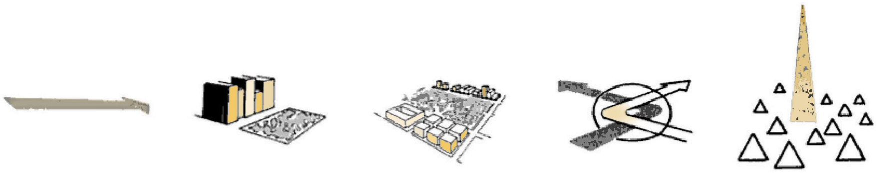

Fig 3.8 : Façade lighting aligned with urban elements , Kevin Lynch (1960)

In addition to supporting navigation , façade lighting stimulates emotional significance and social inclusion in the urban environment, as it creates a perception of safety. Subtle façade illumination can reduce the fear of isolation and increase the usability of urban space during dark hours.
Illuminated façades encourage movement and sense of belonging, by creating spatial experiences that are comfortable, recognizable, and emotionally grounded in daily urban life. Therefore, it becomes an insignificant part in the urban environment rather than just highlighting the form. Survey responses collected in this study showed that 75% described lit buildings to be “inviting”, “memorable” and “welcoming.” These behavioral responses endorse that façade light contributes to spatial atmosphere beyond usability. Thereby, encouraging users to explore, connect with surroundings and socially engage. (Elliott & Hoelscher, 2020).

Façade lighting engages users, primarily through perceived coherence and functional applicability. It adapts according to human dimensions and visual comfort to improve spatial perception. Today, adaptive lighting strategies ensure that light continues to be useful to shifting societal cycles. These vulnerability builds lighting as a dynamic component of the social environment, varying in intensity and purpose based on time and occupancy rather than as a static object. It helps to create atmosphere where lighting is not an additive but a transformational element in function. (de Frutos et al., 2024).

Different regions reveal how lighting strategies can reflect patterns of social behavior and urban life. In Copenhagen , urban planning encourages pedestrian friendly environments. Therefore, façade lighting is scaled to human proportions and low levels of light with warm colour temperature are preferred. This results in soft , ambient lighting that promotes quieter form of social interaction.
Whereas in Mumbai, late night social activities and commercial vibrancy rely on façades that remain brightly lit into late hours, promoting pedestrian flow and informal gathering. While aesthetic interpretations vary between places, the social role of light – enabling safety, inclusiveness and public interaction, remains consistent.

3.5 CULTURAL ROLE OF LIGHT

In addition to the role of functionality and social presence, façade lighting becomes the cultural medium to convey the idea, reflect identity and sustain the collective memory. In an urban space, lighting is an integral part of city´s visual language. façade lighting is often used to communicate traditions, values and narratives that define the cultural character of the space.

Culturally responsive lighting is more inclines towards the value or the intend instead of visibility. façade lighting on heritage structures evoke emotional memory and support historical continuity. It connects the citizens with their past by illuminating architectural details that might have otherwise remain overlooked. For instance, temples, churches and forts with unique features are often lit in a subtle way that reflects narrative and re-establishes its presence in the urban fabric. By means of this, the light becomes an interpretative tool rather than a neutral enhancer. (Narboni, 2015)

façade Lighting also represents ritualistic and symbolic identity of a space. It is often seen during national events and festivals. Some buildings lit their façades during Christmas, making it a landmark of space. On national days monuments are illuminated with the flag coloured lights ,creating a symbolic layer with shared cultural memory and unity.

As discussed in the previous chapter, façade lighting creates a sense of belonging from a social perspective. Culturally, it connects the viewers by revealing materials, forms and details of the architecture that resonates with the local history. By illuminating these elements it nurtures emotional engagement by creating it familiar, lived-in and symbolically significant. According to de Frutos et al. (2024), Light plays an important role in creating layered atmosphere that supports both memory and identity.

In contemporary practice, façades are lit to represent narratives promoting national stories, projecting messages, images for public campaigns and celebrations. There has been a shift in the trend of illuminating façades with growth in the field of technology. These provide opportunities for group memory creation and civic reflection.

façade illumination has not been limited to monuments and heritage buildings, whereas it has also been a part of other functional buildings including the sector of hospitality, retail, commercial and residential.

Ultimately, the objective plays an important role in cultural lighting to decide what element to illuminate and message to convey. Colour temperature, intensity and directionality shapes how the building is perceived and remembered. According to Schulte-Römer et al. (2019), these decisions claim symbolic hierarchy and the cultural value within the nightscape. The following table summarizes social and cultural role of lighting in an urban environment :

Social Role	Cultural Role
Prioritizes use of space	Prioritizes meaning of space
Supports social interaction, visibility & safety	Reinforces memory & symbolic value
Encourages movement & emotional support	Reflects regional customs and narratives
Linked to perception & functionality	Linked to tradition , ceremony and local significance

Fig 3.9 : Interpretation of light as a medium of social interaction and cultural expression, author 2025

3.5.1 RASA THEORY IN LIGHTING

In Indian aesthetics ,light can be connected with the concept of Rasa. This concept is derived from ancient text Natyasatra that refers nine foundational emotional essence of human (Gnoli, 1968). This theory is cultural framework of interpreting how built environment communicates identity, meaning and emotion in the field of design.
Certain Rasas (emotions) connect with the qualities and behaviors of light. This aesthetic approach goes beyond pragmatic and environmental narratives to use light as a cultural storyteller, altering the urban experience in ways that are emotionally and culturally grounded (Application of the Navarasa Theory in Architecture, 2019).

Basically, Rasa is an emotional state, a person perceives in response to activities and changes taking place in surrounding environment. Therefore , the lighting qualities that could be associated with Rasa are interpreted as follows :
Shringara Rasa, associated with love and beauty - emerges when decorative details are highlighted with soft and intricate lighting. Vira Rasa is the emotion of Heroism. It is felt in dramatic lighting of landmarks and monuments, where the architectural strength is highlighted. Bhayanka Rasa, linked with fear and boldness, often overlaps with the Vira rasa . This is experienced when volume and scale is emphasized through lighting. Adbuta Rasa, the sentiment of wonder, arises in dynamic settings where light interacts with users in unexpected manner. Playful and festive lighting evokes Hasya Rasa - related to Joy and amusement. Santa Rasa is similar to the concept of Danish Hygge. We can experience that at religious places and public places where the illumination is soft, warm and gentle generating a sense of tranquility.

Traditionally, Rasas are experienced not just by form and motion but also by colour. While abstracting this theory in lighting design, the colour temperature CCT can influence the rasa, that the space represents. Cooler whites and blues (high CCT) would accentuate Adbhuta or Vira Rasa. Whereas, rich reds or amber colors (low CCT) could accentuate Bhayanaka or Shringara moods. Therefore, color temperature becomes a narrative tool in expressing cultural emotions through light.
These Rasas could also be interpreted and demonstrated by using different lighting design techniques beyond colour temperatures. Placement of the luminaire according to its technical specifications can play an important role in creating scenes that influence emotion , thereby reflecting Rasa.

Rasa	Lighting Qualities
Shringara Rasa (Love/beauty)	Soft and warm tones - highlighting textures
Vira Rasa (Heroism)	High intensity - directional beams
Bhayanaka Rasa (Fear / Boldness)	Lights that create sharp contrast
Adbhuta Rasa (wonder)	Dynamic , interactive lighting design
Hasya Rasa (Joy)	RGB lights – creating patterns
Santa Rasa (tranquility)	Low light levels with minimum glare

Fig 3.10 : Interpretation of lighting qualities with Indian Rasa framework (Emotional States), author 2025

3.5.2 CULTURE OF LIGHT IN INDIA

In India, significance of light is guided by cultural, spiritual and architectural practices. It is often considered as a symbol of purity, divinity, wisdom and victory - an idea based on ancient texts and mythological narratives.
A prominent example is from the Ramayana , where the city of Ayodhya was illuminated with oil lamps (diyas) to celebrate the return of Lord Rama, after his victory. This collective lighting of façades and homes, represented righteousness - (Dharma) and established the cultural reference for using light as an expression of communal joy , reverence and spatial transformation. Dutta,S. (2017)

This became the foundation of festival of Diwali - festivals of lights. During diwali, people across India lit up their homes , façades and streets in celebration. Traditionally Diya - Small earthen oil lamps are used. It is considered to be the symbol of atman - soul and chaitanya - conciousness , representing purity and spiritual awakening. Dutta,S. (2017)

Modern lighting culture in India reflects these symbolic aspects with contemporary concepts and new technologies . The tradition of lighting diyas during diwali, coexists today with the use of LED Lights and projection mapping to decorate the houses, façades and public spaces. People still believe light as a symbol of spiritual growth , joy and celebration. A well lit space is considered to be the sign of hope and social unity. This cultural belief is no longer confined to festivals and celebrations. In many metropolitan cities, façade lighting has become a year round expression of identity and aspiration. Lights are being used to represent their characteristics, status and vibrancy.

This idea has been turned into a policy in Noida. A fast growing city near Delhi. In 2022, The Noida Development Authority has made it mandatory illuminate 40% of the front façade of high-rise buildings along the expressway. The developers must implement this before getting approval for residents to move in. This policy was also applicable for the existing buildings. The aim was to enhance the city's nighttime aesthetics and align its skyline with global standards. Hindustan Times, (2023)

Fig 3.11 : Illustration of cultural dimensions of light in India, author 2025

3.6 LIGHTING PERCEPTION ACROSS REGIONS

Lighting influences people's experience with their surroundings and connections with their cultural identity. Lighting preferences in different places are influenced by geography, climate, and society conventions. Therefore, different approaches of lighting design are followed.

In Northern Europe, where winters are long and sunlight is infrequent, artificial lighting is necessary to compensate the lack of natural light. Due to its geographical characteristics of low sun angle and prolonged twilight, people living in these places typically tend to prefer warm-toned, indirect lighting that makes them comfortable and feel pleasant (Seghi et al., 2022, p. 169). The idea of Swedish "mysigt" and Danish "hygge," encourages mild, layered lighting to enhance well-being. (Madan, 2023, p. 12),

Nordic lighting design relies on preserving darkness rather than eliminating it in cities. However, controlled streetlights combine security with natural twilight atmosphere. Targeting to reduce light pollution while maintaining the character of lengthy winter evenings, this approach also aligns with environmentally friendly initiatives.(Madan, 2023, p. 6).

India, on the other hand, is in the Southern Hemisphere and closer to the equator, thus it receives sufficient sunlight throughout the year. Strong sunlight and a great solar angle provides a lighting environment that encourages high-intensity lights. All of these aspects of the climate contribute to a cultural inclination that provides well-lit environments even after sunset. (Madan, 2023 p. 09). Lighting in India is more about utility and clarity, reflecting the naturally radiant conditions of the country than it is in the north, where it is mainly about providing warmth.

Survey results described further in the report, indicates differences in lighting preferences. Participants from India predominantly favored cooler lighting, whilst those from Northern Europe opted for warm-toned lighting. These results underscore how individuals perceive and engage with light in their environment based on geographical influences, cultural implications, and social behaviors.

Fig 3.12 : Contrasting interpretations of light in India and Northern Europe , author 2025

4. PHASE 1 - INTERNATIONAL FRAMEWORKS & APPROACHES

This chapter discusses regulatory framework, lighting concepts and philosophies from different countries, each offering distinct approach towards façade illumination. These serve as benchmark in evaluating façade lighting according to energy consumption, luminance and environmental responsibility. By examining the technical thresholds and lighting objectives, this phase establishes a foundation for developing a context specific framework.

4.1 LAW , STANDARDS & RECOMMENDATIONS

FRANCE

France has implemented some strict light pollution laws, (Journal Officiel de la République Française , 2018), that has been effective in tackling the environmental effect of artificial light. These rules show a deliberate and careful effort to reconcile urban illumination with environmental preservation.
The ordinance establishes limits of light at 25 lumens per square meter in urban areas including façades, parks, and parking lots. To conserve biodiversity from disruptive light exposure, it limits to 20 lumens per square meter, in rural and protected natural regions.
Lighting curfew proposed in non-residential façade lighting is to be switched off between 1:00 AM and 6:00 AM, excluding heritage sites and special events. This strengthens the dedication to energy conservation and nighttime restoration.
To reduce skyglow, the lights are required to be directed downwards and have an upward light ratio (ULR) of < 1%, ensuring the illumination is optimal
Considering the influence of blue-rich light on circadian rhythms and nocturnal creatures, all exterior lighting is also limited to a color temperature of 3000K.
Luminance is controlled based on the building typology. Landmark and civic buildings are limited to 0.7 cd/m^2 and 1.0 cd/m^2, respectively. whereas, heritage façades cannot exceed 0.3 cd/m^2 after midnight. These activities taken together reveal a technically rigorous and ecologically conscious policy landscape that offers a robust basis for sustainable urban lighting.

DENMARK

Denmark does not have any national legislation particularly regulating façade illumination. Copenhagen, on the other hand, addresses this through its municipal lighting plan Byens Lys and (Copenhagen Technical and Environmental Administration Guidelines), which links lighting design to the larger environmental objectives of the city. The proposal addresses lighting as a required urban design element rather than a simple aesthetic change.
It recommends reducing façade lighting intensity to 2–5 W/m^2 to achieve delicate and context-sensitive illumination that blends with surroundings. Except for cultural monuments and special occasions, smart controls such as dimmers and timers are advised to switch off façade illumination after midnight and help to save energy usage.
To reduce skyglow and glare, all fixtures must be downward-directed or totally covered. To safeguard nocturnal creatures, warm white light (≤3000K) is advised.
Heritage structures require prior clearance from Denmark's cultural heritage agency (Slots-og Kulturstyrelsen), therefore guaranteeing the preservation of architectural integrity.
Urban context-specific luminance criterias include ≤ 1.2 cd/m^2 for commercial streets, <= 0.5 cd/m^2 for mixed-use zones near residential area and up to 2.0 cd/m^2 for transit hubs with adaptive dimming.
Involvement with local communities and lighting experts is encouraged to foster cooperative lighting design.

GREECE

Greece's Technical Directive for Outdoor illumination describes a coherent and regulation-driven method to façade illumination. To meet national energy efficiency criteria, installed power must not exceed 1.40 W/m^2. The regulation also calls for the decrease or removal of upward-directed light to lower skyglow and stop light trespass into neighboring regions.
Luminance criteria vary by building type: historic façades cannot exceed 0.3 cd/m^2 after midnight, landmark buildings are limited to 0.7 cd/m^2, and civic or public buildings are regulated at 1.0 cd/m^2. These progressive restrictions seek to provide visual comfort while preserving environmental and architectural integrity.
Though not legally enforceable, the directive recommends the use of warm white light (≤ 3000K).
Therefore, it provides a clear, legally binding framework for façade lighting that balances technical control with environmental awareness.

INDIAN FAÇADE LIGHTING RECOMMENDATIONS

INDIAN GREEN BUILDING COUNCIL (IGBC)

Currently, there is no specific national law for façade lighting. Instead, guidelines from the Indian Green Building Council (IGBC) offer advisory recommendations to encourage sustainable practices.
It includes regulating upward light emission. External fixtures should not produce more than 5% of total lumens above 90°, therefore minimizing skyglow and light spill.
Regarding energy efficiency, IGBC advises for a 30% reduction in Lighting Power Density (LPD) relative to the ASHRAE Standard 90.1 baseline.
Commercial buildings should maintain a maximum façade brightness of 1.5 cd/m^2 to provide visual comfort and prevent over-illumination. Although these regulations are optional, they encourage ecologically responsible and energy-efficient lighting design.

ENERGY CONSERVATION BUILDING CODE (ECBC) 2017

ECBC 2017, provides guidelines emphasizing energy efficiency practices. Although these are advisory for others, it remains mandatory for certain commercial buildings based on their size and use.
To achieve a 30% reduction from the ASHRAE 90.1 baseline, it recommends decreasing façade lighting power density (LPD) to 2–5 W/m^2.
The guideline recommends incorporating automatic mechanisms such as photo sensors and timers to minimize unnecessary energy use. Upward lighting must not exceed 5% of total lumens above 90° to mitigate skyglow. These sections promote prudent lighting practices along with broader environmental goals.

4.2 DARK INFRASTRUCTURE

The concept of Dark infrastructure (Trame Noire) is an integral part of Light Urbanism. This philosophy is a guiding framework for creating strategic, selective illumination. It relies on selective illumination creating a visual “frame” of darkness that adds depth and contrast, making illuminated features more impactful while preserving the night sky and natural suroundings .Key aspects of this concept include :
Selective Lighting: Darkness is used to "frame" important features that are highlighted by precise lighting. It reduces excessive light spill and enhances the overall aesthetic by letting illuminated areas stand out naturally.
Environmental Responsibility: By focusing light downward and shielding fixtures, it helps to reduces skyglow and limits disruptions to nocturnal ecosystems.
Cultural Sensitivity: lighting explains the narrative of the structure by illuminating only elements that enhance its character. This technique prevents over-illumination and maintains the building’s significance and surrounding atmosphere. Sordello.R.et.al (2021)

"Dark Infrastructure, or Trame Noire, reimagines urban lighting by embracing darkness as a design tool. It frames illuminated features with shadow, enhancing contrast and depth while preserving the nocturnal environment."
- Roger Narboni (2015) Night Vision: The Art of Urban Lighting

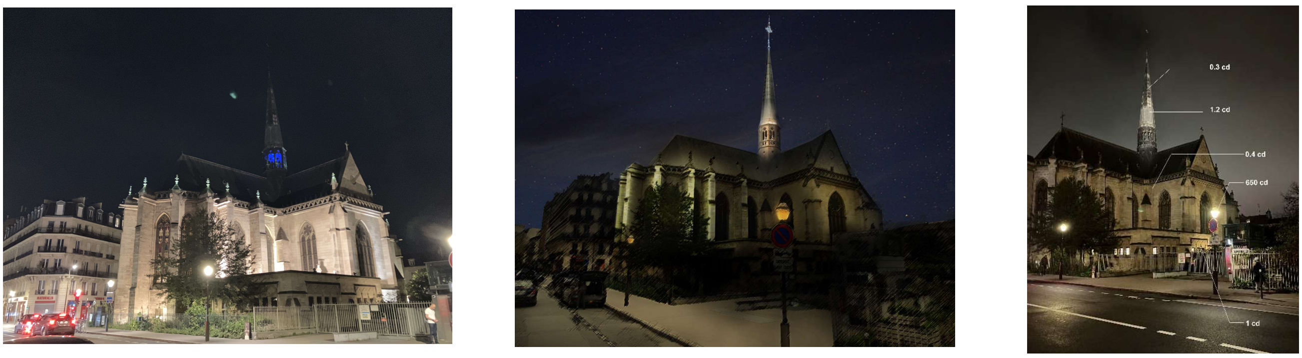

Fig 4.1 Notre Dame de Boulogne: A - Existing ; B – design illustration; C – luminance testing : Concepto Archives (2024)

The lighting redesign project of Notre Dame de Boulogne, which I was involved in during my internship at Concepto, focused on enhancing the church’s architectural presence while aligning with dark infrastructure principles.
The existing system relied on high-intensity floodlights (4000K) that caused excessive glare, uneven illumination, and high energy consumption.
The relationship to natural light was emphasized by the lighting design, which reflected the symbolic significance of light in religious building. electricity-efficient LED projectors were suggested because of their precision and durability, with the objective of enhancing the church's features while consuming 60–70% less energy. Compact projectors for soft background lighting, gobo projectors for emphasizing fine details, and dynamic video projectors for cultural events were key elements.
In order to limit light pollution and prevent modifications to the heritage surfaces, the lamps were carefully positioned on existing structures. The ignition scenarios primarily operated in the nighttime and synced the illumination with public schedules. Cooler tones (3000K) created contrast close to the base, while warm tones (2700K) were recommended for the church's upper section, which had 0.3 cd, to create a gentle glow, as determined by testing.
In accordance with current environmental requirements, this project demonstrated how to integrate contemporary technologies, such as LEDs, to improve energy efficiency and lower light pollution.

