

LIGHTING METHODS AND PROPOSALS FOR THE MODERN HOUSE

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Abstract

Since the early 20th century, architects such as Mies van der Rohe, Le Corbusier, and Alvar Aalto have tried to create a functional architecture that would allow natural light to diffuse inside the house, ensuring a better relationship between its interior and exterior spaces.

The transformation of private houses in modern times is of great interest in the evolving architectural structures and the new construction standards, emphasizing the new lighting technologies applied to them.

A modern house is one system with its user, and lighting needs to follow changes in its needs and desires and, in order to achieve this, it should incorporate this changeability at construction level as well.

The primary purpose of this study is to attempt to highlight the essence of architectural lighting, which must be human-centered and meet the functional requirements of a modern house separately, treating the user as a unique entity.

The development of a qualitative - creative approach to the design of architectural lighting in the modern house offers the possibility of achieving multiple goals. The sense of living in a flexible space that belongs to the residents, experiencing it as their own, and which promotes the comfort and pleasure of those who live in it are elements that make up the architect's effort for a new way of living.

Through examples from modern lighting applications, it is shown that with the new, energy-saving, technological possibilities it is possible to implement any idea and proposal for the quality lighting of a house. Luminaires can now have any shape and be integrated into the structure of a building and form a new architectural identity in space.

Keywords: natural and artificial light, modern house, energy efficient lighting, new lighting Technologies

INTRODUCTION

Natural light has been one of the most critical parameters of building design in the history of architecture. For hundreds of years, all buildings were designed and built under a single light source, the sun with the sources of artificial lighting necessarily attached to the limits of the current lighting technology. Many great architects had perceived the role of natural light as the primary means of bringing people in contact with their environment.

Le Corbusier, by defining his architecture based on light, transforms it into an element capable of not only influencing matter but also shaping it. The main axes of the floor plans of his works, which eventually shape his faces and volume, are directed by light and the way it will penetrate space.

At the same time, Le Corbusier, artificial lighting played a vital role in its architecture. Artificial lighting substitutes natural sunlight during the night by connecting two opposing elements: day and night.

Subsequently, other architects followed who tried to create a functional architecture that would let the light diffuse into the house, ensuring a better relationship between its interior and exterior spaces.

Gio Ponti, in the first issue of *Domus* magazine, “La casa all’ Italiana” (1928), writes: “we need a new way to live and not a new way to build.” Together with Bernard Rudofsky, they discover that the essence of the experience of architecture is not academic, but is hidden in the “dwelling.” The sense of dwelling in a place that belongs to the resident, experiencing it as his own, the inclusion in nature, the extroversion, the light, the particular importance given to the materials used, and the resonance in the city shape the demands of a modern house.

Space and light are two interrelated elements in the architectural composition. The light gives quality and atmosphere in space and, according to Louis Kahn, “space could never have taken its important place in architecture without natural light.” The light exists in all structural elements of the environment (in its natural form or artificial

reproduction), being a key parameter for the visual perception of all the surrounding objects.

Light and architecture connect directly as architecture is primarily expressed with the image, which directly intertwine with the light that makes it perceptible to the human eye. Light is the most essential condition for which architecture is made perceptible.

The study of the use of light in architecture offers multiple levels of analysis. Bearing in mind the two-way relationship of light – architecture and its ability to transform an architectural project, giving it invaluable architectural qualities, an emphasis places on the properties of lighting as an important synthesis tool.

1. The interaction of colors with our visual mechanism

The eye perceives an object based on the amount of light reflected from it. Three factors affect the amount of light that will reflect from the object to the eye: color, texture, and finishing. Light colors reflect more than dark colors. Smooth textures reflect a larger surface than the rough ones. Glossy surfaces reflect more than matte surfaces. Hard surfaces scatter light and significantly reduce the amount reflected the eye compared to soft surfaces.

The apparent brightness of an object also depends on the brightness of the surrounding space or its contrast from one to the other. For example, a dark surface on a dark background will look brighter than a lighter background. Brightly colored surfaces may affect other surfaces that reflect brightly colored light on them. However, the eye adapts to the dominant color, and this reduces the effects of interreflection.