4.3 DARK SKY APPROACH

Dark sky-friendly lighting also known as Dark Sky Approach, is outdoor lighting that reduces light pollution without compromising functionality and visibility. It is designed to reduce unnecessary brightness, prevent skyglow, and minimize light spill into unwanted areas such as the night sky, residential windows, or natural habitats. The goal is to ensure that artificial lighting serves its purpose without disrupting the natural nighttime environment (International Dark-Sky Association, 2021)

To address these issues, the International Dark-Sky Association (IDA) has established guidelines that promote responsible lighting practices. These recommendations are further reinforced by research, providing the following overview.

1. SHIELDING (Directional Lighting)

By directing light downward instead of allowing it escape into the sky, completely shielded luminaires are one of the best solutions for minimizing light pollution. Conventional façade lighting frequently makes use of floodlights, which contribute to skyglow by projecting a large quantity of light toward the sky. A well planned and placed light can ensure that light remains focused on the building's façade. (IDA, 2021).

2. COLOUR TEMPERATURE CONTROL

A light source's color temperature CCT, is a key factor in assessing how it affects the surroundings. Higher levels of blue light are emitted by cool white LEDs (over 4000K), which disturbs nighttime ecosystems and contributes more to skyglow. (Gaston et al., 2012).

3. LUMINANCE AND ILLUMINANCE MANAGEMENT

Excessive brightness is a major contributor to light pollution. (IDA, 2021) suggests maintaining luminance ≤ 0.4 cd/m^2 in low-traffic zones ,while Narboni (2015) emphasizes a ≤ 0.6 cd/m^2 approach for cultural buildings. Using the minimum required illuminance (lux levels) helps prevent over-lighting façades, reducing both glare and energy consumption. Zoning-based lighting regulations, assigning specific brightness limits to urban areas according to their usage, can further promote efficient lighting. (Schulte-Römer et al., 2019)

4. TIMING AND ADAPTIVE CONTROLS

One of the most effective ways to reduce unnecessary façade lighting is through smart lighting control systems. By integrating timers, dimmers, and motion sensors, these systems can adjust brightness levels based on the time of night or human activity.

5. MINIMIZED LIGHT TRESPASS

In addition to shielding, careful angle and intensity control ensures that light only reaches the intended surface, avoiding glare and light trespass and eliminating undesired spill onto windows, streets, and natural areas.

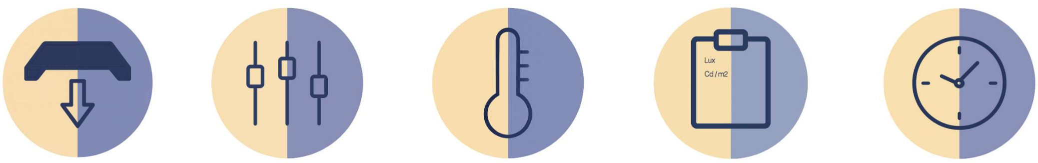

Fig 4.2 : Five principles of responsible outdoor lighting , Dark sky Association (2023)

4.4 ENERGY EFFICIENCY AND DIMMING

Although façade lighting improves architectural aesthetics, at the same time it also raises concerns about energy usage and light pollution, consequently challenging sustainability. As cities develop, the need for lighting increases, resulting in increased energy consumption and carbon emissions. Conventional lighting systems, such as metal halide lamps and halogen lights are less efficient than contemporary LED alternatives, resulting in elevated operational costs and energy wastage (Jones et al., 2015).

Many commercial buildings demand for continuous illumination, which creates the expected ambiance but also contributes to energy wastage. Especially when the space it lit even during off/peak hours. As observed by Schmidt et al. (2020), high intensity lighting is preferred in such industrial sectors, regardless of considering environmental conditions and time of the day. This often intensifies the challenges. Lack of clear guidelines contributes to the problem since buildings use inappropriate lighting practices that waste energy and harm the environment (Kyba et al., 2017).

Dimming technologies offer a compelling strategy to overcome these issues and reduce energy consumption without compromising the visual and functional objectives. It allows the lighting system to operate below the maximum output during off-peak hours. In LED lighting, the relation between dimming and energy consumption is not linear. When a luminaire is dimmed to 50% of its ouput , it does not consume 50% of energy. Whereas it only consumes around 35%, due to its LED drivers performance.

$$\text{Power Consumption} = (\text{Dimming Level})^n \times \text{Full Load}$$

According to this formula, the dimming level can be a fraction e.g 0.5 for 50% and the exponent (n – value) that ranges between 1.2 and 1.8 , is preferred to be kept as 1.5 – a typical average value. (Boyce, 2014). This results in saving upto around 75% of energy by dimming it 40%.

$$\text{Power Used} = (0.4)^{1.5} \times 100 \text{ i.e} = 25.3 \text{ units}$$

therefore , 25.3% of the original energy is used

$$100\% - 25.3\% = 74.7\ \%$$

Schmidt et al. (2020) observed similar results in urban lighting where 80% of energy was reduced by integrating adaptive dimming systems. Dimming can drastically reduce the energy consumption by façade lights at night. Especially in case of heritage and mixed-used buildings, where the context demands for constant illumination. Integrating these systems with timers, sensors and controlled scenarios can enhance their impact, contributing to sustainable lighting design.

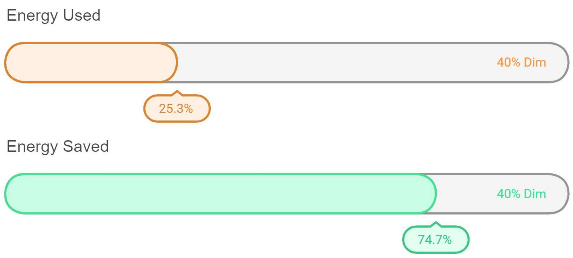

Fig 4.3 : Impact of 40% dimming on energy consumption and savings , author 2025

4.5 SUMMARY OF STANDARDS AND COMPARATIVE ANALYSIS

Country	Luminance (cd/m^2)	LPD	Colour Temp (K)	Operational Guidelines
France (Décret n° 2018-118)	0.3 (heritage), 0.7 (landmark), 1.0 civic	25 lm/m^2 urban, 20 lm/m^2	≤ 3000K	Lighting curfew 1–6 AM, ULR <1%, upward light restricted
Denmark (Byens Lys - Copenhagen)	≤ 1.2 (commercial), ≤ 0.5 (mixed-use), ≤ 2.0 (transit hubs)	2–5 W (recommended)	≤ 3000K (recommended)	Smart dimming, community involvement, downward fixtures, (advisory guidelines)
Greece (Technical Directive)	0.3 (heritage), 0.7 (landmark), 1.0 (civic)	≤ 1.40 W	≤ 3000K (recommended)	Emphasis on reducing skyglow and enhancing visual comfort
India - IGBC	≤ 1.5 (commercial)	30% lower than ASHRAE 90.1	≤ 3000K (recommended)	Upward light <5% above 90°, (advisory guidelines)
India - ECBC 2017	Not specified	2–5 W (recommended)	≤ 3000K (recommended)	Photosensors/timers mandatory, 30% LPD reduction than ASHRAE
International Dark Sky Association (IDA)	≤ 0.4 (low-traffic), ≤ 0.6 cultural	Lowest necessary	≤ 3000K (recommended)	Full shielding, adaptive controls, zone-based strategy (advisory guidelines)

Fig 4.4 : Overview of global façade lighting policies & operational insights, author 2025

The regulations of façade lighting in France, Denmark, Greece and India not only indicate technical disparities, but also represent the differing cultural perception about light and darkness. France's strict curfew and brightness limits reflect their vision of preserving nocturnal identity and minimizing light pollution. Denmark's community-driven lighting philosophy views light as an atmospheric layer rather than an overwhelming display. Whereas, Greece balances between visual comfort and energy efficiency by setting thresholds of ≤ $1.40W/m^2$. India's façade lighting are guided by advisory guidelines by IGBC and ECBC. However, the growing institutional focus on sustainability has brought a major shift in awareness, especially in metropolitan cities.

Despite contextual differences, there are many common concepts that are emerge. The increasing preference towards using warm white lighting ≤ 3000K, reflect the efforts to cut down on light pollution. Growing use of adaptive technologies, implementation of light curfews and integration of dimming system has encouraged a shift from aesthetic illumination to visibility oriented lighting. Besides saving upto 70% of energy, dimming elevates the quality of the space and reduces unnecessary exposure of light. Thereby maintaining the luminance (cd/m^2) level within the space. These concepts and measurable thresholds serves as a foundational model to propose design framework.

5. PHASE 2 : REFERENCE CASE STUDY – COPENHAGEN

This chapter examines façade lighting of Copenhagen as a reference case. It uses the quantitative method on buildings of different typologies, reviews local regulations and lighting design objectives. The insights gathered here, serve as an instance for comparison and will help shape design proposal.

5.1 LIGHTING IN COPENHAGEN

Copenhagen, the capital of Denmark, is known all around for its commitment to sustainability and creative urban development. Covering 179 square kilometers with population of 650000, the city shows a balanced approach to urban lighting combining energy efficiency, aesthetics and environmental responsibility. Emphasizing functional and atmospheric lighting that enhances the urban experience while minimizing light pollution, the city's urban lighting master plan, Byens Lys (City Lights), revolves around the danish idea of "hygge", promoting friendliness and warmth. This impacts lighting choices, resulting in warmer color temperatures (≤3000K) and lower lighting intensity in public settings (Seghi et al., 2022).

Studies show that primarily due to well-run municipal lighting rules, Copenhagen's light pollution has remained constant throughout time. Seasonal changes and policy changes have influenced lighting intensity, which Suomi NPP satellite data, shows has fluctuated only slightly over the last 20 years (Falchi et al., 2016).

façade lighting in Copenhagen has evolved from a decorative feature for historical sites to a sustainable part of urban design. Historically, to maintain visual consistency with the surrounding surroundings, famous buildings such as Rundetårn (The Round Tower) and the Copenhagen Opera House were lit with warm, low-intensity lighting. façade lighting has gradually spread beyond historical monuments to include commercial and cultural areas, hence greatly affecting urban identity and branding.

While upmarket hotels like Hotel d'Angleterre and major retail outlets like Magasin du Nord increasingly use façade lighting to create distinct night images, façade illumination in areas like Nyhavn and Strøget is meant to enhance architectural beauty. Public institutions and cultural centers have installed dynamic and energy-efficient lighting systems, as illustrated by the programmable façade lighting at the Royal Danish Playhouse (Copenhagen Urban Lighting Master Plan, 2019).

5.2 QUANTITATIVE ANALYSIS OF FAÇADE LIGHTING IN CPH

This analysis aims to calculate the Light power density of different of building typologies in Copenhagen, following the methodology developed by Tomasovits, M. (*The impact of exterior lighting in buildings on sustainability and the environment: Methods to control the negative effects of light pollution)* This will help to get a comprehensive overview of façade lighting techniques used in Copenhagen and their compliance with the established threshold.

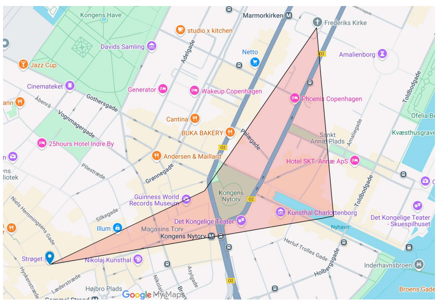

Fig 5.1 : Selected area for analysis in central Copenhagen, source : Google maps

Buildings in the selected area are categorized as follows :

Category	Building
Retail & Commercial	Illum, Magasin du Nord
Hotels & Hospitality	Hotel d’Angleterre, Phoenix Copenhagen Hotel
Cultural & Historic	nyhavn

Fig 5.2 : Typology based selection of buildings - CPH, author 2025

5.2.1 MAGASIN DU NORD

Fig 5.3 A & B : Façade Lighting at Magasin Du Nord, author 2025

Building’s name	Magasin Du Nord
Dimensions of the façade	50 x 20 m Approx
Area of the illuminated façades (m^2)	1000 m^2
Types of luminaires	Spotlights, Linear LEDs
Position of the luminaires and lighting techniques	Up lighting, Grazing, Accent lighting
Total number of luminaires (per type)	Spotlights: 80 , Linear LEDs : 20
Type of lamp	LED
Correlated color temperature CCT	3000 - 3500K
Range of total installed power for each type of luminaires (W)	Spotlights: 10-20W, Linear LEDs: 7-15W
Total installed power of the façade lighting installation (W)	Min: 600W, Max: 1500W
Installed power per m^2 of illuminated façade (W/m^2)	Min: 0.6 W/m^2, Max: 1.5 W/m^2
BUG Analysis	Few Uplight Fixtures are used

Fig 5.4 : LPD Analysis of façade lighting at Magasin Du Nord, author 2025

Magasin Du Nord is a famous department store in Copenhagen. It is a major landmark next to the metro station and helps lit up Kongens Nytorv Square. The façade lighting highlights the heritage character of the building by combining uplighting and accent lighting.
With an installed power density of 0.6 - 1.5 W/m^2, the light is gentle and subtle, blending well into the urban surroundings and meeting Copenhagen's lighting guidance.

5.2.2 ILLUM DEPARTMENT STORE

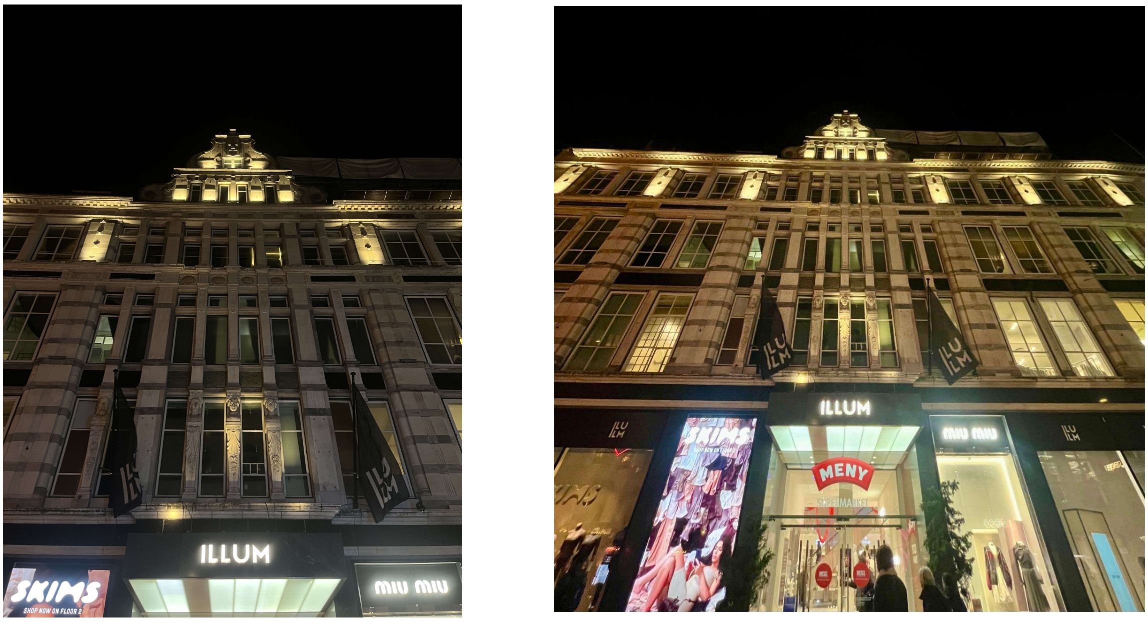

Fig 5.5 A & B : Façade Lighting at Illum department store, author 2025

Building's name	Illum Department Store
Dimensions of the façade	45 x 18 m Approx
Area of the illuminated façades (m^2)	810 m^2
Types of luminaires	Linear LEDs , Wall Grazer
Position of the luminaires and lighting techniques	Up lighting, Grazing
Total number of luminaires (per type)	Linear LEDs: 25, Grazing Fixtures: 15
Type of lamp	LED
Correlated color temperature CCT	3000K
Range of total installed power for each type of luminaires (W)	Linear LEDs: 6-12W, Grazing Fixtures: 8-15W
Total installed power of the façade lighting installation (W)	Min: 390W, Max: 1020W
Installed power per m^2 of illuminated façade (W/m^2)	Min: 0.59 W/m^2, Max: 1.48 W/m^2
BUG Analysis	Uplight Fixtures are extensively used

Fig 5.6 : LPD Analysis of façade lighting at Illum department store, author 2025

Illum is a famous department store in Copenhagen with great influence on the nightlife on Strøget, the major pedestrian street in the city. It is lit with uplighting and accent lights to accentuate architectural elements of the building.
0.59 – 1.48 W/m^2 of installed power density illumination brings liveliness in the urban environment without overwhelming it. Although the design fits Copenhagen's urban lighting plan, altering the position of the fixture might reduce upward light spill.

5.2.3 HOTEL D´ANGLETERRE

Fig 5.7 : Façade Lighting at Hotel d'Angleterre on regular days, author 2025

Fig 5.8 : Façade Lighting at Hotel d'Angleterre during Christmas, Source: travelmade

Building's name	Hotel d'Angleterre
Dimensions of the façade	60 x 18 m Approx
Area of the illuminated façades (m^2)	972 m^2
Types of luminaires	Linear LEDs, Wall Grazing Fixtures,Projectors , Downlights
Position of the luminaires and lighting techniques	Up lighting, Grazing, Accent lighting
Total number of luminaires (per type)	Linear LEDs: 30, Grazing Fixtures: 20, Projectors: 10, Downlights: 18-20
Type of lamp	LED
Correlated color temperature CCT	4000 - 4500K
Range of total installed power for each type of luminaires (W)	Linear LEDs: 6-12W, Grazing Fixtures: 8-15W, Projectors: 10-25W, Downlights: 6-10W
Total installed power of the façade lighting installation (W)	Min: 548W, Max: 1110W
Installed power per m^2 of illuminated façade (W/m^2)	Min: 0.5 W/m^2, Max: 1.2 W/m^2
BUG Analysis	Uplight Fixtures are extensively used

Fig 5.9 : LPD Analysis of façade lighting at Hotel d'Angleterre, author 2025

Hotel d'Angleterre, a heritage luxury hotel in central Copenhagen, with a planned façade lighting design that incorporates uplighting, grazing, and accent illumination.
Ranging from 0.5 to 1.2 W/m^2, the lighting remains elegant , therefore accentuating the grandeur of the structure. It it illuminated with winter theme every Christmas , which makes it a landmark and identity in Kongens Nytorv Square.
Although it follows Danish urban lighting regulations, colour temperature used are above 3000K.

5.2.4 HOTEL PHOENIX

Fig 5.10 A & B : Façade Lighting at Hotel Phoenix, author 2025

Building’s name	Phoenix Hotel
Dimensions of the façade	40 x 20 m Approx
Area of the illuminated façades (m^2)	800 m^2
Types of luminaires	LED Spotlights & Floodlights
Position of the luminaires and lighting techniques	Wall-Mounted Accent Lighting & Uplighting
Total number of luminaires (per type)	30
Type of lamp	LED
Correlated color temperature CCT	3000K
Range of total installed power for each type of luminaires (W)	20-60 W
Total installed power of the façade lighting installation (W)	Min: 600, Max: 1800
Installed power per m^2 of illuminated façade (W/m^2)	Min: 0.75, Max: 2.25
BUG Analysis	Uplight Fixtures are used

Fig 5.11 : LPD Analysis of façade lighting at Hotel Phoenix, author 2025

Phoenix Hotel's classical building is one of the example of simple and elegant façade lighting in Copenhagen. Spotlights with a minimalistic approach wash the buildings warm white colour, highlighting the architectural rhythm.
Installed power per square meter ranges from 0.75 to 2.25 W/m^2.
The overall lighting is warm and ambient, merging with neighboring metropolitan environment.
Though the installation slightly crosses recommended limit, it meets Copenhagen's urban lighting guidance. Some directional alterations to the lighting might assist to reduce upward light output.

5.2.5 NYHAVN

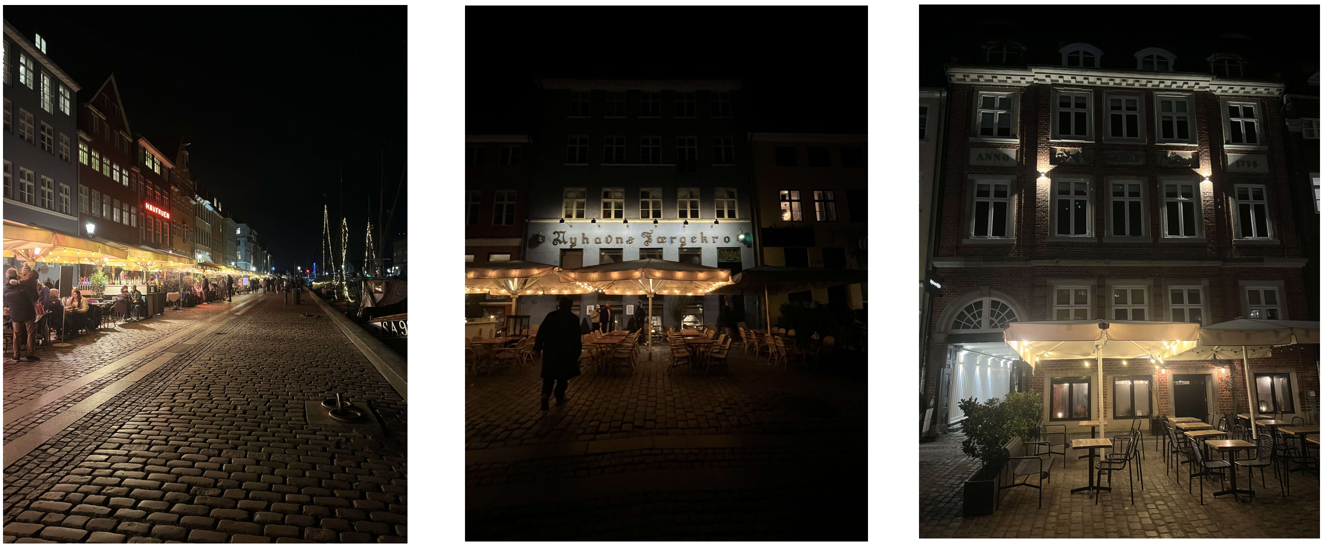

Fig 5.12 A,B & C : Lighting at Nyhavn, author 2025

Nyhavn is a distinctive example of atmospheric lighting in Copenhagen. Lighting on this street is shaped by commercial activities rather than official façade illumination. The natural tones and textures of the colourful heritage buildings blends with the night , making the street lively. The street is filled with a warm glow from restaurants and cafe lights. These lights are generally yellow toned bulbs under the canopies and string lights that makes the space feel vibrant and pleasant.

Each hotel has its different method of lighting. Some use spotlights directed upwards to highlight signs, architectural features ,and the colour of the building , whereas some have a maintained a subtle , decorative lighting theme. Despite of these variations , the overall impact is cohesive and creates a continuous ribbon of liveliness along the coastline. There are also classical neon signs which adds a nostalgic element and further enhancing the layered lighting identity of Nyhavn. The overview is dynamic yet low-impact lighting environment that supports both ambiance and activity without overwhelming the visual character of the space.

No	Building Name	Type of Building	Installed power per m^2 of illuminated façade (W/m^2)			Danish Limit
			Min	Max	Avg	
1	Magasin Du Nord	Commercial	0.6	1.5	1.05	2 – 5 W
2	Illum Store	Commercial	0.59	1.48	1.03	2 – 5 W
3	Hotel d'Angleterre	Hospitality	0.5	1.2	0.85	2 – 5 W
4	Phoenix Hotel	Hospitality	0.75	2.25	1.5	2 – 5 W

Fig 5.13 : Summary of LPD Analysis - Copenhagen, author 2025

5.3 FINDINGS

The Copenhagen case study reflected a lighting culture shaped by seasonal patterns and a strong emphasis on minimalism. This results in a low dependency on artificial lighting and a preference for warm tones. While each building has its unique lighting method, it blends seamlessly with its surroundings, creating a coherent atmosphere.

A notable example is the lighting at Hotel d'Angleterre during Christmas, which employs traditional illumination techniques to express a narrative and reinforce the identity of the square. Overall, façade lighting is primarily reserved for civic buildings and heritage sites, while residential buildings are often left unlit.

The Lighting Power Density (LPD) levels across the analysed buildings remained well below the thresholds, confirming the effectiveness of low-energy design practices.

6. PHASE 3 : APPLIED CASE STUDY - MUMBAI

This chapter explores façade lighting practices in Mumbai by understanding its cultural, spatial, and environmental aspects. It begins with quantitative analysis, applying same methodology as Copenhagen chapter, based on the framework by Tomasovits, M.
The city is sprawled around and doesn't limit to one central center, however many buildings combine contemporary and historic aspects. Therefore, the study examines two buildings within the coastal region, a heritage landmark - Gateway of India and a hospitality building - Taj Mahal Hotel. Alongside a general overview of façade lighting trends of residential buildings in Mumbai suburban. This provides a detailed understanding of façade lighting energy performance through Lighting Power Density (LPD), forming a critical foundation.

6.1 LIGHTING IN MUMBAI

Mumbai, India's financial capital, has seen an increase in light pollution over the last few decades. Spanning 603 square kilometers, it has a population of 12.4 million, making it the third most light-polluted city in India. Rapid urbanization has caused notable land use changes as built-up areas grew and economic activity became more concentrated. These changes have greatly affected the environment including light pollution. The city has many bright of street lighting , high-intensity commercial displays and building façades. These unregulated urban lighting can contributes significantly in Light pollution (Kumar et al., 2019). Excessive and misdirected artificial illumination causes light pollution by changing the natural light levels of a region (Lo, 2002). Large towns, where a diffuse illumination frequently obscures the night sky and makes stars invisible, highlight this problem particularly (Cinzano et al., 2001).

LIGHT AS A CULTURAL NOTION OF PROGRESS

Many cities, including Mumbai, have a cultural perspectives that greater light indicates prosperity and growth. Streets, business areas, and landmarks that are brightly lit, are often seen as signs of a strong economy and modern infrastructure . This viewpoint fuels the need for more illumination, which helps to raise general light pollution. Although well-lit locations can improve appearance, too much and badly controlled illumination can cause major environmental and health problems (Kyba et al., 2015).

EVOLUTION OF FAÇADE LIGHTING IN MUMBAI

The façade lighting in Mumbai has witnessed notable evolution, transforming from its earlier use for landmarks to an essential element reflecting architectural and economic identity. Traditionally, only cultural and historical sites, such as the Gateway of India and Chhatrapati Shivaji Maharaj Terminus (CSMT) were lit to elevate their prominence in the urban environment. In recent years, government initiatives have rapidly promoted other illumination, acknowledging the significant role of monuments in tourism and city promotion. The use of energy-efficient and adaptable lighting technologies has led to the installation of advanced lighting systems that enhance the aesthetics of these structures while facilitating their maintenance. This has evolved into a trend of dynamic lighting and media façades.

6.2 QUANTITATIVE ANALYSIS OF FAÇADE LIGHTING IN MUMBAI

Category	Building
Hotels & Hospitality	Taj Mahal Hotel
Cultural & Historic	Gateway Of India

6.2.1 GATEWAY OF INDIA

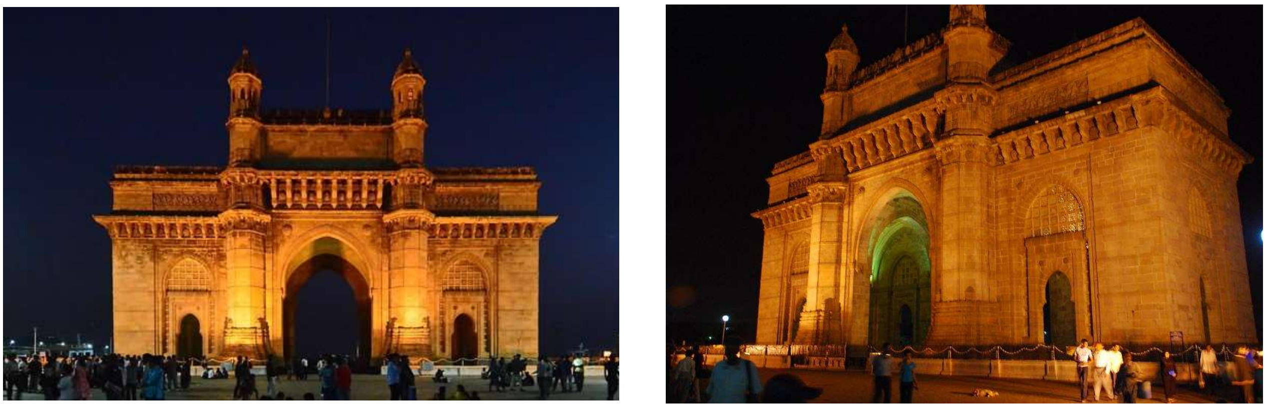

Fig 6.1 A & B : Façade Lighting at Gateway of India. Source: wikipedia

Building's name	Gateway Of India
Dimensions of the façade	20 x 26 m (Approx)
Area of the illuminated façades (m^2)	520 m^2
Types of luminaires	LED Floodlights , spotlights
Position of the luminaires and lighting techniques	Uplighting from the base of the monument , Squinch uplights
Total number of luminaires (per type)	LED Floodlights: 10 (Approx), Spotlights : 8
Type of lamp	LED
Correlated color temperature CCT	3000K (Warm White) for regular days, RGB for events
Range of total installed power for each type of luminaires (W)	LED Floodlights: 100 – 300 W Spotlights: 100-150 W
Total installed power of the façade lighting installation	Min: 1000 W, Max: 4500 W
Installed power per m^2 of illuminated façade (W/m^2)	Min: 1.92 W/m^2, Max: 8.65 W/m^2
BUG Analysis	Uplight Fixtures are used

Fig 6.2 : LPD Analysis of façade lighting at Gateway of India, author 2025

Gateway of India is a heritage monument in Mumbai. It is popularly known as emblem of colonial legacy and waterfront identity of the city.
Currently it its illuminated with 3000K led floodlights and spotlights integrated along squinches to highlighted the ribbed vaults.
It approximately consumes minimum 1.92 W/m^2 and Max: 8.65 W/m^2 energy. Although, all the lights are not turned on , there is high potential of exceeding the recommended limits.
LED dynamic lights with smart controls are used during events and national festivals to highlight the landmark.

6.2.2 TAJ MAHAL PALACE HOTEL

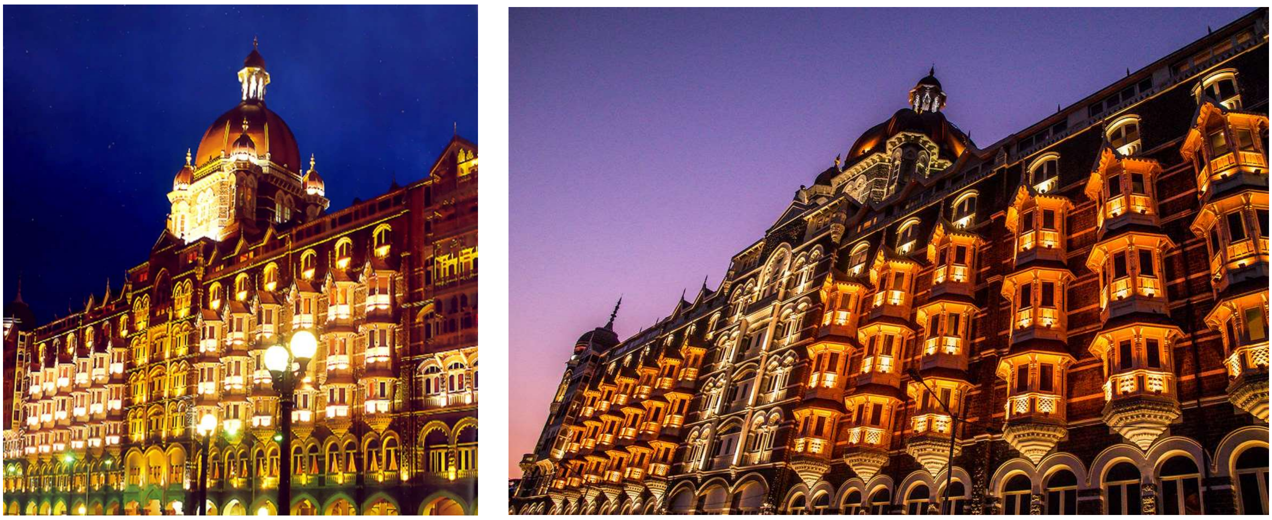

Fig 6.3 A & B : Façade Lighting at Taj Mahal Hotel. Source: The ministry of light

Building's name	Taj Mahal Palace Hotel
Dimensions of the façade	60 m (width) × 35 m (height) Approx
Area of the illuminated façades (m^2)	2100 m^2
Types of luminaires	LED Floodlights, Wall Washers, Accent Lights
Position of the luminaires and lighting techniques	uplighting from the base , grazing along architectural details. Some accent fixtures highlight domes and balconies.
Total number of luminaires (per type)	Floodlights: 40–50 ,Wall Washers: 30–40 ,Accent Lights: 10–20
Type of lamp	LED
Correlated color temperature CCT	Warm White (2700K–3000K) on regular days; Dynamic RGB during special events
Range of total installed power for each type of luminaires (W)	Floodlights: 100–250 W Wall Washers: 40–80 W Accent Lights: 10–40 W
Total installed power of the façade lighting installation (W)	Minimum: 6,400 W Maximum: 15,000 W
Installed power per m^2 of illuminated façade (W/m^2)	Minimum: 3.05 W/m^2 ,Maximum: 7.14 W/m^2 Max exceed 1,40 W/m^2 (non-compliance)
BUG Analysis	Few uplight fixtures are used

Fig 6.4 : LPD Analysis of façade lighting at Taj Mahal Hotel, author 2025

The Taj Mahal Palace Hotel in Mumbai, is a cultural and architectural landmark that stands over the Arabian Sea. The façade is softly lit, which makes it stand out even more in the city's skyline. The lighting design mixes floodlighting with accent lights stressing the domes, arches, and rich features of the building.
During national events and celebrations, the lighting creates an inviting appearance with installed power density ranging from 3.05 to 7.14 W/m^2. Though the well integrated lighting enhances architecture, it possibly exceeds recommended energy limitations.