Each material reflects light differently. The white color diffuses light evenly in all directions, so it covers a wall more effectively than any other color. The light is affected not only by the color of the wall but also by its texture. Different surfaces break and reflect the rays in different ways. The sunlight can flow or spread or bounce over a wall, depending on the texture, and the inert materials suddenly acquire the shades of nature. Dark wood absorbs light, while metal objects are the most reflective.

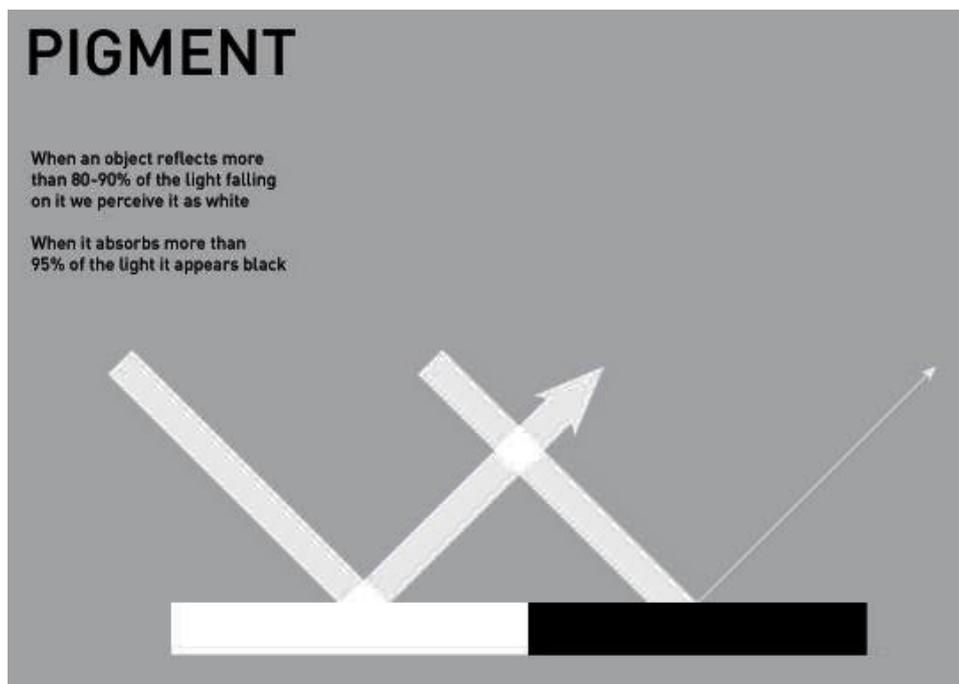


Figure 1. Smooth surfaces reflect light directly and appear lighter color because much of the light falling on them reflects to the eye. Matte surfaces are minutely, sometimes microscopically roughened, and diffuse light evenly, so the reflected light is constant from any angle. The same material appears darker with a rough finish than with a smoother finish, while glossy surfaces reflect more quantity of light.

2. The influence of natural and artificial lighting on psycho-physiological well-being

Biologically, light has a significant effect on the 24-hour cycle of our body that dictates physiological functions, including mood, appetite, and sleep habits. The human circadian rhythm determines by natural light. In normal circumstances, when natural light falls, our body begins to secrete melatonin, the sleep hormone. The color temperature and brightness of light tell our body the time of the day and the functions it should do. Body activity levels are affected by color temperature and brightness of the light. Sleep disorders, depression, seasonal affective disorder, and other disorders can be treated by natural light therapy, which includes exposure to specific amounts of light at specific hours of the day.

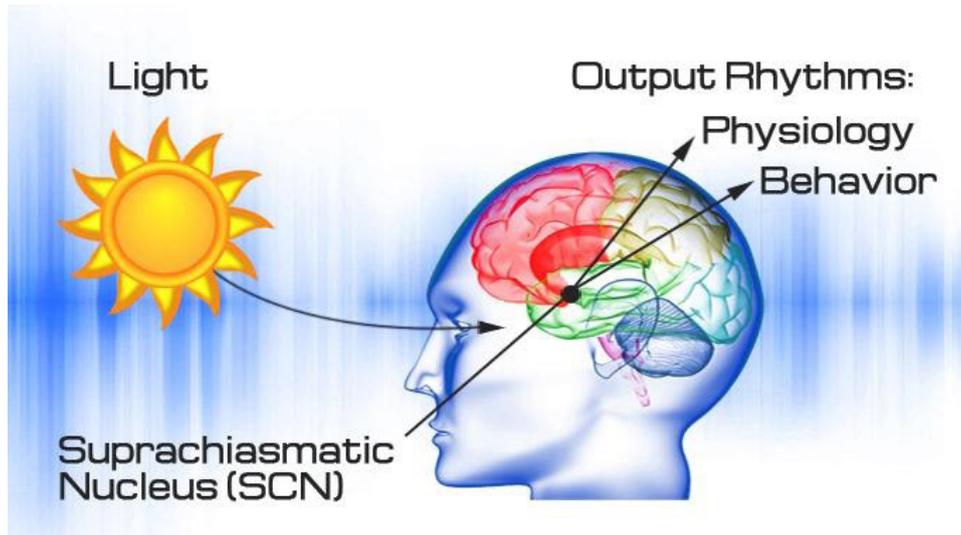


Figure 2. Natural factors within the body produce circadian rhythms. However, signals from the environment also affect them. The primary cue influencing circadian rhythms is daylight. This light can turn on or turn off genes that control the molecular structure of biological clocks.

In the recent past, as far as artificial light is concerned, luminaires with dynamic lighting have been built to simulate the daylight. They were intended primarily for underground spaces or constructions where there was no possibility of natural light entering their interior. The use of this luminaires type aims at avoiding circadian rhythm's disturbance for people, who lived in these spaces for a long time.

3. The lighting design in modern houses

In the 21st century, the use of light in architecture became even more intense and manifold, aiming at the creation and diversification of more and qualitatively different spaces; in essence, the house treats as a multi-use facility. The diversity in the natural and artificial light's use, qualitatively and quantitatively, contributes to the spaces prioritization, and their diversity in terms of function, use and importance.

3.1 Natural lighting

In many cases, natural light in the architectural composition is a primary synthetical tool of the architect – lighting designer, shaping the whole concept based on the atmosphere that is sought to achieve through light. The openings and surfaces that surround the house need special handling and processing, with the light contributing substantially to the performance of the hierarchy in space.

The light-induced transmutations give life and movement to the building, changing its appearance about time and day. Light affects differently each architectural work since it can highlight or eliminate its form, construction, or even its materials.

The natural lighting of interiors gives us information about its orientation. Most commonly, the desired lighting inside a building is sought through various openings on the east and south, while the light on the west and north is limited with solid walls and smaller openings.

East openings diffuse light into space in the morning, while the openings to the west in the afternoon. South-orientated openings create intense lighting. The openings on the north side or in the roof ensure uniform lighting.