6.2.3 OVERVIEW OF FAÇADE LIGHTING TRENDS OF RESIDENTIAL BUILDINGS IN SUBURBS

Fig 6.5 : Suburban Mumbai nightscape highlighting the visual gap between high-lit and unlit residential façades, author 2025

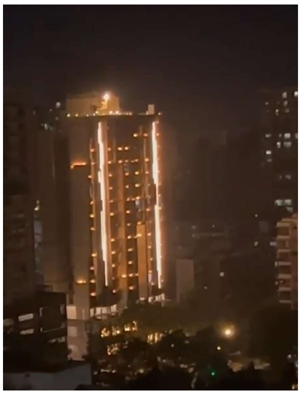

Fig 6.6 A : The 15 storey building uses high intensity led strip light outlining its vertical front façade. While the lighting remains under recommended limits of energy usage, the excessive luminance creates issue of glare, frequently reported by neighboring residents. Moreover, it creates visual clutter and disrupts the ambient nightscape of the locality.

Fig 6.6 B : The 20 storey building is illuminated primarily from individual residential units. Rather than installing lights on the external façade, the glow from linear grazers integrated above windows, form a pattern. It makes the building visible from a distance, hereby making each apartment a part of its identity. Though the lighting is well integrated within energy range, it suggests the possibility of glare for the residents, experiencing it from inside.

Fig 6.6 C : The 30 Storey building presents a similar approach like Fig 6.6 B, where illumination is limited to each apartment rather the main façade of the building. Small spotlights , on the roof of each unit keeps the design with the energy criteria and makes structure look well composed , without overwhelming the surroundings with high luminance.

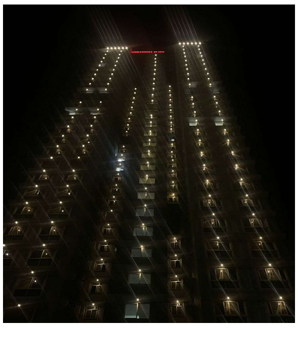

Fig 6.5 is an example of increasing trend of façade lighting in residential buildings especially in new developments.

It is observed although it uses various lighting fixtures including spotlights, linear grazers and wall washers, high intensity of light is primarily preferred. Being under energy threshold limits, the challenge is more about controlling intensity and conveying the narrative.

Fig 6.6 A, B & C : Façade lighting at residential buildings in Mumbai Suburbs, author 2025

6.2.4 FINDINGS

No	Building Name	Type of Building	Installed power per W/m² of illuminated façade			Indian Recommendation Limit
			Min	Max	Avg	
1	Gateway of India	Monument	1.92	8.65	5.2	2 – 5 W
2	Taj Hotel	Hotel	3.05	7.14	5.095	2 – 5 W

Fig 6.7 : Summary of LPD Analysis - Mumbai, author 2025

The Mumbai case study reflects a lighting culture shaped by symbolic aspirations and visually expressive where residential buildings are also lit along with landmarks. The lighting approach is often characterized by preference towards warm white and cool colour temperature with high intensity of light. Despite meeting the energy norms in most of the cases , there is always a possibility to exceed the recommended Lighting Power Density threshold. The unrestricted lighting regulation often leds to fragmented nightscape contributing to the potential of urban glare and skyglow

The chapter continues with literature and background knowledge that gives an overview of the city's evolving lighting landscape and light´s perception as a sign of progress and identity. It also discusses environmental zones in the city underlined by Mumbai Development Plan (MDP 2034), the impact of media façades and gap in regulatory control contributing to light pollution.

6.3 TRENDS IN SPACE AND TIME

Using nighttime light (NTL) data from the Defense Meteorological Satellite Program Operational Line Scanner (DMSP/OLS), Kumar et al. (2019) investigated light pollution trends in Mumbai from 1993 to 2013. Calibrated DN values were used to create geographical and temporal maps showing the prevalence and evolution of light pollution in the metropolis. Particularly in densely populated areas and urban core zones, the study found a notable rise in light pollution intensity.

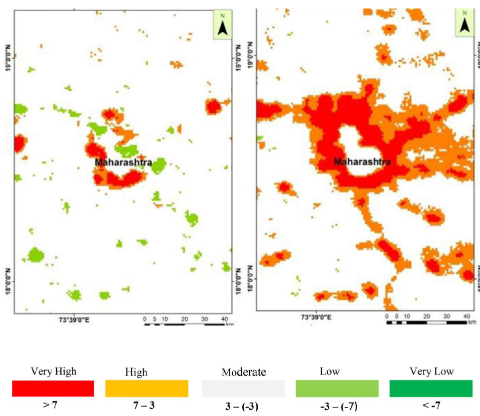

Fig 6.8 : Digital Number (DN) values represent the brightness levels recorded by satellite sensors. Significant increases in light pollution are identified using a threshold value of +3 DN. regions with DN values over +3 show higher brightness while those below -3 show lower brightness.

Brightness Index (Nano-watts/cm²/Sr)		
(black)	0.0 - 0.8	Excellent dark sky
(purple)	0.8 - 1.2	Dark sky
(blue)	1.2 - 2.0	Rural Sky
(light blue)	2.0 - 3.6	Rural/suburban site
(green)	3.6 - 6.7	Suburban
(light green)	6.7 - 13	Bright suburban sky (greyish glow)
(yellow)	13 - 25	Suburban-urban transition (yellowish sky)
(orange)	25 - 50	Urban Sky (key stars not visible)
(red)	50 - 100	City Sky (stars not visible, orangish sky)
(white)	> 100	Inner-city sky (Entire sky is brilliant)
-------------------		Municipal Boundary

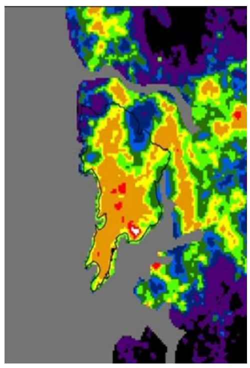

Fig 6.9 : Mumbai’s Night Sky Brightness Map , Bedi (2022)

Satellite imagery and GIS analysis reveal Mumbai's average night-sky brightness at 20.8 Nano-watts/cm^2/sr, which places it among India's most polluted night skies and most of the area lies under Urban sky i.e (Key stars are not visible) Bedi, T. K. (2022, December 18). Light pollution in India: Appraisal of artificial night sky brightness of cities.

Several important factors contribute to Mumbai's growing light pollution. Rapid urbanization causes the city to expand in built-up regions, which increases artificial illumination. Mumbai's varied industrial background, which includes textiles, dyes, fertilizers, thermal power, oil refineries, and pharmaceuticals greatly contribute to the increased artificial illumination. Moreover, pollution in the air spreads artificial light, hence aggravating the issue by creating a more severe skyglow effect. These factors taken together have caused a notable increase in the intensity of light pollution, especially in the densely populated core areas of Mumbai (Kumar et al., 2019).

6.4 MEDIA FAÇADES

Media façades use high-density LEDs, projection and pixel mapping techniques to create visual narratives, making them an important part of the city's evolving architectural identity. Dynamic lighting displays at cultural and national events increase their impact on the shared urban experience. However, this consumes a large amount of energy in comparison to traditional architectural illumination. Research by McKinney et al. (2020) indicates that LED-based media façades can use 10 to 50 times more energy per square meter than static façade lighting. Multi-directional LED emission, reflections off glass and metal surfaces and air dispersion of blue-rich light are all contributing to light pollution equally. Furthermore, their interaction with air pollutants, fog, and surrounding buildings exacerbates skyglow, amplifying unwanted brightness in the night sky.

Recent scientific studies have highlighted the environmental concerns caused due dynamic lighting systems. Wu et al. (2023) has conducted a spectral study using ground based hyperspectral imaging, assessed 74 illuminated façades in Shanghai. The study revealed that the emissions in saturated blue and red wavelengths, used in better visual impact can disrupt human circadian rhythms and plant´s photosynthesis. It further explains that lowering light level is not the only solution to ensure environmental compliance. It is important to consider spectral composition. Therefore , the research has proposed a colour gamut mapping strategy that balances visual aesthetics with ecological responsibility.

This underscores the need to regulate media façade lighting in densely populated and coastal cities like Mumbai, where uncontrolled spectral variety can increase skyglow and disturb nocturnal ecosystems.


Fig 6.10 A : Media Façades on a Residential Skyscraper in Mumbai , source : archdaily
Fig 6.10 B : Promotional projection on a commercial building , source : Economic Times (2020)
Fig 6.10 B : High intensity digital billboards contributing to glare , source : Hindustan Times (2021)

Civic authorities in the city have taken steps to mitigate bright lighting, including decorative lights on public buildings operating hours. however, these policies are implemented at regional level, rather than enforcing across the city. Activists in Mumbai in 2019 underlined the absence of clear guidelines and urged the government or courts to create laws to formulate "too much light as a pollutant," similar to laws for noise or air pollution. Incidents of strong floodlights and digital billboards bothering neighbors drove this campaign, suggesting a growing need for government participation. Mumbai's development control laws and historical standards currently emphasize signage and decorative lights, but do not cover total illumination intensity and skyglow restriction measures.

6.5 MUMBAI ZONING

Mumbai's urban structure has spatial and architectural heterogeneity. Therefore, it doesn't have a defined city center. The city is perceived to be divided into two main zones: South Bombay and Suburbs.
South Bombay serves as the historical and administrative center. It is marked by its colonial architecture, civic institutions, and densely populated commercial areas. Suburbs, extend in northward, which reflect more modern urban development phases. It is characterized by mix of mid to high rise residential buildings, commercial enterprises, and infrastructure centers.
As urbanization continues, residential construction is gradually extending outside its perimeter, hereby generating new architectural approaches. This geographical variety and development of Mumbai offers an intriguing background for examining the relationship of architectural form, lighting techniques, and regulatory regimes.

The study by Sordello et al. (2022) has explained on the concept of Dark Infrastructure as an important ecological network that aims at preservation of natural darkness within the landscapes in an urban environment. The paper highlights the impact of artificial light at night ALAN on ecology that has been preserved as dedicated natural zones. To overcome these issues ,the study has proposed a framework that involves mapping light pollution , identifying the green and blue ecological framework and applying preservation strategies according to the context sensitivity. The main objective of this framework is not about eliminating light completely, but planning the light spatially. Thereby , allowing the sensitive zones to remain undisturbed and facilitate functional needs at the same time. This framework has been implemented in France and Switzerland at municipal and regional level.

MUMBAI DEVELOPMENT PLAN

Urban development of the city is directed by The Mumbai Development Plan (MDP 2034). It classifies different regions of the city into zones as per environmental sensitivity and development limits .
Greens Zones (G1 and G2) are designated for ecological conservation with restrictions on development. No-Development Zones (NDZs) are specified for agricultural and forest protection, where construction activities are majorly prohibited. Coastal Regulation Zones (CRZs) restrict development within distance from the shoreline to protect costal ecology that includes beaches , mangroves and coastal wetlands.
These zones have further specified prohibitions and classifications based on the population density and commercial activities in the region. These existing spatial zoning systems can be used as background framework and enhanced by proposing façade lighting regulations tailored as per each zone´s specific requirements.

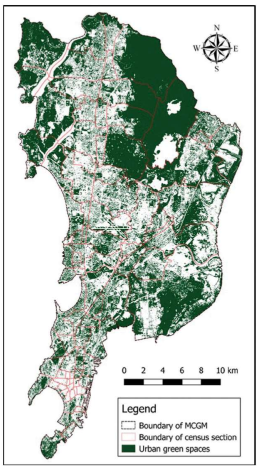

Fig 6.11 : urban green spaces , Mumbai
Source : MCGM, MDP

6.6 SWOT ANALYSIS

Strengths	Weakness
Urban Identity and Aesthetics famous buildings are highlighted strengthening Mumbai's cultural and historical character. Visitors feel invited, which enhances nightlife and business operations. **Energy-Efficient Innovations** Many heritage projects have replaced traditional halogen lights with LEDs and smart lighting to improve energy efficiency. **Contribution to Safety and Security** well-lit buildings can enhance to pedestrian comfort and reduce risk of crime. **Urban Planning Integration** Façade lighting complements street lighting in Mumbai, especially around public squares, transport hubs, and heritage sites.	**Environmental and Ecological Concerns** Mumbai's climatic conditions may exacerbate light scattering, increasing skyglow. Excessive façade lighting can disrupts the circadian rhythms of nocturnal species in and around Mumbai's coastal and green areas. **Regulatory Gaps** Unlike street lighting, the city does not have any specific laws governing façade lighting. There is absence of dark-sky compliance policies. **Over-Illumination and Energy Waste** High-intensity lights and digital advertisements contribute to unnecessary energy consumption. **Aesthetic & Cultural Misalignment** Inappropriate façade illumination could compromise their historical value. Furthermore, the tendency of excessively bright, dynamic lighting contrasts with Mumbai's traditional architectural aesthetics, resulting in visual discord.
Opportunities	**Threat**
Policy Development & Regulatory Frameworks Rising awareness of light pollution and energy efficiency could drive discussions on integrating lighting guidelines into sustainable urban development policies. **Urban Development initiatives** Mumbai's green spaces and heritage zones offer potential for context-sensitive façade lighting with dark infrastructure principles. **Industry & Public Engagement** Growing awareness of sustainable lighting is leading to more discussions, collaborations, and research on its impact in cities.	**Environmental & Energy Challenges** Inefficient façade lighting systems drive up electricity costs and intensify Mumbai's urban heat island effect. **Weak Implementation of Policies** Weak enforcement and lack of incentives could limit compliance with façade lighting guidelines, slowing sustainable adoption. **Climate Constraints** Heavy monsoons and power fluctuations may disrupt façade lighting systems, leading to increased maintenance costs

7. INSIGHTS, SYNTHESIS & RESEARCH FRAMING

7.1. SURVEY INSIGHTS – Cultural and Contextual Perceptions of Façade Lighting

For qualitative analysis a survey was conducted to have users and professionals´s opinion on façade in various cultural and geographical contexts. Participants, largely based in India and Europe submitted 28 responses with different professional backgrounds from lighting design, architecture, urban planning and real estate development.

INTERACTION & PERCEPTION

It was observed that most of the participants frequently interacted with urban nightscapes through walking or working. In a question about what does façade lighting mean to them, respondents could select more than one choice. 23 choose accentuating architecture whereas some connected it to branding ,narrative ,safety and visibility. Few brought up energy waste and light pollution , indication the raising awareness towards environmental impact due to unplanned lighting.

CULTURAL PERSPECTIVE & BUILDING PREFERENCES

The cultural prism was reflected with the variety of responses. It was observed that participants from European cities prefer façade lighting as a medium of storytelling , connecting it with mood , history and and as a part of extended nightscape. Whereas Indian respondents frequently associated façade lighting with power , prestige and symbolic modernity.

When people were asked which types of buildings look the most beautiful when lit up at night, most of them chose heritage buildings (22 people). Bridges and other infrastructure came next (16 people), followed by monuments and landmarks (12 people). The inclination towards illuminating heritage structure was seen across all the countries. Notably , Modern skyscrapers and residential buildings were mentioned by participants from India, reflecting aspirational narratives linked with contemporary architecture and growing cities.

COLOUR & LIGHTING PREFERENCES

Colour temperature preference showed regional variations. Dynamic and tuneable lighting system based on time of the day was a popular choice among participants from Europe - 10 . Meanwhile, warm white was preferred by 9 respondents, predominantly from India, indicating conventional and emotionally resonant approach. Dynamic or colour changing lights were majorly preferred by 25 respondents for special occasions or landmarks, rather that as a general lighting practice.

USERS´S EXPERIENCE

When it was asked about the experience about walking and driving through the city at night , majority 21 participants found the city safer and inviting with façade lights. However, few 3 found these lights overwhelming and uncomfortable, especially due to overlit façades near commercial zones. When it was asked about distracting while driving, 18 respondents confirmed that it can sometimes be distracting. These findings emphasize the need for considering colour intensity, direction and spatial context.

DESIGN PRIORITY

Five important factors that are considered to be most important in lighting design were ranked on the scale and the average was considered for analysis accordingly. Lighting that fits best to the structure was ranked 2.0, followed by aesthetic preference 2.23, using energy efficiently 2.35, reducing light pollution 2.40 and making the area safe 2.62. While safety was the most important amongst all, people all gave importance to the sustainability.

POLICY AWARENESS & SUGGESTIONS

The survey also revealed the gap between the awareness and enforcement of lighting regulations in different regions. 10 participants were unaware about any rules, 8 confirmed that the existing regulations arent enforced , whereas 4 reported strict compliance. When asked about future policies , responses strongly supported eco friendly approaches. Top suggestions included stricter limits on brightness and energy use 16 , applying dimmable or adaptive lighting 15 and enforcing dark sky compliance 13.

REFLECTIONS FROM OPEN ENDED RESPONSES

The open ended responses shared an interest about adaptive and sustainable technologies, shaping the future of lighting design. Respondents highlighted on innovations such as AI driven systems, solar powered fixtures, projection mapping techniques and bluetooth controlled luminaires. Many responses also emphasized biophilic and ciracidian concious lighting, with interactive lighting system allowing users to control the architectural illumination.

When it was asked about to share their favourite examples, European participants chose places like Paris 10th City Hall, the Louvre Museum and the Louisana Museum of Modern Art. They described it preferring the their soft, well integrated lighting. While Indian Participants pointed on landmarks like Gate way of India ,Rajabai Tower and Taj Mahal Palace which use lighting to express civic pride and cultural importance, especially during festivals and national events. Few of them also shared images of retail malls and new residential buildings in their locality.

While discussing the issues of façade lighting , responses raised concerns regarding too bright light being used. Some of them also mentioned about poorly aimed luminaires creating visual clutter and light spill. Misuse of colour was also seen at many heritage sites. Respondents recommended keeping the illumination simple and minimalistic. It was mentioned that the illumination doesn’t have to be dynamic to stand out. A strong narrative driven lighting design can create a powerful identity of the structure within the space. A few people also shared some examples of disturbing lighting with glare, showing the real examples of they experience façade lighting affecting the ambiance and environment in the city.

In summary, these reflections reflect that while there is excitement about new technologies, people want façades to be lit in a planned manner and in tune with its surroundings. The suggestions and preferences demand for a need for an approach that supports sustainability, cultural meaning and better experience for viewers , witnessing the light within the structure as well outside.

7.2 PROFESSIONAL INSIGHTS

To consolidate a strong foundation for the design proposal ,discussions and interviews with lighting designers were conducted from different India, Denmark and France. These conversations shared perspectives on regional strategies, and design decisions that are influenced by environment, culture, and urban realities.