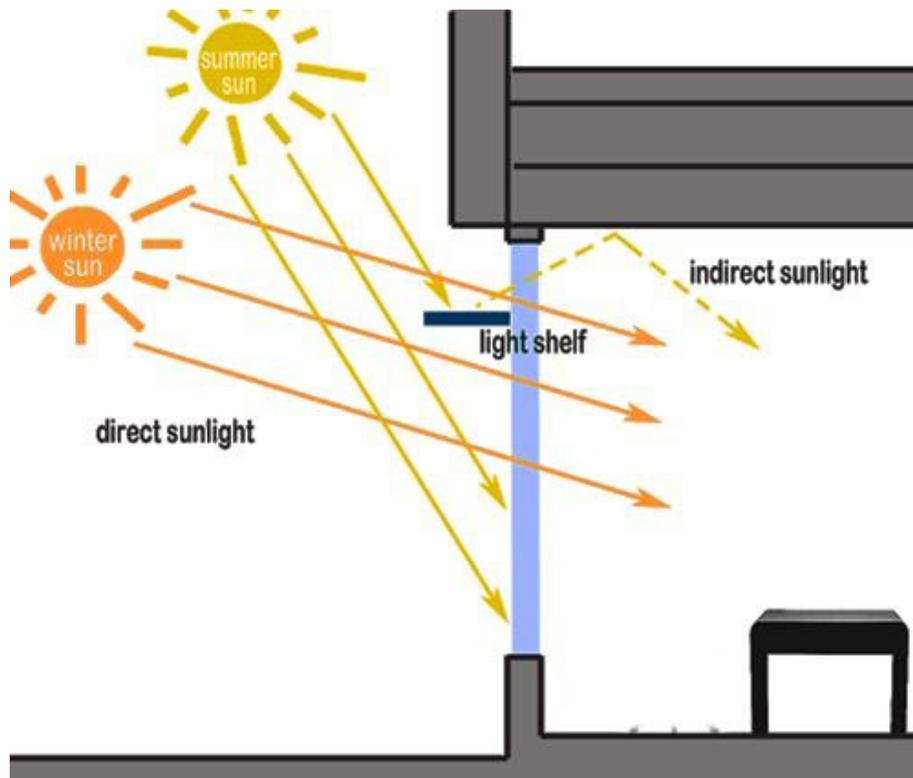


Figure 3. Using daylight is a method to optimize the energy-saving potential of buildings and contributes, therefore, to our health and well-being.

As far as natural light is concerned, the two basic types used in the interior spaces of houses are the following:

- **Direct light**, which enters space directly without being obstructed by any factor and provided that the construction and position of the opening make it a direct lighting source. An opening in the roof projects a direct light in the space.
- **Indirect light** enters space by reflecting on a surface, an object, or a neighboring building. Thus, in order, the light to enter the house's interior is first reflected from a surface, since the building's external environment, its shape, and the openings position do not allow the light beam to pass intact and directly. Usually, the resulting light diffuses better in space than direct lighting. The degree of diffusion depends mainly on the properties of the reflective surface, such as its texture, color, and inelasticity. In a space that is illuminated by indirect (diffuse) light, the shadows created have an unclear contour, or no shadows are created depending on how the light enters.

Appropriate light management can create visual illusions through the reflections it creates in space, which acts as changers of real space. Individually, regardless of its physical size, space may be perceived either as smaller or larger based on its natural lighting. In particular, a small space looks more substantial when it sufficiently lites, while an ample space looks smaller if its light is limited. Thus, reflections of light within space help in the apparent magnification of its capacity.

3.2 Artificial lighting

Artificial light can cause excitement, drama, mystery, romance, or any other mood. This power of light provides the ability to materially influence space looks and transform it literally. Light is the stimulus that influences most the human perception and the psycho-physiological well-being of the individual in everyday life, regulates mood and affects the quality of our lives.

Artificial lighting in the house spaces has significantly changed over the last decade. The technological development in the field of lighting with the use of LED (lighting emitting diodes) gas enabled the creation of compact lighting fixtures that are much more easily integrated into the construction details or are fully integrated into the shell of the building and create an extraordinary atmosphere. The small dimensions of light sources, the choice of color temperature, the low energy consumption and smart lighting (i.e., the lighting system connected to a network that can be monitored and controlled by a central infrastructure or through a Cloud) are the main features that have made lighting in modern houses flexible and functional.

About artificial light in the interior spaces of a house, the following types use according to their mounting:

- Ceiling luminaires: recessed luminaires with trim or without cutting, surface mounted, pendant luminaires
- Concealed lighting on the roof, in architectural details, stairs.
- Wall luminaires, surface mounted, recessed luminaires with trim or without cutting.

- Freestanding luminaires
- Table luminaires
- Inground recessed luminaires

The set of luminaires operate either individually or in groups where they create lighting scenarios that meet the needs of the residents. Based on the scenarios to be determined, it is possible to create a desired atmosphere, and quality of space inside the house.



Figure 4. Architectural lighting design focuses on three fundamental aspects: the aesthetic appeal of a building, the ergonomic aspect and the energy efficiency.

Appropriate artificial lighting can make a difference in how residents feel about their space, helping them perform activities efficiently, feel safe and comfortable, and enjoy the space in all its small but essential details. It can create the right atmosphere for fun or fill the residents with a feeling of serenity and relaxation after a stressful day. The human psycho-physiological balance must regulate the mood and influence the quality of life.