While exploring the need and purpose of whether façades should be illuminated, discussions with lighting designers working across distinct urban environments, revealed that it is a complex and evolving subject. The discussion reflected that consensus was not to eliminate façade lighting but to apply it more thoughtfully. These conversations informed the framework proposed in the next chapter, bridging theoretical exploration with practical design considerations.

A recurring observation was regarding the demand for illuminated façades is increasing as cities expand and urban identity becomes more visually appealing, particularly in developing nations. Further, it is determined upon its cultural context and geographical location. The cities in Asia and Southeast Asia had been emphasized. The festive culture is frequently sustained and transformed into a permanent or a regular façade illumination practice.

In certain cases, the challenge is to maintain a balance between environmental responsibility and visibility. This balance was further reinforced during the discussion with light professionals from France and Denmark, echoing observations and learnings from previous chapters. French designers emphasized, country´s illumination regulations and how the concept of dark infrastructure aims to deprive light pollution by 2030. Whereas Danish professional highlighted energy efficiency supported by cultural preference for low lighting levels and lengthy days during the summer. This approach also contributes to the subtle and atmosphere-oriented façade lighting limited to landmarks and heritage sites.

Unlike European cities where lighting curfews and dimming protocols are well established, Indian cities face the challenge while maintaining the perception of modernity through high intensity lighting. Similarly while discussing about lighting about Indian cities, it was highlighted that there are many different preferences of users, based on cultural and geographical variations. Therefore it is challenging to define a general threshold that fits all the regions. This highlighted the need for context specific lighting design during the discussion.

The unit of measuring and defining the threshold varies in each country. In france ,the limit is set at 25 lumens per sq.m whereas in other countries it is set in terms of watts per sq.m. This raised question and scope to develop a metric system that is generalized and considers energy efficiency , luminance and illuminance equally.

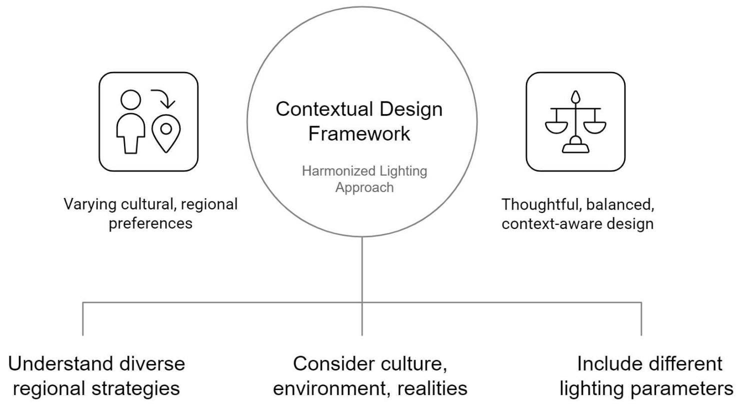

Fig 7.1 : Façade Lighting framework informed by professional insights, author 2025

7.3 SYNTHESIS : Bridging comparative analysis and research objectives

The comparative analysis of façade lighting techniques in Mumbai and Copenhagen, along with the insights of from the literature study, highlights notable differences in how each city implements façade illumination. These variations highlight notable discrepancies in Mumbai's lighting landscape, offering the opportunity for new research emphasis.

Beyond the emphasis on low light levels and color temperatures, the differing lighting practices in Copenhagen and Mumbai show diverse cultural narratives. Maintaining a minimalist urban character, façade illumination in Copenhagen preferred to be minimal, reserved mostly for landmarks and heritage buildings. Whereas, façade lighting of Mumbai includes, all the typologies from commercial and residential structures, hence expressing a more general cultural story in which light denotes visibility, celebration, and prestige. This cultural disparity emphasizes how façade lighting not only defines urban character but also challenges important issues about maintaining a balance between cultural expression, energy efficiency and regulatory control, a scope that motivates the developing study.

Mumbai's façade lighting techniques represent scattered visual story created by undefined lighting policies across building types. Though the lighting designs have contextual significance, heritage buildings are sometimes lit with high-intensity projectors to highlight the structure, hence producing overbearing and disconnected depictions. On the other hand, modern high-rises use generic, financially driven lighting strategies that overlooks the architectural character and cultural story embedded in the urban environment.

In contrast, Copenhagen's façade lighting is distinguished by a seamless blending of cultural narratives and legal frameworks. Copenhagen Lighting Master Plan (2024) recommends luminance levels, dimming schedules, and zoning-specific controls. The objective promotes visual coherence between the architectural built and the surrounding environment, while making an attempt to follow dark sky principles and energy efficiency requirements.

While Copenhagen's master plan gently control façade lighting through enforced criteria, Mumbai's Development Plan overlooks façade lighting. Though IGBC and ECBC 2017 recommends few guidelines, however there lacks specific regulations for façade lighting right now. This may cause fragmented installations and inconsistent lighting treatments that can add visual clutter and light pollution.

It is apparent that a single standard cannot be applied to all structures or locations when considering regulatory needs and people´s preferences. Some areas may require stringent lighting limits, while others can have more creative lighting. The findings taken together discover a structural gap in Mumbai's façade lighting practices highlighting the need of a context-specific framework in balancing cultural integration with energy efficiency and an attempt towards a light pollution free night sky.

7.4 RESEARCH QUESTION

This study started with a comprehensive observation on the influence of façade illumination on urban identity, while addressing environmental issues. As the research developed through literature analysis, regulatory comparisons and user surveys, it became essential to frame the study within the cultural and geographical characteristics of Mumbai.

Applying multidisciplinary perspectives, environmental performance (natural science),user perception (social science) and cultural significance (humanities) the focus is narrowed to represent the city's intricate architectural typologies and zoning potentials. This results in the development of a refined research question.

How can façade lighting in Mumbai be re-imagined through a culturally sensitive, energy-efficient and dark sky compliant design strategy that responds to architectural typologies, urban zoning and user perception ?

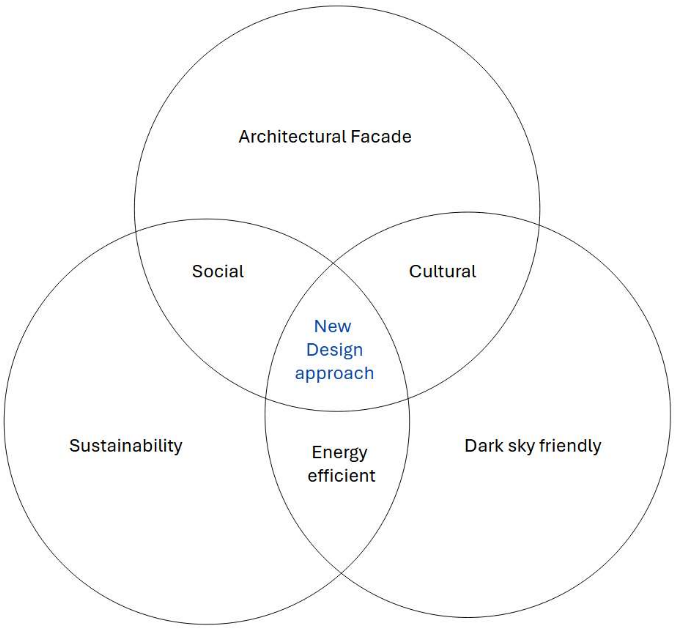

Fig 7.2 : Integrated Design Approach for Façade Lighting , author 2025

8. DESIGN

The design framework combines user´s expectations and experiences from façade lighting with existing recommendations. It includes insights from user survey and findings that were studied in earlier chapters . Insights are compared with regulations and recommendations of France, Greece, Denmark and India. Parameters included in these regulations are taken into consideration to design the proposal.
Mumbai's urban zoning has been planned by MDP 2034, which splits the city into regions according to their ecological sensitivity. This make it easy to plan and implement the lighting solution.
The design also acknowledges current trends and requirements for brightness and cooler tones, offering reasonable recommendations applicable to Mumbai's high-density metropolitan.

The proposed design framework functions through a two tier approach – (zone based and building typology based framework) that includes interdependent lighting parameters inspired from global lighting concepts and energy regulations.

It begins with zone identification, followed by building typology. Design elements tailored specifically for Mumbai in chapter 8.1 are first contextualized according to the zone i.e CRZ, NDZ, or Mixed-Use. (explained in chapter 8.2). Once the zone is identified, the designer can determine the building's typology. From heritage, residential, or high-rise with glass façade (mentioned in chapter 8.3) and apply the relevant lighting strategies.

This method ensures that both environmental sensitivity and architectural identity are addressed, allowing façade lighting to be designed with creativity and dual compliance: zone-specific regulations and typology-based design guidelines.

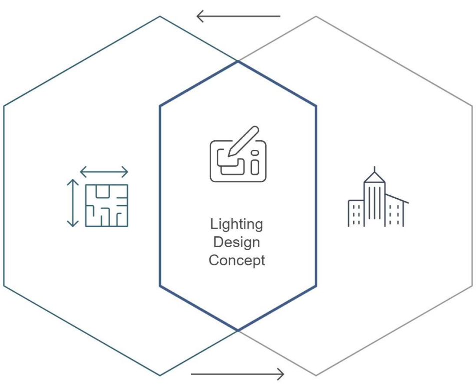

Fig 8.1 : illustration of design framework, author 2025

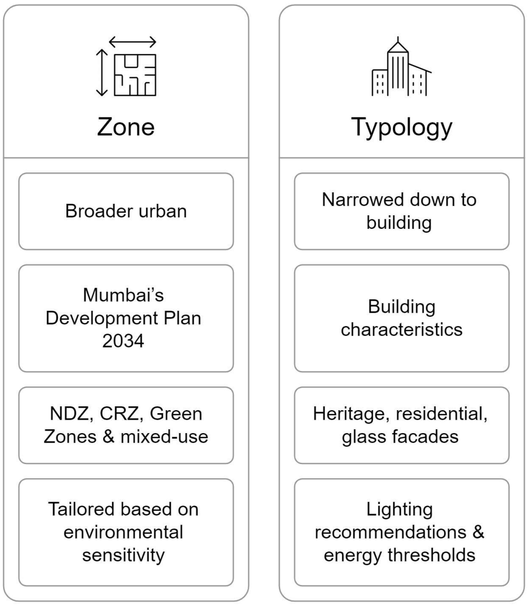

Fig 8.2 : Illustration of framework, author 2025

8.1 PROPOSED DESIGN FRAMEWORK - PARAMETERS

1. SHIELDING

façade Light fixtures are recommended to be shielded in order to prevent the light spill in upward direction. The beam angles for downlights must be below 60° from the vertical plane to minimize skyglow and glare, following the BUG rating system. In Glass façade buildings, it is recommended to use louvers and control intensity.

2. COLOUR TEMPERATURE

Although Warm colours are better for dark sky friendly environment, considering the user´s preference , warm to neutral white tones 2700K - 3500K should be used for façade lighting. To balance this, it is advised to check the spectral power distribution and minimize the use of blue light in ecological zones. For mixed zones and heritage structures 2700K – 3000K is appropriate, to create context sensitive environment.

3. LUMINANCE

Luminance levels should align with the overall urban brightness while also avoiding over-illumination and visual discomfort. Therefore, it is recommended to limit the luminance of heritage façades to 1 - 5 cd/m^2, residential buildings to 1 cd/m^2 and Glass façade buildings to 1.2–1.8 cd/m^2 to balance visibility.

4. LIGHT POWER DENSITY (LPD)

façade lighting should be energy efficient while reducing operational costs and minimizing environmental impact. Therefore, it is recommended to limit lighting power density (LPD) to ≤ 2.0 W/m^2 for heritage structures, 2.5–3.5 W/m^2 for residential buildings and ≤ 5.0 W/m^2 for high-rise glass façade buildings with dynamic content.

5. CURFEW + DIMMING

Lighting Curfew should be introduced using time based controls to reduce light pollution during night time hours. The city being vibrant, it is recommended to implement the curfew between 10:00 PM to 5:00 AM for all non essential façade lighting. It can be implemented with two options :

1. Switching off lights completely
2. Dimming it to 40% output

The light curfew should apply to residential, commercial, and heritage buildings. Exceptions for hospitality or cultural events could be permitted with programmable or sensor-based lighting control.

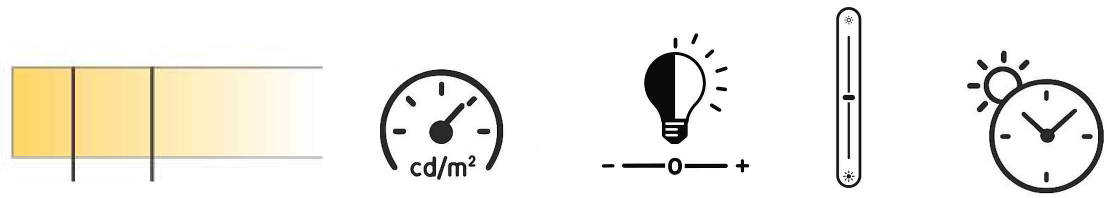

Fig 8.3 : Design framework parameters, author 2025

8.2 ZONE BASED FRAMEWORK PROPOSAL – Aligning with MDP 2034

Mumbai Zoning By MDP 2034, can be used as background to identify light pollution patterns with changing impacts and challenges across different categories. The Green zones G1 and G2 are the primary zones with increasing infrastructure expansion, that causes light spill in ecologically sensitive area like Sanjay Gandhi National Park, which spans across a large area in the city. Therefore, the zones can be considered as Dark-Sky zones to reduce artificial lighting.

In No development zones NDZs, existing development with unregulated lighting causes light pollution. This can be mitigated by reducing glare with appropriate shielding. Coastal Regulation Zones (CRZs) faces issues related to excessive façade and billboard lighting near the waterfronts, causing skyglow over the Arabian Sea. This may affect the biodiversity. Therefore, minimum luminance levels with light curfews should be implemented for coastal buildings.

Mixed-Use Zones buildings also contributes to light pollution through 24/7 illuminated façade. This results in energy waste, visual disturbance and excessive urban brightness. Solution for these zones include introducing curfews, luminance limits with dimming.

The proposed zoned based lighting strategy offers threshold references, which can be considered with detailed lighting design framework based on building typology.		
Zone type	Lighting Challenges	Proposed Lighting Strategy
G1 & G2 Green Zones	Increased development causes light spill into rich bio-diversity zones.	Declare as Dark sky zone , shielding of light is recommended Lights should be restricted to use low intensity and CCT to ≤2700
NDZ No Development Zones	Unregulated lighting causes light trespass and glare in low density agricultural regions	Shielded luminaires with minimal uplight are recommended CCT should be restricted to ≤3000
CRZ Coastal Regulation Zones	Excessive façade lighting and digital billboards near waterfront cause sky glow and also impact marine biodiversity.	Luminance limit of ≤ 0.6 is recommended. Dimming should be mandatory after 10 PM
Mixed Use Zones	Continuous façade illumination causes visual discomfort , energy waste and increase in urban brightness.	Dimming or Light curfew after 11 PM should be made mandatory

Fig 8.4 : Zone based framework proposal, author 2025

8.3 TYPOLOGY BASED DESIGN PROPOSAL

Building Type	Lighting Technique	Proposed Application	L (cd/m²)	CCT (k)	Energy Consideration
Heritage Buildings Cultural Monuments	Mixed Techniques , Silhouetting	Low-intensity lighting to highlight architectural details.	≤ 0.5	2700 K - 3500 K	Shielded LED projectors (≤ 2 W/m²) dimming post-midnight.
Residential	Soft uplighting & indirect lighting	Avoid light spill into apartments, focusing on subtle , inviting perimeter lighting.	≤ 1	2700 K - 3500 K	2.5–3.5 W/m² dimming after 10 PM
High Rise Building with Glass façades (Commercial, Residential)	Media façades & vertical accent lighting	Controlled brightness with programmable dimmers .	1.2 - 1.8	2700 K - 3500 K	≤ 5 W/m² with dimming recommendations after 10 PM
Occasion / Event	projection mapping	Theme based projections. Limited to special occasions to prevent overuse.	≤ 0.6	2700 K - 3500 K	≤ 5 W/m² Limited Duration

Fig 8.5 : Building typology based framework proposal, author 2025

To assess the practicality of the framework, lighting concepts are developed and tested at two representative sites in Mumbai, in the following chapter. A heritage structure in Coastal Regulations Zone and a residential high rise in Mumbai suburbs. Zone based and typology based framework are taken into consideration to ensure contextual alignment. These concepts are then examined combining quantitative and qualitative methods involving user perception. This methodology helps to evaluate how the design takes into account factors that align the research question.

9. SITE SPECIFIC APPLICATION OF FRAMEWORK

9.1 RE IMAGINING FAÇADE LIGHTING OF GATEWAY OF INDIA – CRZ Zone

9.1.1 INTRODUCTION

The Gate Way of India is Mumbai´s one of most visited landmark. Being located facing the Arabian Sea, it marks the departure for ferry and yacht tours. Historically it has been regarded as a ritual space of arrival and departure. Standing adjacent to Taj Mahal Palace Hotel , it forms a symbol of culture and architectural significance.

The structure is built in Indo Sersenic style, with basalt and yellow sandstone. It has a central arch with detailed carved latticed stone screen, commonly known as Jalis. This architectural element is not only ornamental but also functional, as it filters air and natural light by softening the harsh coastal climate and casting patterned shadows during the day.

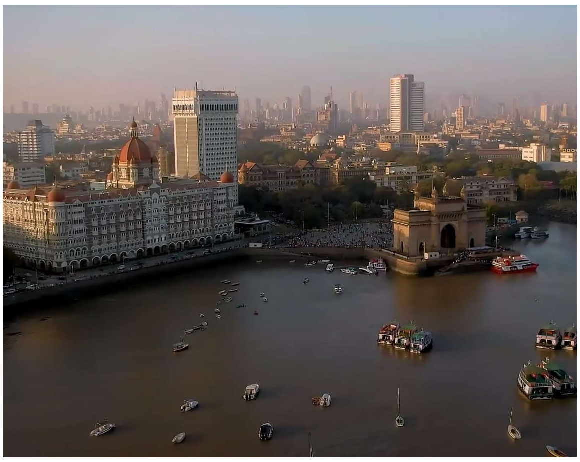

Fig 9.1 : Aerial view of Gateway of India, source : CyArk

Fig 9.2 : Gateway of India – existing lighting , source: TOI

The structure becomes an attractive silhouette during sunset. The sun's rays penetrates through the jalis, creating a connection of light, stone, and the water. This spectacle draws local and tourists, reinforcing monument´s cultural identity and spatial presence in the city.

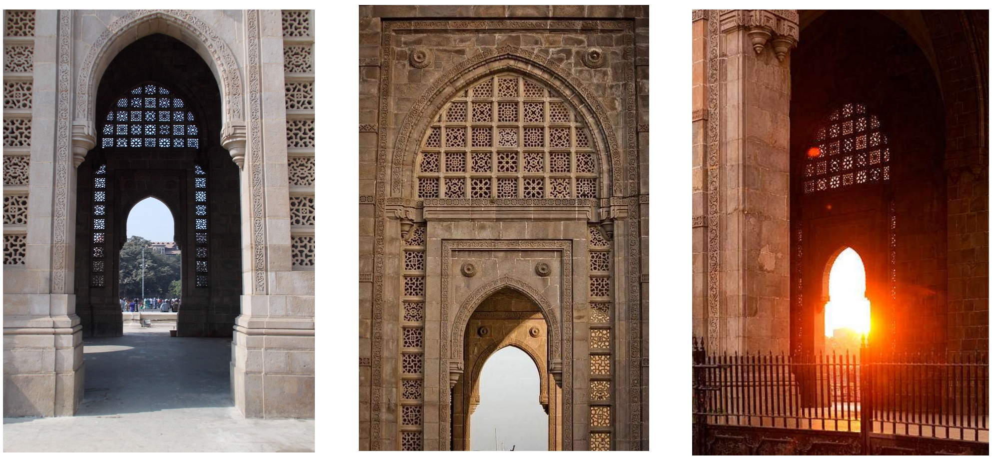

Fig 9.3 A, B & C : carved lattice stone screen - Mood Board, source: wikipedia, pinterest

9.1.2 EXISTING LIGHTING

The existing lighting at the Gateway of India mostly uses high-output floodlights positioned at low angle, directed upward across the façade. Warm color temperature of fixtures are used to generate a golden wash that gives a strong and visually striking presence at night. Although this arrangement makes the monument visible and lively during tourist hours, it lacks highlighting architectural details, making the stonework look flat and washed out.

Spotlights installed at squinches inside the monument illuminates beam on the ribbed vaults and domes. Since the beams are complex in structure, they create a strong contrast between dark and bright areas, overlooking the layered geometry.

Fig 9.4 : Interior view of GOI , source: pinterest

Fig 9.5 : spot lights highlighting ribbed vaults, source: wikipedia

Fig 9.6 : Existing Lighting , source: Pinterest

9.1.3 CONCEPT : LIGHT BREATHING THROUGH STONES

The design concept is to continue the atmosphere of golden hour with a subtle interior illumination from the carved lattice stone screen – Jalis. By using grazing techniques the light can reflect a soft glow after dark, creating an effect of monument breathing light from within.

Being under Coastal Regulation Zones (CRZ) and close to the Arabian Sea, it has potential to implement the concept of Dark Infrastructure by using selective lighting. The objective of the design is highlight the details of porous geometry of stone screen without flooding the light and creating a contrast with surroundings.

Minimal luminaires with controlled intensity are planned to be placed in such a way that the narrative is achieved by fulfilling all the requirements of the new design proposal. Therefore, projectors, LED Light grazers, projectors and LED flex are suggested in this design.

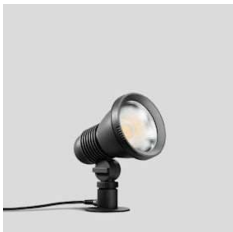

Fig 9.7 A : LED Light Grazers ; B : Slim linear grazer ; C : LED Flex ; C : LED Projector , source : Kinwai, Bega

Fig 9.8 A & B : Sectional illustration of light placement and distribution across domes, arches, and jali screens, author 2025
Source : CyArk - section drawings

The lighting design for gateway of India adopts a heritage conscious approach by using energy efficient luminaires that enhance the architectural form as well as the cultural expression. LED Flex strip with warm tones and RGB compatibility will create a soft, indirect glow that not only accentuates the dome but also gently illuminates the interior arches, creating an internal radiance that highlights the monuments depth and geometry. It will allow the structure to glow from within. The tunability of this cove light can create dynamic scenes for themes related to national days and other events.LED light grazers will produce a soft light through the stone lattice, whereas the thin vertical grazers will enhance the archway. Projector lights with filter lenses, installed at the existing light poles in front of the structure will create a soft glow on the overall structure. These placement will create minimal light spill and maintain harmony with the surrounding nightscape.

Arch. Element	Luminaires	Lighting Technique	W	CCT	Beam	Mounting
Domes	LED Flex	Indirect Light	8 W/m	2700 - 3500K and Tunable RGB	Diffuse 120°	Fits within existing cornice
Stone Screens - Jali	LED Light Grazers	Internal grazing through lattice	5 W/m	2700 k	10° x 60° asymmetric	Recessed in side frame – clamp track
Arch – Vertical inner faces	Slim linear grazer	Vertical wall grazing	5 W/m	2700 - 3500K	15° x 55°	Mounted vertically inside arch groves
Main façade	LED projector	Soft façade glow	25 W/m	2700K	65° wide flood	Mounted on existing street light poles

Fig 9.9 : Proposed lighting specifications for façade of Gateway of India , author 2025

HERITAGE SENSITIVITY AND FIXTURE INTEGRATION

Being a Heritage Structure, it is challenging and important to follow conservation principles like non-invasiveness and minimal visual impact. Therefore the fixtures are planned to be placed using the existing structure and minimal additional features.

The Stone Grill – Jali has a recessed ledge that can be used used to subtly be used to place 10 – 15 mm of LED grazing – Linear lights. Whereas the slim fixtures can be fitted in tracks and clamped with wooden supports in deep arches with side voids, so that stone is not in direct contact. Linear flex light can be seamlessly installed in the existing cove of the dome, without any additional alteration.

Wires can be concealed in brackets within the mortar joints with matched colour sleeve for a coherence.

9.1.4 LPD OF DESIGN PROPOSAL

$$\text{LPD (W/m}^2) = \frac{\text{Total Wattage (W)}}{\text{Illuminated Surface Area (m}^2)}$$

Arch. Element	No.	Luminaires	Quantity	Total Length	Power Used	Total Power Used	LPD	Framework Compliance
Dome - Main	1	LED Flex	15 M	15 M	8 W/m	120 W	0.34 W/m^2	Yes
Domes small	2	LED Flex	6 M	12 M	8 W/m	96 W	0.21 W/m^2	Yes
Arches	3 x 2 = 6	Slim linear grazer	8 M	8 M X 12 units = 96 M	5 W/m	480 W	1 W/m^2	Yes
Stone Screens - Jali	2 X 2 = 4	LED light grazer	5 M	5 M X 4 Units = 20 M	5 W/m	100 W	1.32 W/m^2	Yes
Main façade	1	LED projectors	2	2 Units	25 W/m	50 W	0.1 W/m^2	Yes

Fig 9.10 : LPD Analysis of proposed lighting concept – Gateway of India, author 2025

9.1.5 ALIGNING CONCEPT WITH FRAMEWORK PARAMETERS

SHIELDING : Most of the lights installed according to this concept are placed under the structure. Hereby keeping it under beam angle below degrees and reducing the risk of light spill upwards.

COLOUR TEMPERATURE : proposed are 2700K – 3000k to reflect the heritage tone and mimic the sunlight passing through the Jalis - perforated stone screen with patterns. It also aligns with the preserving the biodiversity in the surrounding locality. Cove light from the dome has tuneable lights which has the possibility to change the colours as per theme of the event.

LUMINANCE : The luminance will be comparatively low than the existing lighting , considering the illuminance from the surrounding and adjusting accordingly.

LIGHT POWER DENSITY : Strategically placed lights within the structure, allows the design to adhere with ≤ 2.0 W/m^2 threshold.

DIMMING : The lighting is proposed in two phases to balance visual impact with energy conservation. façade lights facing the sea will be switched off by 10 PM, while the dome's cove lighting will gradually dim. The dome lighting will gently pulse, dimming and brightening at half-hour intervals to evoke a rhythmic, breathing effect. At midnight, all lighting will turn off except for the jali backlighting, which will remain on at just 40%, preserving the structure's presence while minimizing energy use and light pollution.

Time Interval	Phase	Dimming	Outcome
Sunset – 10:00	Full Lighting	All façades and Dome lights - ON	Visibility increased and monument is highlighted
10:00pm - 12:00am	Partial Dimming	Sea Facing façade lights – OFF Cove light dims and pulses at 30 minute intervals	Ambient light - narrative of breathing effect in dome
12:00 am - Dawn	Minimal Lighting	All lights off , except Jali backlight at 40% output	Minimal presence is preserved with energy efficiency.

Fig 9.11 : Proposed dimming schedule for Gateway of India, author 2025

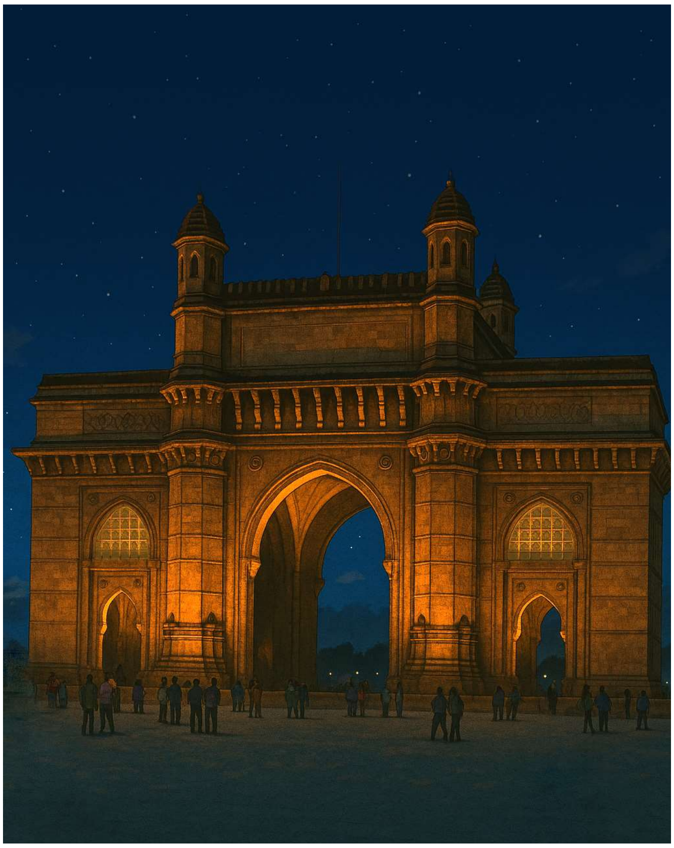

Fig 9.12 : Illustration of Design Concept , author 2025

Fig 9.12 : Illustration of indirect light – interior view, author 2025

9.1.6 QUALITATIVE EVALUATION

A visual questionnaire combined with semi-structured interview was conducted with ten people who interact with the surroundings of Gateway of India in different and significant ways to validate the narrative and perceptual efficacy of the proposed lighting design. The participants were selected to get different viewpoints connected to real life experiences. The group included

Local Photographers who frequently document the monument and are familiar with the monument and its surroundings. They have experienced how light changes the appearance of monument across time and seasons.

Tourists and regular visitors have fresh viewpoints offering insights about first impression of the monument and their spatial experiences.

Local residents and designers have been aware about the monument in detail. They have thoughts about monument as cultural memory and landscape beyond being a landmark in the locality

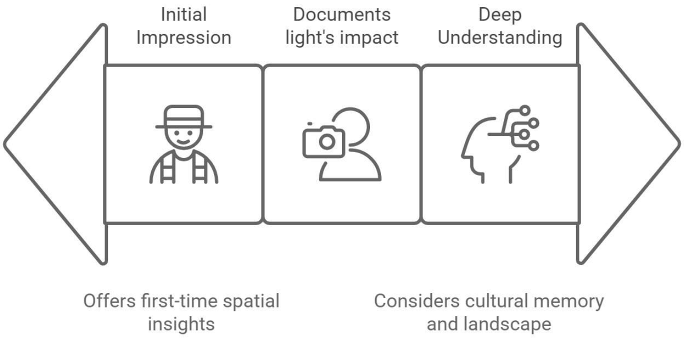

Fig 9.15 : Participant groups of qualitative evaluation, author 2025

Every participant was shown a visual representation on the proposed lighting design as well as the existing light. They were invited to choose from a list of the words describing Rasa-based emotional descriptors to describe their emotional connection with the monument under each lighting scheme and answer open-ended questions centered on:

- Emotional Response : How light influences mood & sensory experience
- Symbolic Integration : Whether cultural & historical significance is conveyed.
- Architectural Alignment : Which lighting approach better enhances the structure´s texture , depth and architectural character.

Fig 9.16 : Isometric illustration, author 2025

PARTICIPANT RESPONSES

1. Emotional Responses (Rasa Theory):7 out of 10 respondents described the feeling Shanta Rasa (tranquility) when they were shown the lighting design concept. They added that it reflected the surrounding as serene, contemplative, and relaxing atmosphere. The interior glow of the jalis and the indirect dome lighting encouraged 3 individuals to express Karuna Rasa (compassion).

2.Symbolic Perception : 9 participants indicated the proposed illumination communicated in detail with the Gateway of India's legacy and spirit, hence reflecting a favorable symbolic and cultural perspective. Some said the monument seemed "less commercialized" and "more authentic." The delicate light of the jali screens stood out, with one participant calling it "a glow emerging from within the stone," hence stressing its spiritual and cultural importance.

3. Architectural legibility : The proposed lighting design aligned with architectural legibility, as all 10 participants felt it improved the visibility of details and textures (Adbhuta Rasa), particularly in the carved stonework and arches. Current lighting was seen as diminishing these elements , making the façade appear flat. Many regular visitors added that they have seen this structure as large volume but never noticed these details before.

Participant´s Response	Perception	Associated Rasa
“ It felt like the structure is breathing ."	Rhythmic Symbolism	Shanta Rasa (Peaceful)
“ It looks calm and respectful. The structure itself speaks without glorifying it”	Emotional Atmospheric	Karuna Rasa (Compassion)
“The Jali illuminations feels sacred to me … it reminds me of temples at night”	Symbolic Spiritual	Karuna Rasa (gentle reverence)
“I use to see Gateway as a tourist spot , now it looks like something worth pausing for.”	Symbolic	Adbhuta Rasa (Wonder)
“The older light was good but it often lacked the depth. This light makes the monument lively.”	Architectural Legibility	Adbhuta Rasa (Wonder)
“It draws you in instead of pausing and taking pictures from far.”	Cultural Expression (Memory and Identity)	Adbhuta Rasa (Wonder)
“As a photographer, I feel more details. The arches and domes make it more dimensional”	Textural Visibility	Shringara Rasa (beauty)
“The lighting feels like it belongs to the stone and not added later”	Material integration	Karuna Rasa (gentle)
“I can imagine how poetic it would feel if dimming and fading is added !!”	Rhythmic Symbolism	Shringara Rasa (Love/beauty)
“It used to be like a billboard , now its about presence of the structure ”	Cultural Expression (Memory and Identity)	Shanta Rasa (stillness and remembrance)

Fig 9.17 : Participant´s response , perception and association with Rasa, author 2025

9.1.7 CONCLUSION OF SITE 1

The current lighting was seen as diminishing architectural elements, making the façade appear flat and lacking depth. The addition of cove lighting around the dome was appreciated for introducing a gentle sense of structure and rhythm, enriching the silhouette without dominating the architecture. The variety of participants provided a comprehensive knowledge of how lighting influences spatial experience and cultural perception of Gate way of India.

The validation from different fields backs up the proposal. From natural science perspective, illumination is within $< 2\ W/m^2$, following the principle of dark infrastructure and making it compliant with the proposal. For social science and humanities field, users affirm the structure to have emotional and symbolic depth that connected with memories and identity.

These results therefore confirm that the design fits with typology, zoning and user experience in a way that is culturally sensitive, energy efficient and compatible with dark sky strategy.

9.2 RE IMAGINING FAÇADE LIGHTING OF RESIDENTIAL BUILDING

9.2.1 INTRODUCTION

façade lighting has evolved the nightscape of Mumbai. From previously being used as a decorative element, it has now been a necessary identity defining component in residential buildings. Although residential buildings might not need functional lights, but it plays an important role in highlighting the building´s visibility, promoting nighttime safety and representing aspirational living for consumers. façade lighting creates an inviting atmosphere with social identity where residents desire status and security.

Unlike heritage buildings ,lighting design in residential buildings prioritizes on comfort, privacy and energy efficiency while considering the architectural narrative. In suburbs of Mumbai, dense residential construction is gradually transforming into skyline that reflects both cultural ambitions and environmental concerns. Therefore, façade lighting plays an important, evolving role in defining this skyline.

In residential façade lighting , the narrative and identity changes depending on the perspective of the viewer. The developer, architect and tenants are the primary groups that experience the building structure. Each group has its unique expectations, hence it is important for the lighting design to adapt with different briefs. A cohesive lighting design concept has to connect with these demands, creating a unified expression that respects design intent,enhances market value and promotes daily livability.

SITE BACKGROUND

For this study, I collaborated with a developer in suburban Mumbai to plan a façade lighting design for a 30-story residential tower that is currently under construction. By discussing with architect of the project and interviewing 3 potential flat owners in the building, a comprehensive understanding from different perspectives was built. These insights supported in developing lighting plan that is cohesive with architectural purpose, development goals, and future user experiences.

The residential building presents an utilitarian and functionality driven approach. The façade has horizontal bands formed by overhanging eaves or roof covering, known as Chhajjas in Indian Architecture. They not only enhance the elevation but also provide shade and rain protection in Mumbai´s tropical climate. The uniformly set located windows, creates a grid rhythm. Currently, it subtly emphasizes its distinctiveness by being the tallest building in its surrounding locality. The uppermost levels have tall parapet walls with fins and cutouts that makes the building recognizable from a distance.