Figure 5. The objective of lighting design is the human response, to see clearly and without discomfort.

Poor light distribution, with high contrast in brightness or reduced color rendering, can adversely affect the psychological state of people and cause discomfort and depression.

4. Design Lighting Techniques

Artificial light is a design tool that, depending on its handling, can determine the human experience and not be limited in covering the functional requirements of the space but also to its emergence.

It is the most volatile and adaptable environmental material, and it creates emotions in a variety of ways while having a profound effect on the way people perceive, and experience their environment. It helps to carry out the

activities easily, strengthens the sense of security and comfort and the perception of space with all the small but essential details.

Depending on the use of lighting, there are four main categories:

- **decorative lighting or accent lighting**, which is used to bring out architectural elements and details,
- **functional lighting**, which is used for practical purposes and safe movement within the house (diffuse, route, downlighting, entry, stairs),
- **working lighting**, which makes it possible to carry out specific tasks (kitchen table, office space),
- **and safety lighting** for safe movement in case of power failure and prevention of burglars, thieves, vandals.

Illuminance(lx)	1	2	5	10	20	30	50	75	100	150	200	300	500	750	1000	1500	Ra value
Living room						General lighting					Recreation	Reading					80 or more
Children's room/Study room						General lighting					Play						
Dining room						General lighting						Table	Study/Reading				
Kitchen							General lighting					Sink					
Bedroom		Late at night		General lighting									Reading/Makeup				
Bathroom/Washroom							General lighting				Shave/Makeup/Basin						
Toilet							General lighting										
Corridor/Stairs		Late at night			General lighting						Take off shoes/Display shelf						
Entrance(inside)							General lighting						Mirror				
Gate/Entrance(outer)			Passage	Nameplate/Newspaper slot/Bell button													

Figure 6. Room activity and illuminance (an example of recommended illuminance levels).

Space can “breathe” from the dynamic in lighting. Light’s small variations can have a calming effect on humans. Brightness guides the eye, focuses on a particular object, creates a hierarchy, and increases understanding of space.

Artificial lighting is the most crucial factor in creating an atmosphere in any space. A space-based approach that uses light in conjunction with color, texture, materials, and shadows creates a setting that causes people a variety of emotions. It allows the creation of scenes that complement and lead to other readings. It stimulates the senses and causes our imagination to transform the space completely.

5. Study cases

5.1. Bloc Architects + Kevin Lloyd Architects, Umhlanga House #8, 2017

Umhlanga House #8 built in a forest estate in Durban, South Africa. The architects designed a house of high standards, comfortable, intimate, and relaxing. The house built on a hill, has unlimited views of the forest and tries to frame the landscape with clear horizontal lines.

The factors led to the building’s organization were the view, the sunlight, and the wind’s direction. The original conception based on a shell - a box “floating” on the hill to the forest, with verandas on cantilevers, skylights for natural lighting, and large glazed surfaces in the spaces so that residents have direct contact with the natural environment.

The house has an externally rugged concrete texture. The most significant part of the floor circumferentially covers by large openings, and wooden sliding panels (blinds). There, the wing of the bedroom stands out in the whole structure, is cut off from the central volume and slightly rises to take advantage of the maximum height allowed in the area. In this way, the southern part of the upper level differs from the north in a nearly sculptural way. House’s central staircase, with its diagonal geometry, serves the vertical movement between the levels, and was also placed in this slot.

The rooms were designed to take full advantage of the sun and the view, while small skylights allow natural light, even in the bathrooms, which would otherwise be exclusively dependent on artificial lighting.



Figure 7. Large openings and wooden sliding panels circumferentially cover the house.

5.2 RS Sparch, House in a Garden, 2016

It is a house surrounded by the dense urban fabric of Athens. Exploiting the plot's potential in terms of orientation and vision was a primary pursuit of the design. The house consists of a concrete base and a white metal-structure 'beam,' a linear projecting 'bridge' that balances on the base, its folded ends open to the view. Glass panes are placed in-depth to provide the necessary sun protection.



Figure 8. House view from outside in the night.