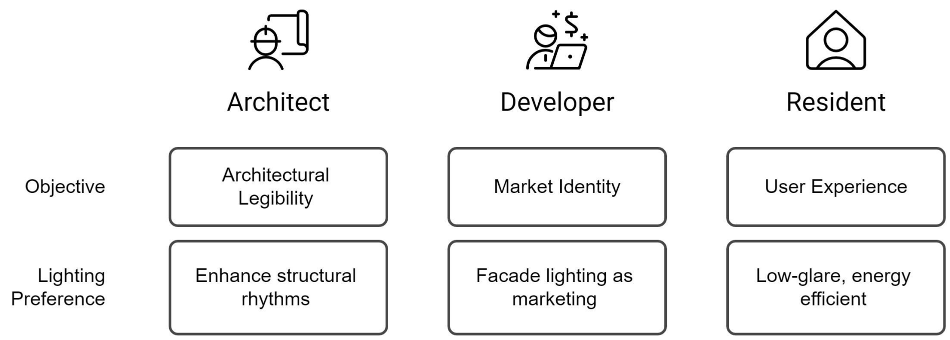

Fig 9.18 : User Groups and lighting preferences, author 2025

PROJECT BRIEF AND PERSPECTIVES

Architects´s Perspective : Architect preferred to highlight the architectural details and the unique elements that make the building distinct from other residential buildings. The suggestion was to represent the form and maintain the integrity of the elevation.

Developer´s Vision : Developer preferred to illuminate the building for visual branding. The suggestion was to reflect the uniqueness and premium value, therefore contributing to its aesthetics in a competitive residential area.

Resident´s Expectation : Prospective flat owners preferred a mild , non-intrusive lighting. They favored visual comfort , privacy and energy efficient lighting, ensuring that light would improve their everyday living instead of disrupting.

9.2.2 CONCEPT : THE LIVING FAÇADE

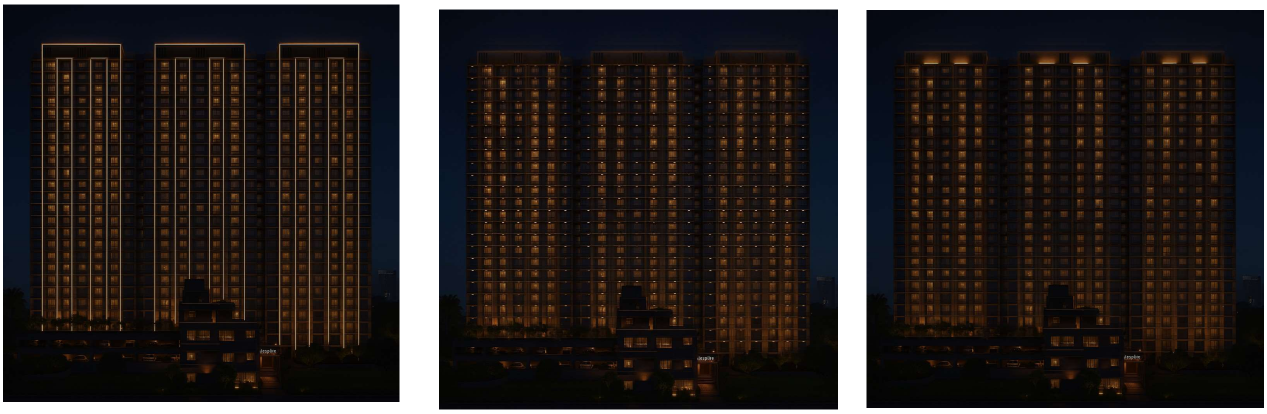

Fig 9.19: A - Zone 1; B - Zone 2 ; C - Zone 3 , author 2025

The lighting design concept builds upon the structured rhythm of the building which is characterized by modular windows and chajjas. The idea is to highlight minimal elements with precision to articulate architectural elements rather than applying external flooding.
To achieve this ,three different concepts are developed as per preference groups and zones of illumination. These can collectively be a coherent lighting for the overall façade as well as an independent concept fulfilling each project briefs.

Zone 1 (Vertical edge lighting) : LED Flex strip with silicon case, fixed along the vertical edges of the façade including the rectangular elements will enhance the aesthetic of the building. It will create a soft flow, reinforcing the structural grid and identity of the building without creating excessive spill light and glare for the residents and other viewers.

Zone 2 (Soft Downlight at eaves) : Narrow beam, glareless spotlight recessed within the overhead roof coverings outside each window will create a subtle, warm and indirect indirect glow. This layer will recreate an ambiance of lantern lit outside each window, thereby adding warmth to the façade and expressing the presence of life within the building without invading the privacy of the interiors.

Zone 3 (Parapet Grazering) : Slim linear grazers, positioned strategically at an angle avoids spill and traces the fins at high parapet walls. It offers a soft crown-like articulation to the building’s silhouette. This subtle highlight makes the building distinctive within the skyline without overwhelming it. The lighting can be minimal, time-controlled and be tuned on occasions to create theme based scenes.

Arch. Element	Luminaires	Lighting Technique	W	CCT	Beam	Mounting
Vertical Element	LED Flex - Silicon	Along the edges of façade	8 W/m	2700 - 3500K	Diffuse 120°	Fits along the edges of façade
Overhangin g Eaves	Spotlight	Downlight (Soft Glow)	5 W	3000 k	Glareless 30°	Recessed within the roof covering
Parapet walls	Slim linear grazer	Vertical wall grazing	15 W/m	2700 - 3500K and Tunable RGB	15° x 55°	Mounted with upward spill control along with the fins

Fig 9.20 : Proposed lighting specifications for façade of Residential building, author 2025

9.2.3 LPD OF DESIGN PROPOSAL

$$\text{LPD}\ (\text{W}/\text{m}^2) = \frac{\text{Total Wattage (W)}}{\text{Illuminated Surface Area}\ (\text{m}^2)}$$

façade Zone	No.	Luminaires	Quantity	Total Length	Power Used	Total Power Used	LPD	Framework Compliance
Zone 1 Vertical Edges	40	LED Flex	15 M	15 M	8 W/m	4800 W	1.27 W/m^2	Yes
Zone 2 Window chajjas	180	LED Flex	N.A	180 units	5 W/m	900 W	0.24 W/m^2	Yes
Zone 3 Parapet crown	3 x 2 = 6	Slim linear grazer	8 M	8 M X 12 units = 96 M	15 W/m	720 W	3 W/m^2	Yes

Fig 9.21 : LPD Analysis of proposed lighting concept – residential building, author 2025

9.2.4 QUALITATIVE ANALYSIS

Mock-Up Evaluation and Setup

Mock-up for the residential building was intended to get a thorough validation of how every light interacts with user groups and their views on the lighting stup. Three lighting zones were tested in on a small scale that included vertical linear lighting, roof shed lighting, and crown illumination. Each zones was meticulously set up to evaluate energy efficiency and visual effect under different conditions. User groups were asked to choose from a list of the words describing Rasa-based emotional descriptors to describe their emotional connection with light.

Zone 1 - Vertical edge light

The vertical linear lighting was implemented using LED Flex with Silicon covering , along the structural elements, extending along 5 meters height at 1st floor to 2nd floor. During the test, the brightness levels were initially set to full output followed by a 50% dimming further reduction to 20%. Colour temperatures of 6000 k , 3500k and 2700k were tested at different dimming levels. The testing was observed and evaluated from ground level and interior of the apartment where the illuminated façade intersects with window lines.

Fig 9.22 A : LED Flex Light at 50% dimmed output, author 2025

Fig 9.22 B : luminance image source: fusion optix

Fig 9.23 A : LED Flex Light at full output, author 2025

Fig 9.23 B : luminance image source: fusion optix

Fig 9.24 : light tuned at 2700K, author 2025

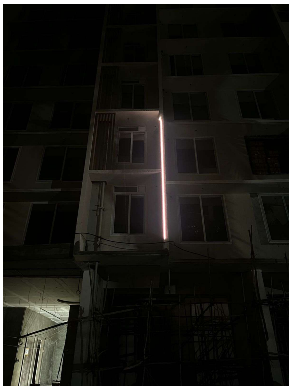

Fig 9.25 : light tuned at 3500K, author 2025

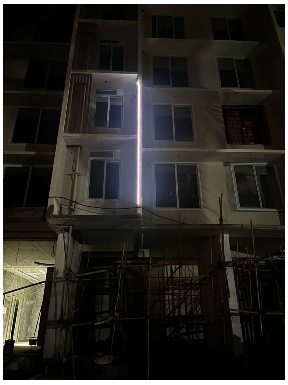

Fig 9.26 : light tuned at 3500K, author 2025

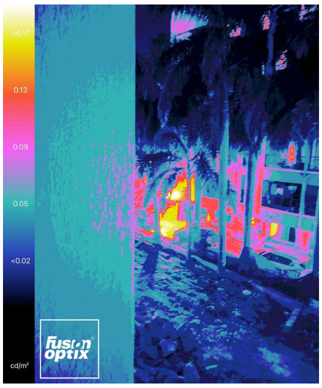

Fig 9.27 : Luminance image from apartment, fusion optix

Evaluation & Feedback :

Residents initially were concerned about the glare that can be possibly caused into their apartments but the testing clarified that the structural element being extruded from the main building façade, created no glare. Furthermore, residents couldn't determine if the light was turned on or off.

Architect appreciated the vertical emphasis and preferred dimmed – output (Fig 9.24)to prevent over emphasis.

Developer endorsed lighting effect, adding that it elevates the building's skyline identity. Dimming can mitigate their concerns about energy usage and budgeting.

Overview: 3500K of light was preferred by all of the groups at 50% dimming, which made the light coherent with the surrounding environment. When it was asked to choose Rasa, architect and developer found it to an expression of massiveness - Vira Rasa whereas residents found it to be an element of beauty – Shingara Rasa

Zone 2 Spot Lights – Overhead eaves

For the overhead roof (chajjas), narrow beam , spot light with 3000K was recessed producing a warm, diffused glow. The testing was made experienced by user groups and evaluated from the interior of the apartment.

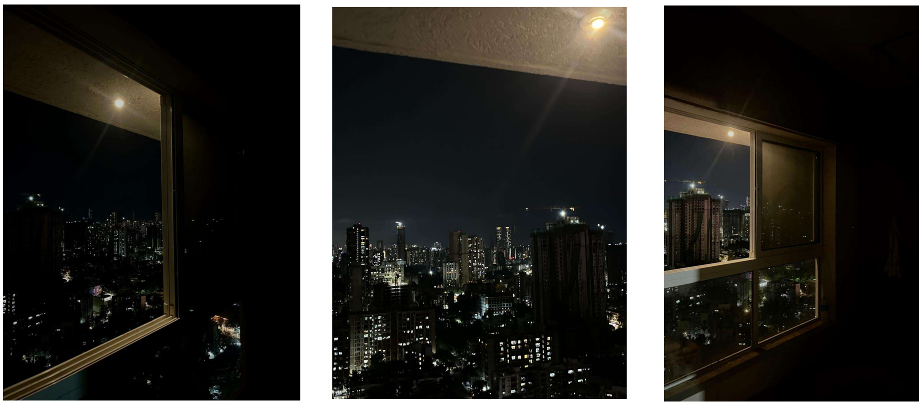

Fig 9.28 A,B & C: 3000K recessed spotlight experienced from the apartment, author 2025

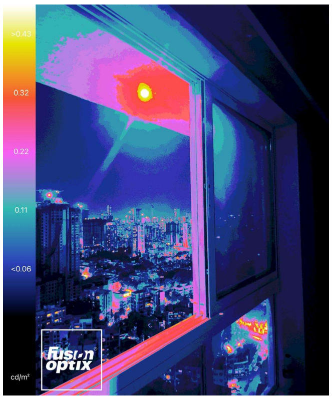

Fig 9.28 D : luminance image
source: fusion optix

Evaluation & Feedback :

Residents responded positively to this lighting concept, emphasizing the sense of warmth and comfort without direct glare. As a result, they specified that this light zones should be operated within specified time period instead and not all night.

The architects praised the design for maintaining the architectural rhythm, while developers suggested that a longer duration of operating hours during weekend evenings could enhance visibility from street level.

Zone 3 - Parapet walls (Topmost level of the building)

This zone involved using thin linear grazers with 3000K. They were placed by adding an additional member at the edge of fins. It was placed at an angle to illuminate the fins and frame like structure that is created with high parapet walls.

The testing was observed and evaluated from ground level and interior of the uppermost residential apartment of the building.

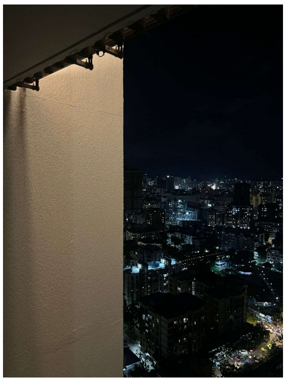

Fig 9.29 : luminance image
source: fusion optix

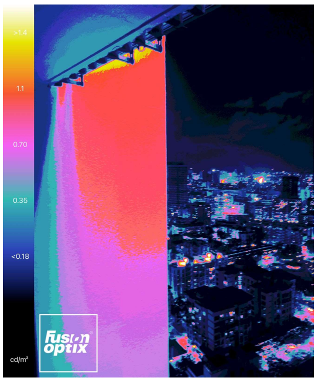

Fig 9.29 B : luminance image
source: fusion optix

Fig 9.30 A & B : Installation observed from ground level, author

Evaluation & Feedback :

Residents on the uppermost floor had a indirect light which was the result of installed linear grazers. They affirmed this lighting design with a suggestion to operate it and dim at late night.

The architects suggested to have different colour temperatures and possibly make it dynamic with RGB lights on all three sets of the crown themed lighting.

Developer was convinced with lighting zone, adding that it highlighted the identity of its highrise, thereby increasing visibility of the building within its surrounding area.

9.2.5 ALIGNING CONCEPT WITH FRAMEWORK PARAMETERS

SHIELDING : The spotlights are aimed downward, narrow linear grazers lit the frame-shaped elevation to efficiently avoid upward spill. The vertical linear flex are dimmed keeping low glare and ensuring that all lights are shielded.

COLOUR TEMPERATURE : All the lighting zones are are proposed to use 2700 to 3500 K. Zone 3 - the crown highlighting can be made dynamic with RGB on events and occasions.

LUMINANCE : The luminance will be minimal , considering the illuminance from the surrounding and making it cohesive accordingly.

LIGHT POWER DENSITY : Strategically placed lights within the structure and at different angles, allows the design to have independent concepts that are cohesive and adhere with ≤ $5.0 W/m^2$ threshold.

DIMMING : The lighting is proposed to be dim as per the feedback received during mockup testing. Zone 1 - vertical linear lights will be dimmed at 50% at regular operations and will be turned off after 11 pm. Zone 2- spotlights near window can be shut down after 9:30. Zone 3 – Parapet walls highlighting the uppermost floor of the building will be dimmed to 50 % and can be operational only on weekends and special events and occasions. It can be tuned and programmed to themes as per RGB modes for festivals and events.

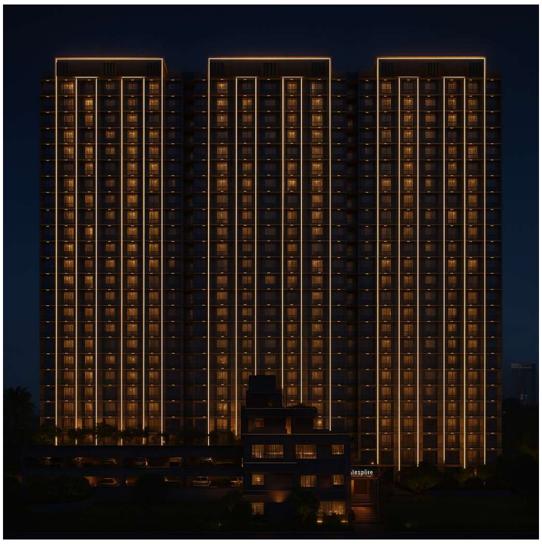

Fig 9.31 : Illustration of Zone 1 & Zone 2 , author 2025

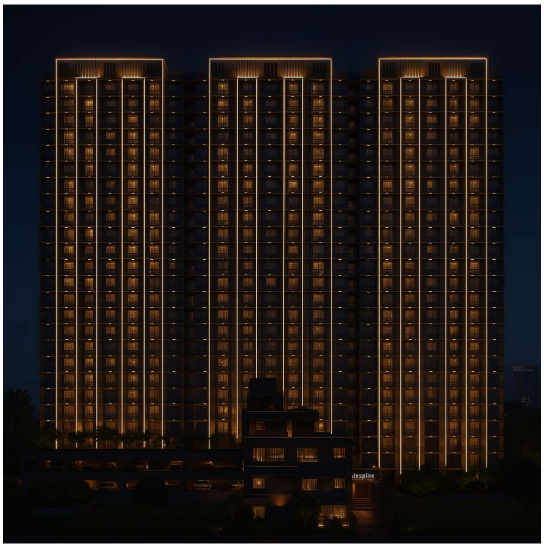

Fig 9.32 : Illustration of All Zones , author 2025

9.2.6 CONCLUSION OF SITE 2

Three different lighting concepts were integrated into a unified lighting strategy that fulfils diverse expectations of user groups for residential building. While the total energy was much higher as compared to the previous site , the organized and proportionate distribution made the overall lighting with proposed threshold limits of energy as well as luminance.

A common challenge was about controlling intensity of vertical illumination on residential buildings as observed in prior case studies. This was taken into consideration during mockup and attempted to resolve by dimming the light by about 50 percent. It not only saved energy but also prevented light spill and glare , as marked in luminance images.

The simple yet thoughtful lighting approach made it possible to comply with the research goals and thereby meet the framework proposal.

10. DISCUSSION

In urban context, façade illumination typically expresses beliefs, aspirations, and identities, in addition to basic needs. In cities like Mumbai, light is sometimes considered to be a symbol of progress. A consistent pattern is observed in this study associating higher intensity as an expression of culture formed by sacred beliefs, societal desire and visual competitiveness. This perspective may result in over illumination, energy waste and decline of dark sky at night.

This thesis attempts for a transition from the high-luminance paradigm and toward more nuanced, context-sensitive lighting practices while maintaining its cultural identity. Analytical comparison of lighting in Copenhagen and Mumbai shows how different cities perceive light, shaped by distinct parameters that reflect diverse approaches of façade lighting. It further helps to discover the gap and need for a framework that considers light as an instrument of narration rather than a sign of extravagance.

Therefore, a two-pronged approach is proposed to meet the vision. Referring existing development plan and other background studies helped to develop zone based proposal. It defines distinct thresholds with specific restrictions adapted to the urban setting. The building typology based framework further defines thresholds encouraging rhythm and user flexibility that fits into different architectural form.

Design interventions is implemented at two sites of different building typology in different zones, to test the proposed framework . Redesign lighting of Gate way of India , aims at restoring cultural and emotional presence of the monument that emphasizes selective illumination, aligning with the principles of Dark Infrastructure. Being under CRZ , concept extends beyond the monument itself, opening up the possibility to integrate surrounding streets and public spaces to create a cohesive environment that balances monument´s illuminance with its urban and ecological context. Responses from participants showed a change from spectacle to symbolic. The lighting of the monument was perceived to be peaceful, less overpowering and emotionally resonant that aligns with shanta and adbhuta rasa.

On the other hand , lighting design for residential building in Mumbai Suburbs addresses the challenge of visual consistency. The layered concepts attempts to fulfill the requirements of user groups associated with building making it cohesive without hindering residents privacy. The design challenges the notion that brightness represents luxury and liveability by demonstrating that distinctness can be represented with warm tone and precise illumination.

The inferences from both the sites, re-imagines lighting design approach for façade that recognizes light as a mediator between built environment and its social, cultural and ecological context. The thesis conveys light as an important element in urban language that is measured, purposeful and responsive, over the myth of “ more light = progressive city “

11. CONCLUSION & FUTURE WORK

The study explores and opens discussion about about the interaction of façade lighting between urban identity and sustainable practice. While it proposed a structured framework, it also suggests many general challenges and possibilities that could be considered.

The zone based lighting framework is at its primary stage. It is proposed by considering the existing development plan of the city and an objective to classify façade lighting strategies across different metropolitan zones. Although, in a developing city with many layers , it becomes difficult to fit all the buildings , streets and neighborhood precisely into a category.
Therefore , it is necessary to include and leave rooms for certain exceptions in the future version of this framework.
It is also necessary to acknowledge that lighting framework needs to be flexible and open eneded to relate it to real context in different geographical locations.

There are many possibilities in considering new technologies. Smart lighting technologies that respond to movement, time of the day or environmental conditions could make the façade lighting more adaptive and efficient for creating ambiance as well as sustainability. Testing these in different neighborhoods could help to understand how people perceive light and thereby plan façade lighting according to site specific circumstances.

This study could be benefited and further developed by interdisciplinary involvement. urban planners, ecologists, local authorities, and residents could be a part of discussion, for getting lighting concept ideas. Their perspectives could help shape lighting practices that are not just technically sound, but socially and culturally rooted.

Concluding it, the thesis aims to promote more investigation into how urban design could integrate façade lighting with shifting cultural and ecological narratives. The objective is to lit the buildings in thoughtful and environmentally responsive method that also reflects the richness of life within in.

Click to view video documentation on Google Drive

https://drive.google.com/drive/folders/1EqEKR6zkxtagzIPE62ZVOLrg05YyVFHj?usp=sharing

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Appendix

Site 1

Visual Questionnaire was used for qualitative analysis .Participants were shown two sets of images :

1) existing lighting for Gateway of India
2) proposed lighting design concept (light breathing through stones) The following questions were asked :

1. what does this lighting make you feel ?
2. Which Rasa (emotional essence) do you resonate with this monument under this lighting scheme. Shanta – peace, Karuna – compassion, Adbhuta – wonder, Raudra – intensity, Hasya – joy, etc
3. Do you find any difference in the monument or lighting specifically ?
4. does the proposed lighting feel more appropriate to the identity of monument ?
5. Do you find any narrative reflected from the monument (the way the monument is lit) ?
6. In which design , do you see more architectural details of the monument ?
7. Based on both visuals, which lighting approach feels more appropriate for the Gateway of India and why?

SITE 2

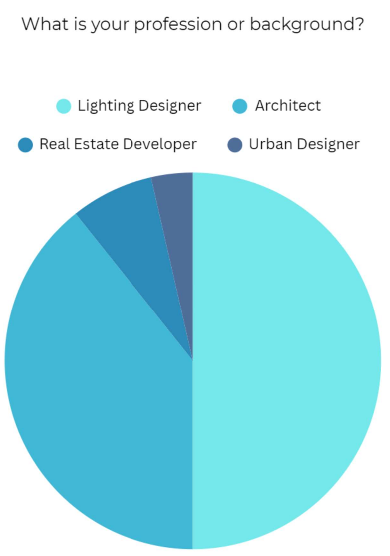
Questions asked to User groups for their insights (before design)

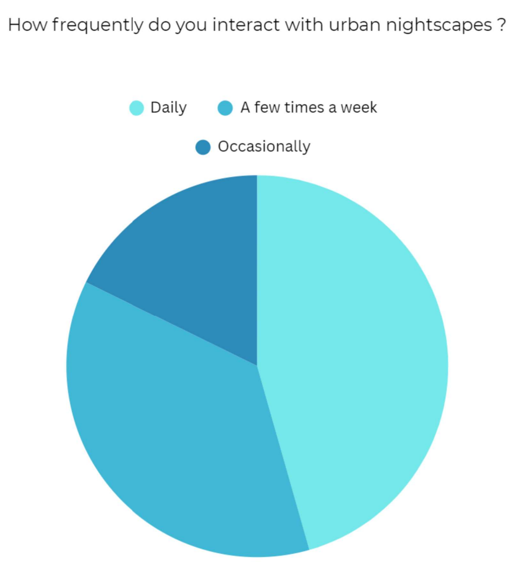
1. What do you expect façade lighting to communicate in a residential building? - safety , identity , comfort , branding , luxury
2. what kind of lighting do you prefer ?
3. what are your concerns regarding façade lighting ?
4. How do you want your building to appear during nighttime ?

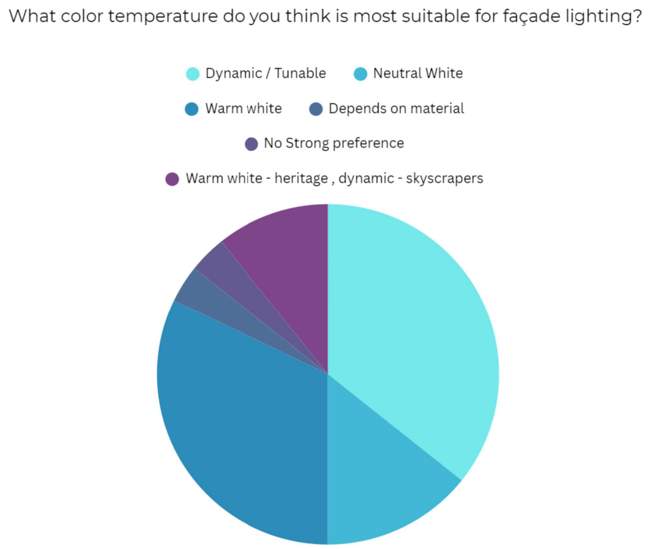
Questions asked to User groups during mockup and testing

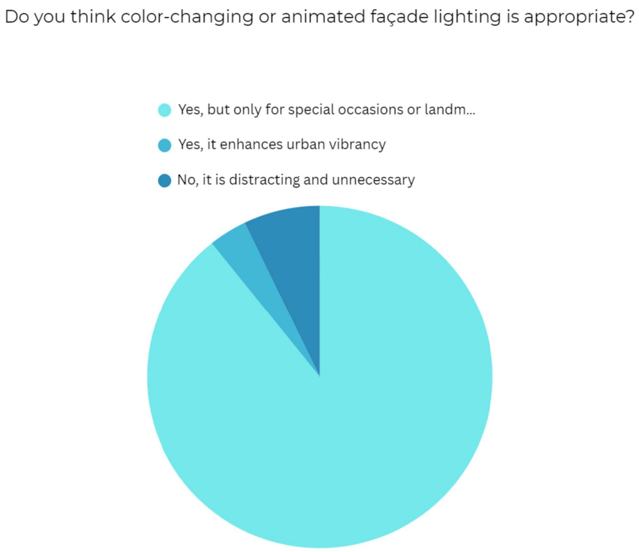
1. Does the lighting highlight the architectural feature of the building ?
2. Is the lighting soft and non-intrusive when experienced from the interior of apartment ?
3. Does the light reflect any kind of identity ?
4. Does the lighting feel calm and welcoming or does it create glare ?
5. Which Rasa (emotional essence) do you resonate with under this lighting scheme. Shanta – peace, Karuna – compassion, Adbhuta – wonder, Raudra – intensity, Hasya – joy, etc

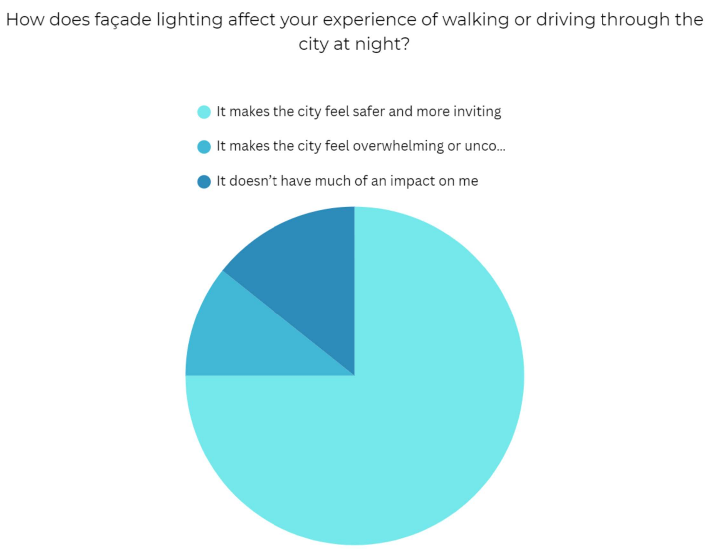
SURVEY RESULTS

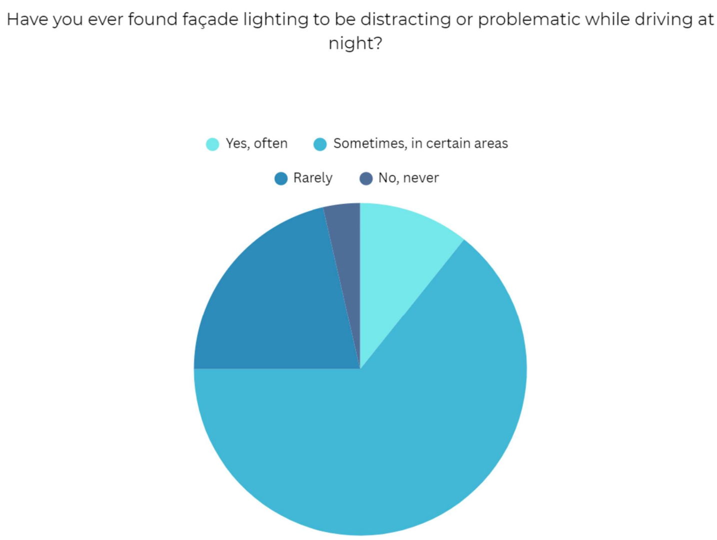




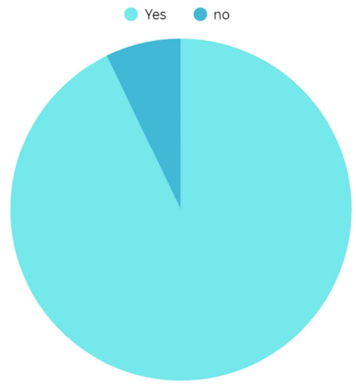




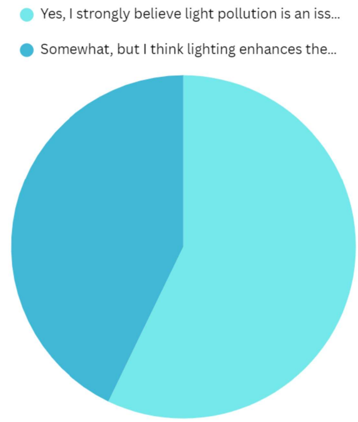




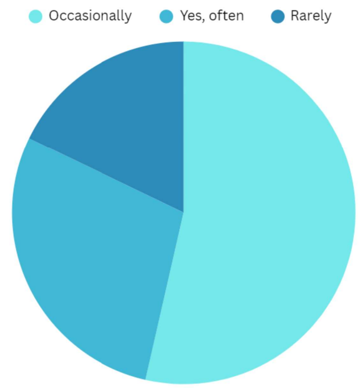
Have you encountered façade lighting in different cities?



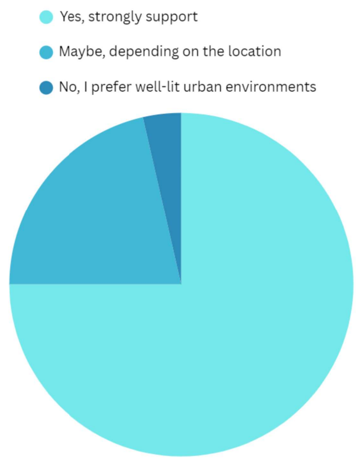
Are you concerned about the impact of façade lighting on the night sky and surrounding environment?



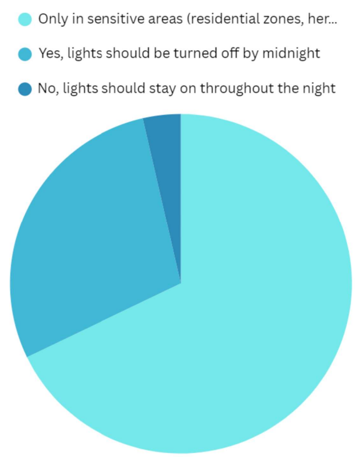
Have you noticed façade lighting spilling into unwanted areas (homes, parks)?



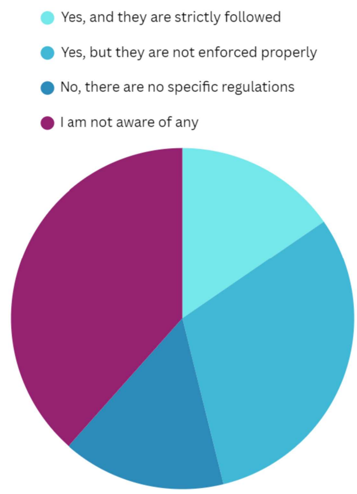
Would you support reducing façade lighting intensity in residential or nature-adjacent areas?



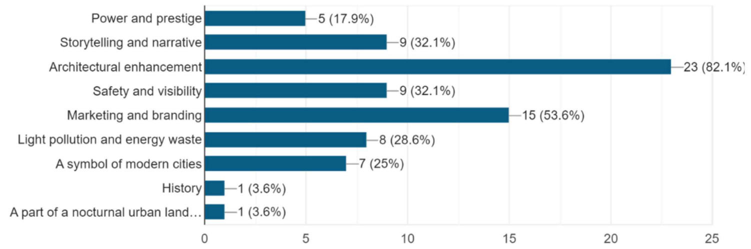
Should cities have restrictions on how long façade lights remain on at r



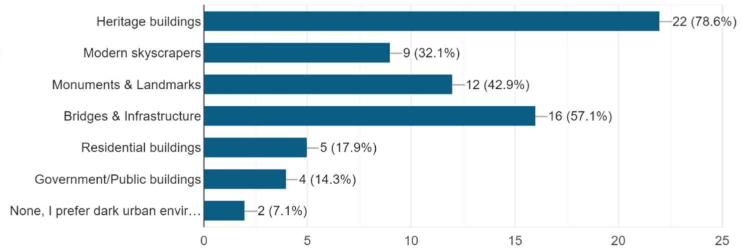
Are there existing regulations in your region for façade lighting?



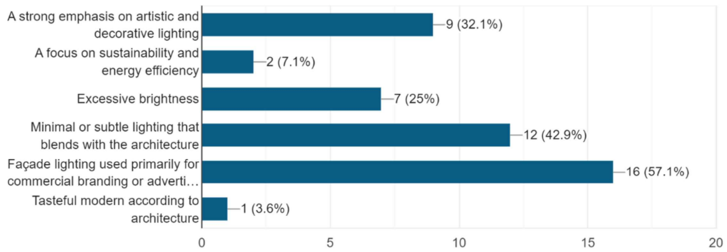
What does façade lighting represent to you?



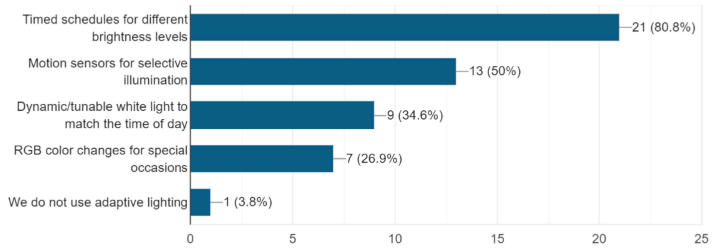
Which types of buildings do you find most attractively lit at night?



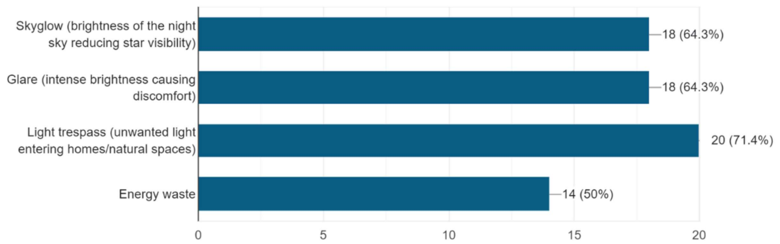
What is your experience with façade lighting in your city?



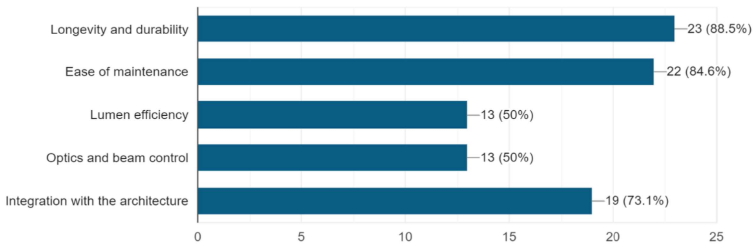
How do you incorporate adaptive lighting ?



Which aspects of light pollution do you think façade lighting contributes to?



What factors dictate the choice of lighting fixtures for façades?



What would you suggest for future façade lighting policies?