The house, protected from prying eyes with the high perimeter fencing, stands in the surrounding area of the rectangular plot, which acts as an architectural continuum of its interior. Large openings from the ground to the roof, on the inside, guarantee the visual unification of the interior - exterior, while the pool is pulling ephemeral reflections of the sky and clouds deep into the house.

A glass-enclosed patio introducing indirect natural lighting into the center of the building volume designed on the roof of the house.



Figure 9. The natural light is one of the most desirable attributes in a space, both to showcase the design and décor and to create a warm and welcoming environment.

The patio, with its simple design, is a main element of the architectural composition as it placed on the ceiling of the central dining room. The advantages of having the patio are optimizing lighting while reducing energy consumption during the day, and it is particularly vital space.

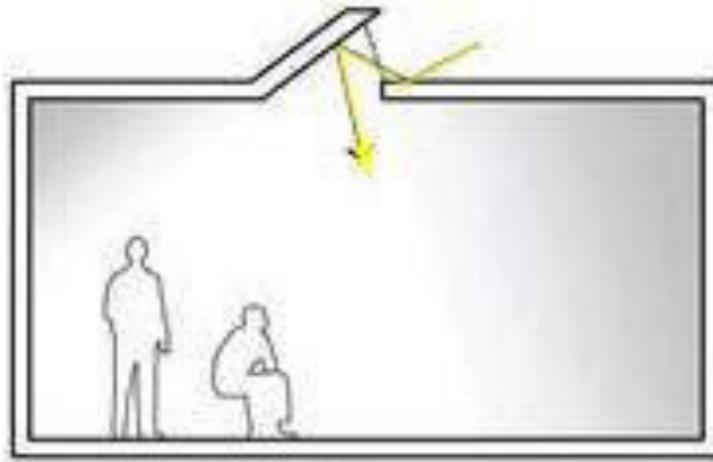


Figure 10. Skylights (provide indirect light) are often used in the daylighting design of residential buildings, mainly because they serve as both an architectural aesthetic feature and a method of introducing natural light into space.

As far as the way of managing artificial lighting is concerned, it designed according to the architects' suggestions. Throughout the house, general lighting has adopted through linear led luminaires placed in the false ceiling where they change intensity according to the mood and the needs of the residents, thus contributing to the particular atmosphere of the house.

More specifically, lighting design has been studied to meet the following objectives fully:

- The visual comfort.
- Visual perspective of the building's architectural volume.
- Ability to create lighting scenarios.
- The artworks emergence of the building's interior.
- Application study for energy saving.

The proposed lighting solutions strictly followed the simple architectural lines of the building, are integrated into it, and become one with the roof, highlighting at the same time the different materials, textures, and colors. This goal achieved by selecting "trimless" luminaires, with which the luminaire volume is "lost," fully integrated into the ceiling. At the same time, this type of luminaire prevents unwanted glare. Indoor lighting has been distributed to diffuse without intense contrasts, and shifts of light and shadow. Great importance was given to energy saving, using state-of-the-art light-emitting diode luminaires, with high light output and excellent illumination quality (CRI 90).



Figure 11. Extruded aluminum luminaires "trimless" create perfectly straight lines of light on the ceiling.

Also, track-mounted spot-lights were used to highlight artworks, concealed lighting, table lights and floor lamps to create more lighting options in the house.



Figure 12. House interior view, the combination of natural, and artificial lighting, contributing to the particular atmosphere of the house.

CONCLUSION

Light determines our spatial environment. The architect, in collaboration with the lighting designer, uses natural and artificial light to give life to the house's space. Light's effect quality decisively influenced by the reflecting surface materials as the materials quality is directly related to the intensity, color, and shape of the reflected light.

During the construction phase, lighting design integration into the central concept of the house's general design, works much better in terms of the result produced. Design involves the natural light with the building's orientation, the creation of a patio, or the use of frames in the structure's shell to manage the amount of light entering the interior.

The same design principle also applies to artificial lighting, since new technologies, and its management systems often require their inclusion in the building shell during its construction.

The use of natural or artificial light as a synthetic tool and a guide to the architectural process determines the subsequent human experience and offers the visual quality that users themselves need for health, safety and enjoyment in their house.

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